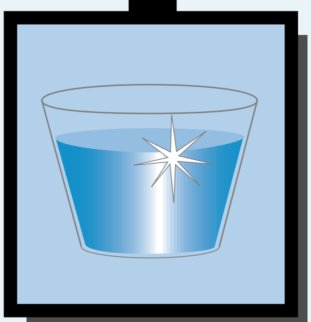
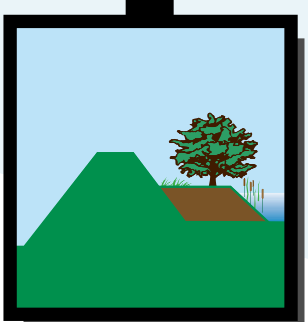


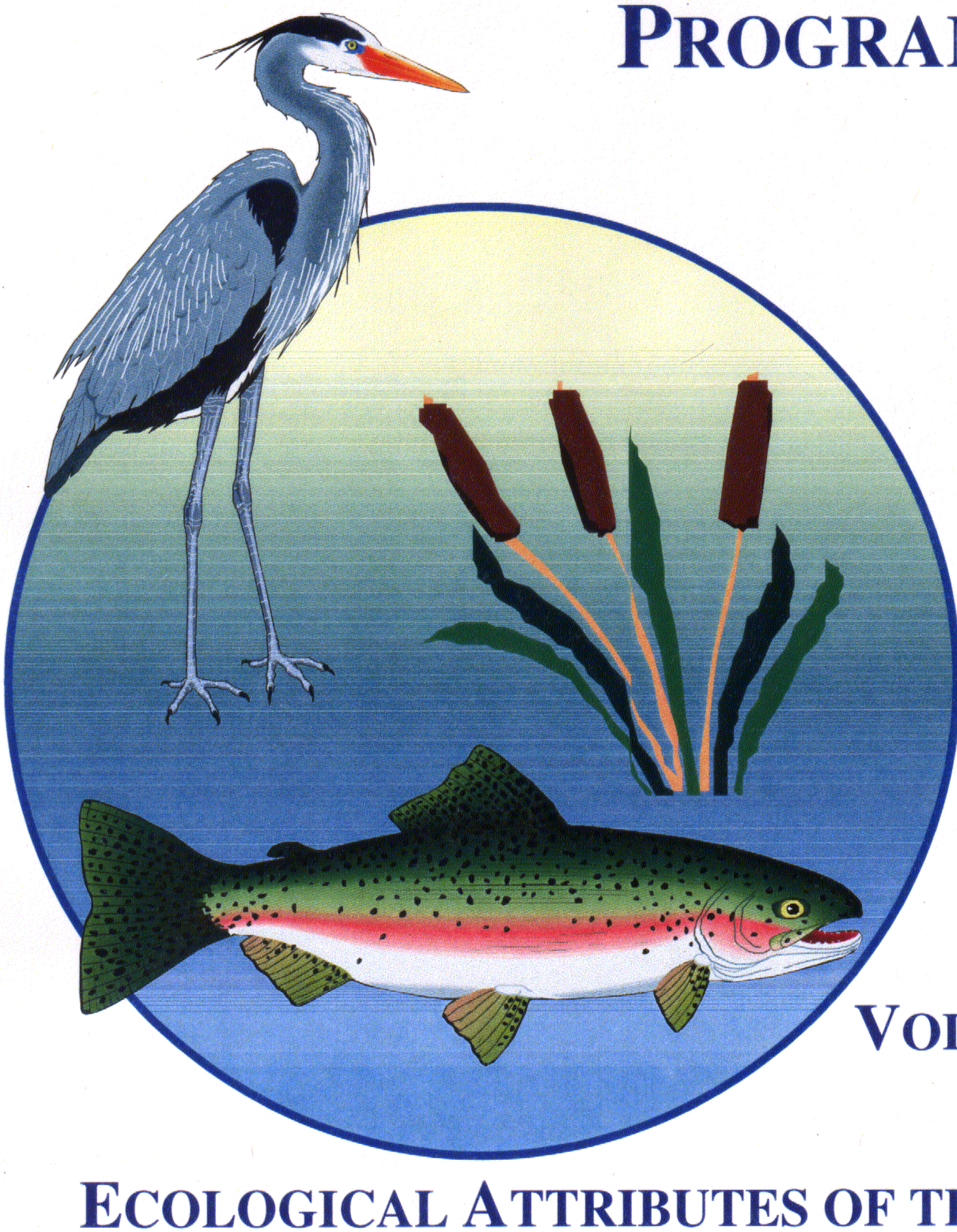

CALFED
BAY-DELTA
PROGRAM

Ecosystem Restoration Program Plan
Volume I: Ecological Attributes of the San Francisco Bay-Delta Watershed

Final Programmatic EIS/EIR Technical Appendix

July 2000

ECOSYSTEM RESTORATION PROGRAM PLAN



VOLUME I

ECOLOGICAL ATTRIBUTES OF THE SAN FRANCISCO BAY-DELTA WATERSHED

CALFED BAY-DELTA PROGRAM

JULY 2000

CALFED BAY-DELTA PROGRAM
ECOSYSTEM RESTORATION PROGRAM PLAN

VOLUME I: ECOLOGICAL ATTRIBUTES OF THE SAN FRANCISCO BAY-DELTA WATERSHED

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OVERVIEW

The mission of the CALFED Bay-Delta Program is to develop a long-term comprehensive plan that will restore ecosystem health and improve water management for beneficial uses of the Bay-Delta system. The Program addresses problems in four resource areas: ecosystem quality, water quality, levee system integrity, and water supply reliability. Programs to address problems in the four resource areas have been designed and integrated to fulfill the CALFED mission.

Ecosystem goals presented in the *Strategic Plan for Ecosystem Restoration* will guide the Ecosystem Restoration Program (ERP) during its implementation phase. Strategic Goals include the following:

1 Achieve recovery of at-risk native species dependent on the Delta and Suisun Bay as the first step toward establishing large, self-sustaining populations of these species; support similar recovery of at-risk native species in the Bay-Delta estuary and the watershed above the estuary; and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed.

2 Rehabilitate natural processes in the Bay-Delta estuary and its watershed to fully support, with minimal ongoing human intervention, natural aquatic and associated terrestrial biotic communities and habitats, in ways that favor native members of those communities.

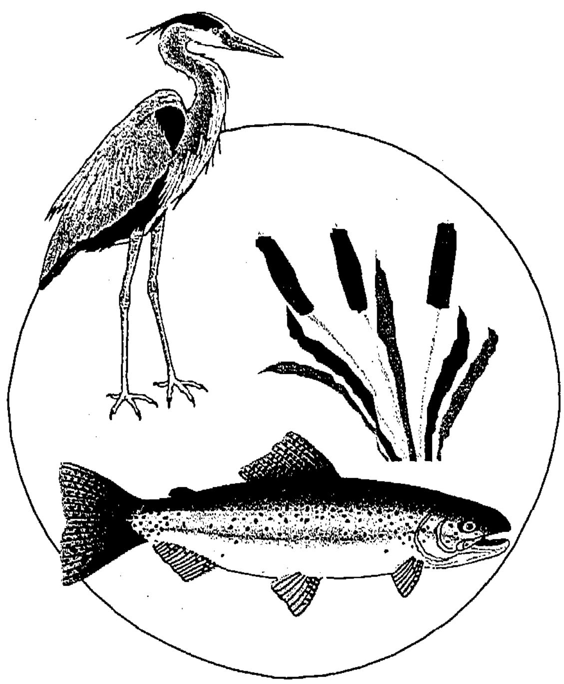
3 Maintain and/or enhance populations of selected species for sustainable commercial and recreational harvest, consistent with the other ERP strategic goals.

4 Protect and/or restore functional habitat types in the Bay-Delta estuary and its watershed for ecological and public values such as supporting species and biotic communities, ecological processes, recreation, scientific research, and aesthetics.

5 Prevent the establishment of additional non-native invasive species and reduce the negative ecological and economic impacts of established non-native species in the Bay-Delta estuary and its watershed.

6 Improve and/or maintain water and sediment quality conditions that fully support healthy and diverse aquatic ecosystems in the Bay-Delta estuary and watershed; and eliminate, to the extent possible, toxic impacts to aquatic organisms, wildlife, and people.

The ERP addresses these Strategic Goals by restoration of ecological processes associated with streamflow, stream channels, watersheds, and floodplains. These processes create and maintain habitats essential to the life history of species dependent on the Delta. In addition, the Program aims to reduce the effects of stressors that inhibit ecological processes, habitats, and species.



ORGANIZATION OF THE PLAN

The ERP comprises three volumes: a Strategic Plan and the two volume restoration plan.

- Strategic Plan for Ecosystem Restoration
- Volume I: Ecological Attributes of the San Francisco Bay-Delta Watershed
- Volume II: Ecological Management Zone Visions.

STRATEGIC PLAN FOR ECOSYSTEM RESTORATION is the guidance document for implementing the Ecosystem Restoration Program Plan. It defines an ecosystem-based approach that is comprehensive, flexible, and iterative, designed to respond to changes in the complex, variable Bay-Delta system and changes in the understanding of how this system works. The Strategic Plan also presents broad strategic goals and objectives and establishes "Adaptive Management" as the primary tool for achieving ecosystem restoration objectives. The Strategic Plan describes how conceptual models should be used in developing restoration programs and defining information needs. Note: The Strategic Plan for Ecosystem Restoration (2000) is derived from the Strategic Plan for the Ecosystem Restoration Program (1998).

VOLUME I: ECOLOGICAL ATTRIBUTES OF THE SAN FRANCISCO BAY-DELTA WATERSHED presents the visions for ecological processes and functions, fish and wildlife habitats, species, and stressors that impair the health of the processes, habitats, and species. The visions presented in Volume I are the foundation of the ERP and display how the many ecosystem elements relate to one another and establish a basis for actions which are presented in Volume II.

VOLUME II: ECOLOGICAL MANAGEMENT ZONE VISIONS presents the visions for the 14 ecological management zones and their respective ecological management units. Each individual ecological management zone vision contains a brief description of the management zone and units, important ecological functions associated with the zone, important habitats, species which use the habitats, and stressors which impair the functioning or utilization of the processes and habitats. Volume II also contains strategic objectives, targets, programmatic actions, and conservation measures which describe the ERP approach, and which balances and integrates the needs of the Multi-Species Conservation Strategy (2000) in order to improve the ecological health of the zone and its contribution to the health of the Delta. Rationales are also contained in Volume II which clarify, justify, or support the targets and programmatic actions.

INTRODUCTION TO VOLUME I

Volume I contains information related to problems, theory, and concepts linked to the Central Valley ecosystem and includes descriptions of important ecological processes and functions, habitats, species, and stressors which impair or otherwise adversely effect the other ecosystem elements (Figure 1). Individually and cumulatively, the visions for the ecosystem elements establish the foundation and scientific basis of the ERP. Volume I also incorporates important elements from the Multi-Species Conservation Strategy (2000) such as standardized species designation, conservation measures for evaluated species, and species goal prescriptions.

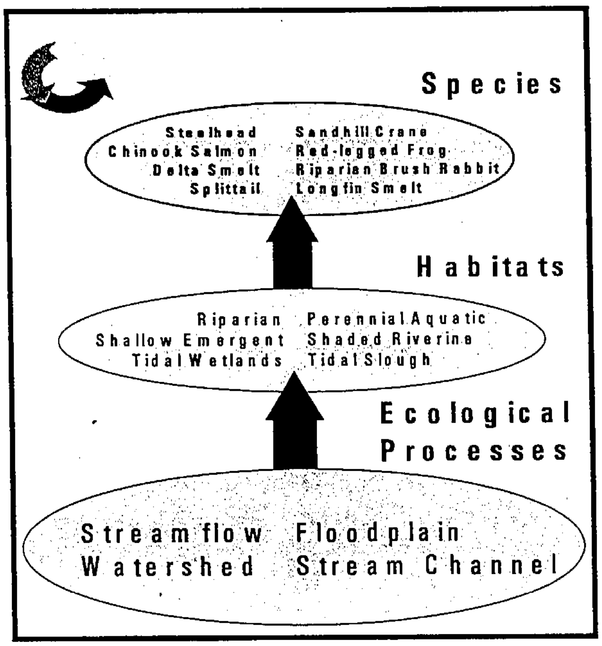


Figure 1. Relationship of ecological processes, habitats, and species in the Ecosystem Restoration Program Plan.

Each section follows the same format and begins with introductory information regarding the ecosystem elements. Three introductory tables summarize the strategic objectives, basis for selection as an ecosystem element, and the distribution of ecosystem elements by ecological zone.

Individual visions begin with an introduction followed by a description of the relevant process, habitats, species, or stressors. These are followed by the ERP vision for the element, how restoration of the process, habitat, or species, or reduction or elimination of the stressor integrates with other ongoing restoration or management programs. The relationship or linkage of the ecosystem elements to other elements is then discussed followed by a presentation of the strategic objective, targets, narrative summary of programmatic actions, and MSCS conservation measures which provide additional detail to the programmatic actions.

PERSPECTIVE

The ecological hub of the Central Valley is the Sacramento-San Joaquin Delta and Bay. The ERP signals a fundamental shift in the way ecological resources of the Central Valley are managed. For many decades, government entities, non-profit organizations, and the private sector have engaged in managing, protecting, regulating, and in some cases propagating fish and wildlife species of the Bay and Delta - yet many populations have not recovered sufficiently and remain in decline. In spite of constant human intervention to repopulate fish and wildlife that have commercial, recreational, and biological importance to society (e.g., hatchery programs and expensive re-engineered water diversions), populations have not been sustained at stable, healthy levels that support historic use of those resources.

Historic efforts of individual species regulation and management will be replaced by an integrated systems approach that aims to reverse the fundamental causes of decline in fish and wildlife populations. A systems approach will recognize the natural forces that created historic habitats and use these forces to help regenerate habitats. The Bay-Delta ecosystem is not simply a list of species. Rather, it is a complex living system sustained by innumerable interactions that are physical, climatic, chemical, and biological in nature, both within and outside of the geographic boundaries of the Delta.

The ERP is fundamentally different from many past efforts in another way as well. It is not designed as mitigation for projects to improve water supply reliability or to bolster the integrity of Delta levees; improving ecological processes and increasing the amount and quality of habitat are co-equal with other program goals related to water supply reliability, water quality, and levee system integrity. Solving serious and long-standing problems in each of these resource areas will require an ambitious, integrated, long-term program. We do not know the balance needed between restoration efforts in the Delta and Bay and restoration efforts upstream. However, aquatic species cannot be the sole driving force for ecosystem restoration. Ecosystem restoration must involve the integration of the needs of terrestrial and aquatic species and plant communities.

> The central theme of the ERPP is the recognition that truly durable and resilient populations of fish and wildlife inhabiting the Bay and Delta require, above all else, the rehabilitation of ecological processes throughout the Central Valley river and estuary systems and watersheds.

The ERP, like all components of Bay-Delta solution alternatives, is being developed and evaluated at a programmatic level. The complex and comprehensive nature of a Bay-Delta solution means that it will necessarily be composed of many different programs, projects, and actions that will be implemented over time. During the current phase of the Program, solution alternatives have been evaluated as sets of programs and projects and broad benefits and impacts have been identified. In the implementation phase of the Program, more focused analysis, environmental documentation, and implementation of specific programs and actions will occur. The CALFED goal for ecosystem quality will be achieved by further developing and adhering to the *Strategic Plan for Ecosystem Restoration.* A major effort toward reaching target levels will be emphasized during the first 7 years of the implementation program. Special effort will be directed to actions that can be implemented to restore ecological processes. The restoration of these processes is intended to restore and maintain habitats, and to provide for the needs of the species dependent on a healthy Bay-Delta system. For example, restoring stream channels contributes to sediments, nutrients, and a variety of habitats. The strategy recognizes that not all processes can or should be completely restored and that intervention, manipulation, and management will be required. For example, streambed gravel may have to be introduced, habitats may have to be constructed, and vegetation planted. Still, an important part of the approach is to recommend measures that in the long-term will limit the need for continued human intervention.

Implementation of the ERP is further guided by the recognition that all landscape units and physical and biological components of the ecosystem are interdependent and dynamic. Interdependence means that actions and stressors in one part of the system can and do affect populations and conditions that may be separated by hundreds of miles (e.g., in watersheds and spawning tributaries), or affect the food web in ways that may not be felt for several years.

Natural systems are dynamic; i.e., they are characterized by response to cycles of change and episodic catastrophes that are driven by natural or human factors. Most habitats undergo expansions and contractions, or shifts in space and time. The dynamic nature of healthy habitats is the cause of much biological diversity, and complex habitats tend to make species populations more resilient to change. If the mosaic of habitats distributed across a broad landscape is complex, and if large areas of habitat are connected by smaller patches and corridors such as those associated with riparian systems, then healthy areas of the ecosystem can be relied upon to sustain species during temporary setbacks in other areas.

GEOGRAPHIC SCOPE

The geographic (spatial) scope of the ERP is defined by the interdependence and linkage of the ecological zones which encompass the Central Valley. These ecological zones include the upland river-riparian systems, alluvial river-riparian systems, the Delta, and Greater San Francisco Bay (Note: These ecological zones are more fully described in the section on Key Ecological Attributes of the San Francisco-Bay Delta Watershed which follows this section). The geographic scope defines the locations where actions might be implemented to maintain, protect, restore, or enhance important ecological processes, habitats, and species. Some rivers or watersheds have ecological attributes which are valued higher than the attributes of others areas. These ecological values include the condition of important ecological processes and how well they support a diversity of habitats and biotic communities. The communities include the fish, wildlife, and plants which occupy or utilize the habitats within these local areas.

The species addressed in the ERP depend on habitat conditions in Suisun Bay, the Delta, Sacramento River, San Joaquin River, and many of their tributary streams. For these reasons, the primary geographic focus of the ERP is the Sacramento-San Joaquin Delta, Suisun Bay, the Sacramento River below Shasta Dam, the San Joaquin River below the confluence with the Merced River, and their major tributary watersheds directly connected to the Bay-Delta system below major dams and reservoirs. In addition, streams such as Mill Creek, Deer Creek, Cottonwood Creek, and Cosumnes River, are emphasized due to their free-flowing status and relative high quality of habitats and ecological processes.

Secondarily, the ERP addresses, at a broader, programmatic level, Central and South San Francisco Bay and their local watersheds (Note: The primary geographic focus area for the ERP can be divided into 14 management zones, each characterized by a predominant physical habitat type and species assemblage, Figure 2). These 14 ecological management zones constitute the geographic areas in which the majority of restoration actions will occur. The upper watersheds surrounding the primary focus area are important and addressed through general actions that focus on watershed processes and watershed planning, management and restoration. The CALFED Watershed Program addresses the coordination of planning and restoration actions in the upper watershed

MULTI-SPECIES CONSERVATION STRATEGY

CALFED has developed a Multi-Species Conservation Strategy (MSCS) to serve as the framework for compliance with the Federal Endangered Species Act (FESA), the California Endangered Species Act (CESA), and the State's Natural Community Conservation Planning Act (NCCPA) (Multi-Species

Conservation Strategy 1999). The Conservation Strategy has identified a subset of species which are federally and State listed, proposed, or candidate species, other species identified by CALFED that may be affected by and for which the CALFED Program and the ERP have responsibility related to (1) recovery of the species, (2) contribute to their recovery, or (3) maintain existing populations.

IMPLEMENTATION STRATEGY

A large and diverse ecosystem like the Bay-Delta is extremely complex. There are many processes and relationships at work in the ecosystem that are not fully understood. Thus, there are many difficulties and uncertainties associated with a program to improve ecosystem health. In some cases, problems are well understood and the steps to improvement are clear. In other cases, there is some understanding of the reasons for decline but this understanding is not sufficient to warrant full-scale implementation of remedial measures. In still other cases, additional research is needed before solutions can be identified with certainty.

The difficulties and uncertainties of ecosystem restoration call for an implementation strategy that is flexible and can accommodate and respond to new information. The foundation of the ERP implementation strategy is adaptive management. Adaptive management is a process of testing alternative ways of meeting objectives, and adapting future management actions according to what is learned. Adaptive management relies upon the identification of indicators of ecosystem health, comprehensive monitoring of indicators to measure

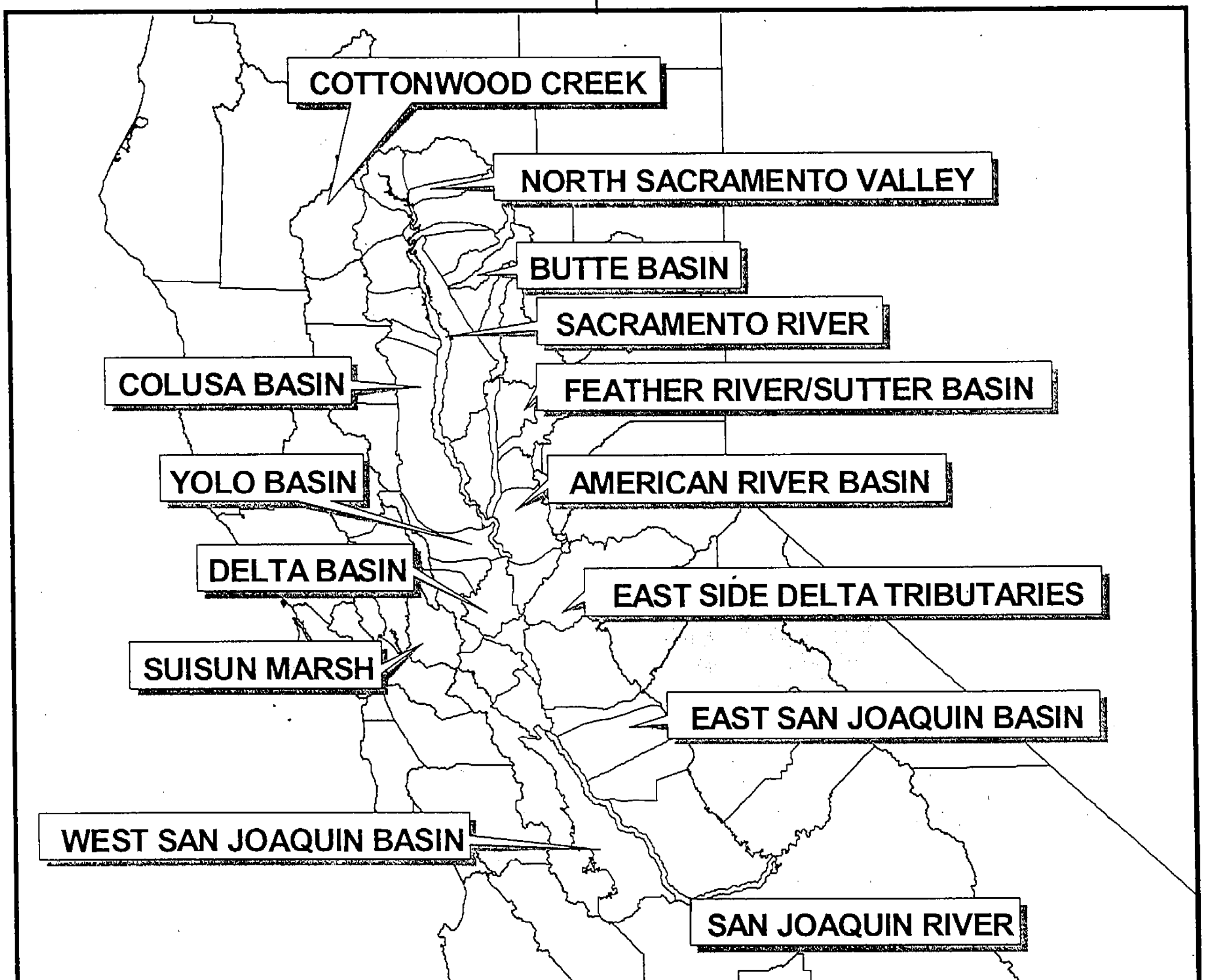


Figure 2. Location Map of the 14 Ecosystem Restoration Program Ecological Management Zones

improvement over time, focused research, and phasing of actions.

INDICATORS are quantitative measures of ecosystem attributes or elements that are expected to change over time in response to implementation of the ERP. Indicators are selected to provide measurable evaluations of important ecological processes, habitats, and species whose status individually and cumulatively provide an assessment of ecological health. Indicators of ecosystem health are the gauges we will use to measure progress toward the goal. Some indicators are very broad in scale while others are very specific. For example, a very broad or landscape level indicator of ecosystem health might be a comparison of the total area of riparian forest to historic coverage or an evaluation of the average distance between patches of such forest with closer patches indicating better health than more distant patches. A more specific indicator might be the concentration of toxic substances in the flesh of adult striped bass.

COMPREHENSIVE MONITORING is the process of measuring the abundance, distribution, change or status of indicators. For example, contaminant concentrations in fish tissues can be measured at various locations and times in the system to determine if contaminant levels are changing. This will allow progress to be measured, allow actions to be modified if necessary, and provide assurances that the restoration objectives are being achieved. (Note: A Comprehensive Monitoring, Assessment, and Research Program is being developed. A description of that program is presented later in this section.)

DIRECTED RESEARCH will help answer questions about the system and its components and increase the certainty surrounding the relationships of ecological processes, habitats, and species. For example, the relationships among streamflow, storm events, flow-related shaping of river channels to modify habitat, and the physical and chemical signals that flow provides for aquatic species all need to be better understood for effective management of the system.

STAGED IMPLEMENTATION is the logical sequence of implementing restoration actions to achieve CALFED goals as effectively as possible. Staging will consider all targets and programmatic actions and will be used to prioritize actions. For example, actions directed at recovering endangered species and which are consistent with the long-term restoration program and contribute to ecological resilience have a high priority.

Stage I is defined as the first 7 years of program implementation and will include restoration of ecological processes and habitats that are most important for endangered species recovery, reduction of stressors that affect threatened and endangered species, and other actions that may reduce conflicts between beneficial uses in the system. Later implementation stages will be shaped through adaptive management by the results of restoration actions in the first 7 years of the program.

The ERP will be refined and implemented according to the steps listed below.

1. **REFINE THE ERP** based on broad public participation, and using the best scientific knowledge currently available in the short term.
2. **CREATE AN ECOSYSTEM SCIENCE PROGRAM** to provide ongoing scientific evaluation of the ERP. The Science Program will be a collaborative effort among local and national, independent stakeholder and agency scientists and technical experts convened to address outstanding scientific issues and review the ERP.
3. **PREPARE CONCEPTUAL MODELS** to describe the Bay-Delta ecosystem and the proposed actions of the ERP. Restoration or rehabilitation programs for complex ecosystems must be based on clear concepts about how the system is believed to function, how it has been altered or degraded, and how various actions might improve conditions in the system. Conceptual models can provide a basis for quantitative modeling or identify critical information needs for research or monitoring. In ecosystem restoration, they can be used to link human activities or management actions to outcomes important to society. In adaptive management, the most important uses of conceptual models are for: linking human activities to valued outcomes, highlighting key uncertainties where research or adaptive probing might be necessary, and identifying monitoring needs.

4. **DEVELOP TESTABLE HYPOTHESES** for proposed ERP actions. The hypotheses underlying the ERP will be tested through experiments using the conceptual models and on-the-ground research. The results from these experiments will feed back into the adaptive management process and will support proposed actions, suggest revisions to actions, and identify needs for further research.

5. **CONDUCT IMMEDIATE DIRECTED RESEARCH** to improve understanding of the ecosystem and the causes of problems identified in the conceptual models and testable hypotheses. Use results from short-term studies to adjust the way that objectives are achieved, making refinements to the final ERP targets, actions, and implementation schedule.

6. **DEVELOP AND BEGIN A STAGED IMPLEMENTATION PROGRAM THAT ENTAILS:**

- short-term implementation of ecosystem restoration demonstration projects (e.g., through the CALFED Restoration Coordination Program and related programs), including stressor reduction measures, to help threatened populations begin recovering and to test the viability and effectiveness of targets and actions,
- coordinated monitoring, evaluation, and reporting of the results of recovery efforts, and the status of ecological indicators in the Bay-Delta and other zones, and
- adaptive management of each successive stage of ERP implementation, including pragmatic adjustments to ecosystem targets, funding priorities, and restoration techniques to ensure that public and private resources are well spent and complement other related efforts.

During refinement and implementation of the ERP, public accountability and program effectiveness will be assured through continuing public involvement as well as environmental impact analysis and documentation.

COMPREHENSIVE MONITORING, ASSESSMENT, AND RESEARCH PROGRAM

The CALFED Bay-Delta Program is organized around the concept of adaptive management because there is incomplete knowledge of how the ecosystem functions and the effects of individual project actions on populations and processes. Monitoring key system functions (or indicators), completing focused research to obtain better understanding, and staging implementation based on information gained are all central to the adaptive management process. The process necessarily includes numerous assessment and feedback loops so that management decisions are based on the best and most current information. This process entails an institutional framework to ensure that the correct questions are identified for monitoring and research actions, that monitoring and research are conducted appropriately, that the data collected and obtained are stored properly and available to those with an interest, and that relevant information is developed from the data obtained to further the incremental process of adaptive management. The Comprehensive Monitoring, Assessment and Research Program (CMARP) is being developed to meet these needs.

A substantial monitoring effort in the Bay and Delta has been carried out for many years under the auspices of the Interagency Ecological Program (IEP). The purpose of the CMARP is to build on the work of IEP and other efforts to assure that information gathering and evaluation necessary to the success of the CALFED Program is developed and carried out. CMARP will help provide those new facts and scientific interpretations necessary for implementing the CALFED Program and for the public to judge the Program's success. Major efforts will include documenting and explaining the status and trends of the resources, providing timely information for real-time management, and participating in design, execution, and analysis of adaptive experiments. CMARP must routinely make available information on major indicators of program progress. CMARP efforts must be subjected periodically to independent scientific review to evaluate the Program's relevance and approach and to maintain public confidence in the Program.

CMARP Scope

CMARP is designed to provide information on all of the CALFED program elements, including the Ecosystem Restoration Program, the Multi-Species Conservation Strategy, Water Quality Program, Levee Program, Water Use Efficiency Program, Water Transfer Program, Storage, Conveyance, and the Watershed Program. CMARP also has responsibility for organizing and evaluating data generated by projects of the Restoration Coordination Program. In addition, CMARP will contribute to the design of monitoring for any mitigation efforts of CALFED. Finally, CMARP will be coordinated with existing monitoring and research programs so that they can provide a foundation of information for the Program. The CMARP will include options to ensure that monitoring, assessment, and research needs are:

- identified
- coordinated to provide comprehensive system-wide coverage
- performed by the most appropriate party
- completed in a comparable manner by all parties
- accomplished with minimum redundancy and optimum efficiency and effectiveness.

The CMARP must also ensure that results from the monitoring are:

- interpreted
- made readily available to all interested parties in a timely manner
- incorporated as feedback to facilitate adaptive management.

CMARP must also assure that study and monitoring designs are sufficient to detect statistically significant and ecologically relevant impacts or changes.

The scope of CMARP includes both institutional and environmental considerations. It seeks to balance specific knowledge needs of water managers and the public versus an understanding of ecosystem processes and what can actually be obtained and measured from the field. For example, CALFED agencies presently monitor the abundance of several key species and environmental attributes such as streamflow at the State and federal diversion facilities in the Delta to understand better which species are entrained, when, how many, during what life stage and under what kind of environmental conditions. Although much of this monitoring is designed to address institutional needs, limits on knowledge obtained are based on limitations of monitoring design which in turn are limited by the physical system to be monitored. Thus, the programmatic scope of CMARP must consider both institutional needs and environmental considerations and should maintain sufficient flexibility to respond to both as they change over time.

CALFED has determined that monitoring, assessment, and research efforts are a critical component of the adaptive management process, and should be integral to all program elements. The application of CMARP will be very different for individual CALFED programs. However, each program element has similar needs that include gathering and assessing data. In addition, the CMARP must also address the monitoring and assessment needs of the CALFED Conservation Strategy, as well as any mitigation required as a result of CALFED program actions.

Restoration/rehabilitation projects require special consideration. A requirement for funding is that project proposals contain monitoring elements to determine if stated objectives have been met and to provide guidance for assessing future restoration/rehabilitation needs. CMARP will include recommendations to ensure that monitoring data from all these projects are technically sound, broadly usable, and provide meaningful information to guide future actions.

The CMARP Plan will take into consideration the broad variety of factors that can affect the environment, its physical structure, chemical makeup and biotic communities. The recommended program will necessarily be limited to monitoring only a small fraction of the possible physical chemical, and biological attributes of the environment. Conceptual modeling will play a key role in helping decide which attributes to monitor.

CMARP Objectives

Objectives have been established for CMARP's monitoring and assessment and research functions that are consistent with the adaptive management strategy adopted by CALFED.

Monitoring and Assessment Program Objectives

- Provide information necessary to management necessary to evaluate the effectiveness of program actions and to support ongoing adaptive management actions.
- Describe conditions in the Bay-Delta and its watershed on appropriate temporal and spatial scales.
- Evaluate trends in the measures of environmental conditions.
- Identify the major factors that may explain the observed trends.
- Analyze data and report results to stakeholders and agencies on a timely basis.

Research Program Objectives

- Build an understanding of physical, chemical and biological processes in the Bay-Delta and its watershed that are relevant to CALFED program actions.
- Provide information useful in evaluating the effectiveness of existing monitoring protocols and the appropriateness of environmental attributes.
- Test causal relationships among environmental variables identified in conceptual models
- Reduce areas of scientific uncertainty regarding management actions.
- Incorporate relevant new information from all sources.
- Revise conceptual models as understanding of the system increases.

CMARP Program Activities

The CMARP development process has included the following steps:

1. **Identify the goals, objectives and needs** of CALFED Program elements, related programs, and agency major program goals and objectives.
2. **Develop a conceptual framework** that focuses on development of explicit conceptual models for use in designing monitoring and research programs. (This task is being accomplished in coordination with monitoring and research programs from Puget Sound, Chesapeake Bay and South Florida).
3. **Monitoring program design**
   - Inventory existing monitoring programs
   - Develop monitoring elements
   - Develop a process for data management
   - Develop a process for data analysis and monitoring
   - Restoration coordination monitoring institutional process
4. **Design a CALFED focused research program** to investigate causes and trends, reduce areas of scientific uncertainty, and corroborate relationships in conceptual models.
5. **Develop an institutional structure for monitoring, assessment and research** to focus on identifying institutional functions, and recommending how a monitoring and research program should operate. The *CMARP Program Report*, a separate appendix to this *Programmatic EIS/EIR*, recommends that there be a chief scientist, a science coordination team, and a science review board.

CALFED recognizes the need for reducing uncertainties about the factors affecting the resources of the Bay-Delta system. Although a traditional monitoring, assessment and research program will meet this need over a period of decades, CALFED needs to reduce key uncertainties at a more rapid rate to meet program goals. Therefore, CALFED will undertake an active program of adaptive resource management. Such a program will require a partnership between resources managers and scientists in which effects of key factors are better defined by informed management experiments. Resource managers will thereby increase chances of avoiding catastrophes and responding successfully to unexpected events. Informed adaptive experiments require policy-level recognition and acceptance of some risks to the resources.

TERMS USED IN THE ERPP

The following terms are used in the ERP:

CONSERVATION MEASURE: Two types of conservation measures were developed under the MSCS: 1) measures designed to avoid, minimize, and compensate for CALFED's adverse effects on NCCP communities and evaluated species (applicable to species with "R," "r," and "m" conservation goals; and 2) measures to enhance NCCP communities and evaluated species that are not directly linked to CALFED's adverse impacts. The conservation measures presented in Volume 1 and Volume II of the ERP are the latter type: conservation measures to enhance NCCP communities and evaluated species.

ECOSYSTEM-BASED MANAGEMENT: Ecosystem-based management is a resource management concept of achieving species management objectives by sustaining and enhancing the fundamental ecological structures and processes that contribute to the well being of the species. A basic tenet of CALFED's implementation of ecosystem-based management is, to the extent feasible, to restore or rehabilitate the natural processes that create and maintain the important elements of ecosystem structure. Ecosystem-based management differs fundamentally from the more traditional approach of species-based management, which seeks to manipulate specific environmental factors (e.g., direct removal of predators from the environment to reduce predation levels on the target species) thought to be limiting target species populations at levels below management objectives.

ECOSYSTEM ELEMENT: An ecosystem element is a basic component or function which, when combined with other ecosystem elements, make up an ecosystem. An ecosystem element can be categorized as a process, habitat, species, species community, or stressor.

ECOSYSTEM REHABILITATION: Within CALFED's concept of ecosystem restoration, the ERP will largely focus on ecosystem rehabilitation. In the context of CALFED, ecosystem rehabilitation is defined as the process by which resource managers reestablish or refurbish key elements of ecological structure and function within the Bay-Delta ecosystem to a level necessary to achieve ERP goals and objectives.

ECOSYSTEM RESTORATION: Ecosystem restoration is a term sometimes used to imply the process of recreating the structural and functional configurations of an ecosystem to that present at some agreed to time in the past. Because the structure and function of many elements of the Bay-Delta ecosystem have been severely disrupted and cannot be feasiblely restored to a specified historic condition, within the context of CALFED, ecosystem restoration is more realistically defined as the process by which resource managers ensure that the capacity of the ecosystem to provide ecological outcomes valued by society is maintained, enhanced, or restored.

ECOLOGICAL PROCESS: Ecological processes act directly, indirectly, or in combination, to shape and form the ecosystem. These include streamflow, stream channel, and floodplain processes. Stream channel processes include stream meander, gravel recruitment and transport, water temperature, and hydraulic conditions. Floodplain processes include overbank flooding and sediment retention and deposition.

HABITATS: Habitats are areas that provide specific conditions necessary to support plant, fish, and wildlife communities. Some important habitats include gravel bars and riffles for salmon spawning, winter seasonal floodplains that support juvenile fish and waterbirds, and shallow near-shore aquatic habitat shaded by overhanging tule marsh and riparian forest.

LONG- AND SHORT-TERM OBJECTIVES: Objectives can be both short-term and long-term. Short-term objectives should be clearly feasible, relatively easy to measure, and achievable in reasonable length of time (usually less than 25 years). The time period is not the same as Stage I of the CALFED process. Long-term objectives may be more difficult to determine and require additional resources and knowledge to achieve. (Note: these differ from Strategic Objectives which are defined later in this section.)

PROGRAMMATIC ACTION: A programmatic action represents a physical, operational, legal, or institutional change or alternative means to achieve a target. The number of actions and their level of implementation is subject to adjustment by adaptive management. For example, the number of diversions screened may be adjusted up or down depending on the overall response of fish populations to screening and other restoration actions.

An example of a programmatic action is to develop a cooperative program to acquire and restore 1,500 acres of tidal perennial aquatic habitat in the Suisun Bay and Marsh Ecological Management Unit.

SPECIES DESIGNATION: The classification system used to organize species by status. The species designations used in the ERP for species evaluated in the MSCS are identical to the designations used in the MSCS (recover, contribute to recovery, and maintain), and include additional designations for species or biotic communities not addressed in the MSCS. The two additional ERP designation include enhance and/or conserve native biotic communities, and maintain and enhance harvestable species. The species designated for recovery, contribute to recovery, maintain and enhance and/or conserve native biotic are addressed by Strategic Goal 1. Species designated as maintain and enhance harvestable species are addressed by Strategic Goal 3 (maintain and/or enhance populations of selected species for sustainable commercial and recreational harvest consistent with other ERP strategic goals).

SPECIES GOAL: Goals recommended by the Multi-Species Conservation Strategy Team for evaluated species. The MSCS species goals include recover, contribute to recovery, and maintain. The analogous ERP terms are found in the Strategic Objective for Strategic Goal 1 which addresses at-risk species.

SPECIES GOAL PRESCRIPTIONS: A performance standard to measure progress toward the species goal by providing habitat or population targets. (Note: Species Goal Prescriptions originate from the MSCS. The ERP equivalent is species target. For species designated as recover, contribute to recovery, or maintain, the ERP species target is identical to the MSCS species goal prescription. For species not evaluated in the MSCS, the ERP species target is the performance standard to measure progress toward the objective.)

SPECIES AND SPECIES GROUPS: Certain species or groups of species are given particular attention in the ERP. This focus is based on four criteria that might be met by a species (including fish, wildlife, and plants): 1) it is a formally listed threatened or endangered species (e.g., winter-run chinook salmon, delta smelt), or it is a species proposed for listing; 2) it is economically important, supporting a sport or commercial fishery (e.g., striped bass, signal crayfish); 3) it is a native species or species community that is presently not listed by which could be if population abundance or distribution declines, or 4) it is an important prey species (e.g., Pacific herring).

STAGE 1 EXPECTATIONS: Stage 1 expectations are meant to be measures of the progress towards meeting short-term objectives in the first 7 years of implementation program. These expectations have two basic components: improvements in information to allow better management of the ecosystem and improvements in physical and biological properties of the Bay-Delta ecosystem and watershed.

STRATEGIC GOAL: Strategic goals are the broad statements that define the scope and purposes of the ERP. Strategic goals provide guidance in structuring Strategic Objectives, developing targets, and evaluating proposed restoration actions.

The hierarchy for goals, objectives, targets and programmatic actions follows:

- *Strategic Goal*
    - *Strategic Objective*
        - *Target*
            - *Programmatic Action.*

Hierarchy of Goals, Objectives, Targets and Actions and Their Relation to Species Visions

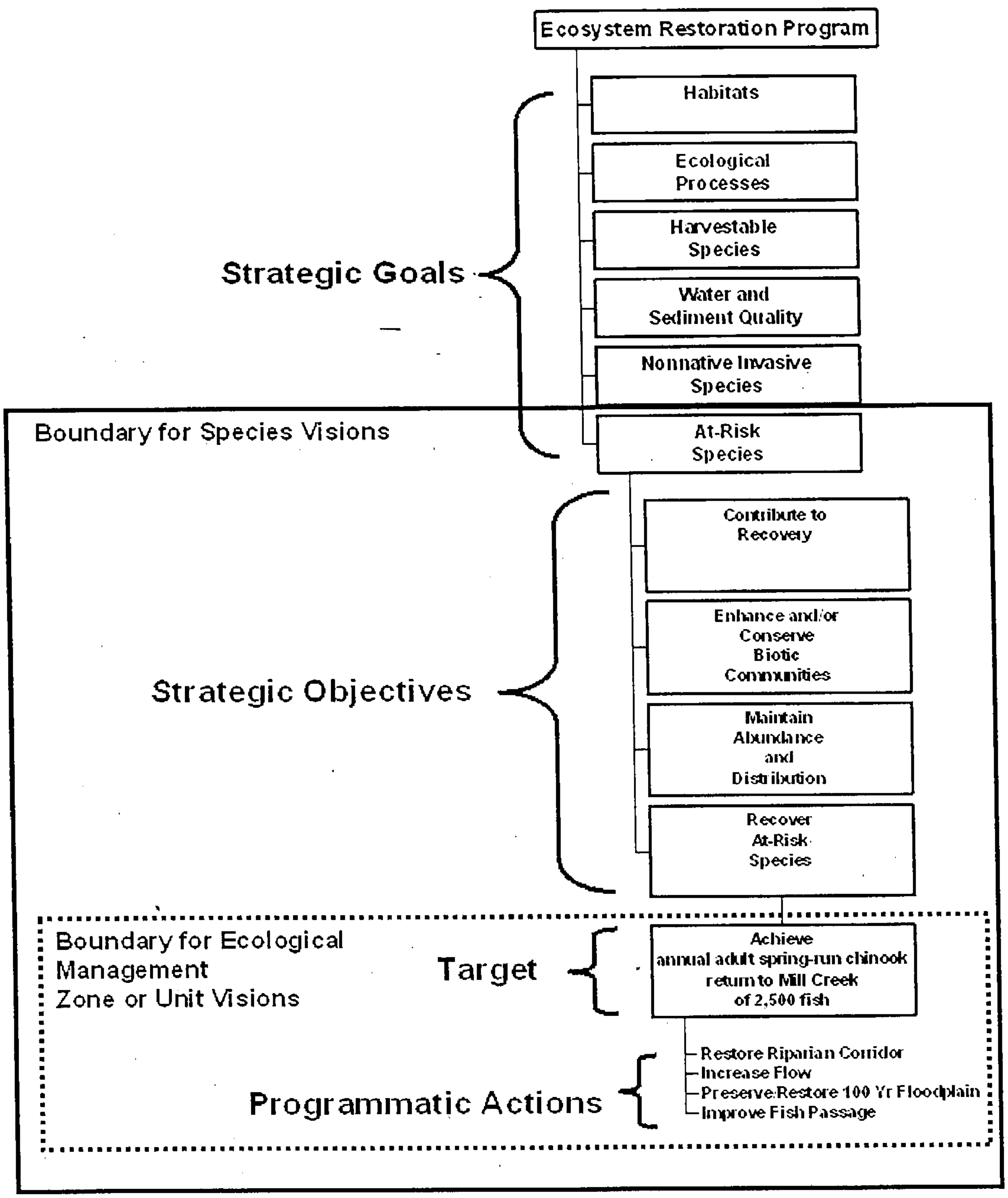


Figure 3. Relation of ERP visions. Visions in ERP Volume I are broad and encompass the entire ERP focus area. Visions in ERP Volume II are narrow and address needs within an Ecological Management Zone or Unit.

STRATEGIC OBJECTIVES: Strategic Objectives are associated with the Strategic Goals and areintended to assess progress toward achieving the associated goals. Strategic Objectives are fixed and are not expected to change over time. Strategic objectives are a more detailed delineation of the Strategic Goal components and provide a framework to develop and organize targets and programmatic actions. A strategic objective is the most specific and detailed description of what the ERP strives to maintain or achieve for an ecosystem element. The objectives are stated primarily in terms of management actions designed to have a favorable impact on the Bay-Delta system, however, some are also stated in terms of studies that will teach us how the ecosystem behaves so that principles of adaptive management can be better employed. (Note: Strategic Objectives differ from long- and short-term objectives.)

STRESSORS: Stressors are natural and unnatural events or activities that adversely affect ecosystem processes, habitats, and species. Environmental stressors include water diversions, water contaminants, levee confinement, stream channelization and bank armoring, mining and dredging in streams and estuaries, excessive harvest of fish and wildlife, introduced predator and competitor species, and invasive plants in aquatic and riparian zones. Some major stressors affecting the ecosystem are permanent features on the landscape, such as large dams and reservoirs that block transport of the natural supply of woody debris and sediment in rivers or alter unimpaired flows.

TARGET: A target is a qualitative or quantitative statement of a Strategic Objective. Targets are something to strive for but, unlike Strategic Objectives, may change over the life of the program with new information and progress, or may vary according to the configuration of storage and conveyance in all alternatives. Target adjustments will be science driven and based on the results of adaptive management. Targets may include a range of values or a narrative description of the proposed future value of an ecosystem element. Targets are to be set based upon realistic expectations, must be balanced against other resource needs and must be reasonable, affordable, cost effective, and practicably achievable.

The intent of the ERP is to achieve ecosystem health; targets are flexible tools to guide the effort. The level of implementation for each target will be determined or adjusted through adaptive management. Targets are categorized according to the three levels of certainty described above: (1) targets that have sufficient certainty of success to justify full implementation in accordance with program priorities and staged implementation; (2) targets which will be implemented in stages with the appropriate monitoring and evaluation to judge benefits and successes; and (3) targets for which additional research, demonstration and evaluations are needed to determine feasibility or ecosystem response.

Examples of targets include restoring 2,000 acres of tidal perennial aquatic habitat in the South Delta Ecological Management Unit (quantitative target) and reducing entrainment of juvenile salmon, steelhead, sturgeon, and splittail into water diversions to levels that will not impair stock rebuilding or species restoration (qualitative target).

VISION: A vision is what the ERP will accomplish with the stated objectives, targets, and programmatic actions for an ecological process, habitat, species or species group, stressor, or geographical unit. The vision statements included in the ERP provide technical background to increase understanding of the ecosystem and its elements. Two types of vision statements are included in the ERP: visions for ecosystem elements (landscape level visions in Volume I) and visions for ecological zones and units (ecological zone level visions in Volume II).

The broad landscape level resource visions address an individual ecological processes, habitat, species or species group, or stressor, while the ecological zone and unit visions address the integration of ecological processes, habitats, species, and stressors within a clearly delineated geographical area. Cumulatively, the visions also provide detailed descriptions of the ecosystem and its elements as they will look and function after restoration is accomplished.

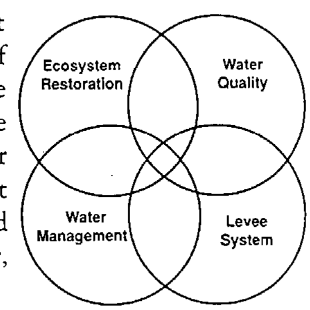
Table 1. Crosswalk of ERP and MSCS Terminology.

ERP Term	MSCS Term	Clarification
Strategic Goal	-----	The MSCS has no equivalent term for strategic goal.
Strategic Objective	Species Goal	The ERP has adopted the MSCS species goals for evaluated species (recover, contribute to recovery, and maintain) which are reflected in three of the objectives for at-risk species. The ERP has two additional species-oriented objectives that include enhancing and conserving biotic communities and maintaining and enhancing harvestable species.
Target	Species Goal Prescription	ERP species targets are analogous to the MSCS use of species goal prescriptions for evaluated species. The ERP includes targets for species not evaluated in the MSCS including biotic communities and harvestable species. The ERP terminology is "target" for processes, habitats, and stressors and "species target" for species to differentiate from the MSCS use of "species goal prescription" for evaluated species.
Programmatic Action	Conservation Measure	ERP programmatic actions and MSCS conservation measures are closely related but are not synonomous. Programmatic actions are physical, operational, or regulatory activities to improve ecological health while conservation measures provide guidance on the manner in which the programmatic actions are implemented. MSCS conservation measures also provide additional detail to some ERP programmatic actions.

Relationship of Other CALFED Common Programs to Ecosystem Restoration

Three fundamental concepts related to the Bay-Delta system and its problems have guided the development of proposed CALFED solutions. These concepts are not new, but CALFED has looked at them in new ways to develop options for solving problems successfully.

First, the four resource areas (ecosystem quality, water quality, water supply reliability, and levee system integrity) are interrelated. CALFED cannot effectively describe problems in one resource area without discussing the other problem areas. It follows that solutions will be interrelated as well; many past attempts to improve a single resource area have achieved limited success because solutions were too narrowly focused.



Second, there is great variation in the flow of water through the system and in the demand for that water at any time scale that might be examined (from year to year, between seasons, even on a daily basis within a single season). The value of water for all uses tends to vary according to its scarcity, quality, and timing. This leads to the need for a water management strategy.

Finally, the solutions must be guided by adaptive management. The Bay-Delta system is exceedingly complex, and it is subject to constant change as a result of factors as diverse as global warming and the introduction of exotic species. CALFED will need to adaptively manage the system as we learn from our actions and as conditions change.

INTERRELATIONSHIPS

In the past, most efforts to improve water supply reliability or water quality, improve ecosystem health, or maintain and improve Delta levees were single-purpose projects. A single purpose can keep the scope of a project manageable but may ultimately make the project more difficult to implement. The difficulty occurs because a project with narrow scope may help to solve a single problem but have impacts on other resources, causing other problems. This in turn leads to conflict. Ultimately, either no problem is solved, or one problem is solved while others are created.

The CALFED Program takes a different approach, recognizing that many of the problems in the Bay-Delta system are interrelated. Problems in any one problem area cannot be solved effectively without addressing problems in all four areas at once. This greatly increases the scope of our efforts but will ultimately enable us to make progress and move forward to a lasting solution.

Thus, the most important single difference between the CALFED Bay-Delta Program and past efforts to solve resource problems is the comprehensive nature of CALFED's interrelated resource management strategies. A comprehensive CALFED solution will also be supported by governance and finance mechanisms that overcome problem-specific or resource-specific limitations of previous, more narrowly focused, approaches.

Significantly, there are many linkages among the objectives in the four problem areas and among the actions that might be taken to achieve these objectives. Solving problems in four areas at once does not require a four-fold increase in the cost or number of actions. Most actions that are taken to meet program objectives, if carefully developed and implemented, will make simultaneous improvements in two, three, or even four problem areas.

Eight Program Elements Working Together to Solve the Four Problem Areas

- Long-Term Levee Protection Plan
- Water Quality Program
- Ecosystem Restoration Program
- Water Use Efficiency Program
- Water Transfer Program
- Watershed Program
- Storage
- Conveyance

What kinds of actions can be taken to solve problems in the Bay-Delta system? The actions can be grouped into categories of levee system improvements, water quality improvements, ecosystem restoration, water use efficiency, water transfers, watershed management, water storage, and Delta conveyance modifications. Specific actions range from physical restoration of habitat in the Delta to water conservation measures.

While CALFED generally does not expect to rely on new regulations to implement Program objectives, it does recognize that existing regulatory programs will continue to be implemented by CALFED agencies. CALFED represents a unique opportunity to provide high-level coordination of these regulatory programs so that regulatory implementation works in furtherance of CALFED Program goals. The CALFED Bay-Delta Program specifically defines incentives and voluntary partnerships to implement many individual actions in the Program. Incentives allow stakeholders to participate in CALFED actions which may not have been economical to them without the incentives. Partnerships allow stakeholders and CALFED agencies to leverage their individual resources by teaming together to implement certain actions.

Some regulations, like those contained in the State and federal Endangered Species Acts (ESA) and Section 404 of the Clean Water Act, are ones that CALFED must satisfy as the Program is implemented. Many other regulatory actions can be made more effective and constructive as a result of CALFED actions. For example, water quality regulatory agencies are obligated to develop total maximum daily loads (TMDLs) for certain water quality constituents in the Bay-Delta system. CALFED efforts in monitoring and research will provide valuable information which will assist regulatory agencies in developing these TMDLs. CALFED incentive-based source control actions will help reduce the load of these and other pollutants. In this way, the CALFED Bay-Delta Program will help in meeting many ongoing regulatory requirements.

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◆ Key Ecological Attributes of the San Francisco Bay-Delta Watershed

Note: The following section is a summary of information provided by the Indicators Workgroup (1998).

RATIONALE

Understanding the structure, function and organization of ecosystems is necessary for planning and implementing environmental restoration, rehabilitation and protection projects. Such understanding enables managers to assess, during planning phases of a program, the degree to which prospective restoration sites diverge from a "healthy" or "natural" condition, as well as to evaluate, after actions have been undertaken, project progress and effectiveness. In a management context, perhaps the most practical means of summarizing the most relevant existing information on ecosystems is to develop, over an appropriate hierarchy of spatial and ecological scales, a list of key system attributes - those fundamental natural ecological characteristics that together define and distinguish these systems, their status, and/or their interrelationships. Such lists of attributes may serve as a convenient and necessary "check list" of environmental factors that might be addressed in an ecological restoration/rehabilitation context. At sites for which comprehensive restoration is the goal, a full suite of applicable attributes would presumably be addressed. More commonly, at sites where partial restoration (rehabilitation) is the goal, actions and efforts would be focused upon an appropriate subset of attributes.

Some individual system attributes - such as water temperature - may be evaluated directly. Others, such as "habitat continuity," are more nebulous, and must be evaluated by developing appropriate "indicators" - measurable parameters that provide a means to objectively (preferably quantitatively) evaluate individual attributes that in themselves are not readily measured. The term indicator is also used in a broader context to refer to a *subset* of system attributes (or their measurable parameters) that are derived and used *as a group* to provide a convenient way to evaluate *overall* system status. Thus, the term "indicator" is commonly used in two somewhat different ecosystem management/restoration contexts, representing two differing scales of resolution: that of *individual* attributes, or alternately, that of *groups* of attributes. In either case, "indicators" are simply a convenient way of measuring or evaluating that which is of primary concern - system attributes. An additional, and most useful tool in understanding and describing fundamental characteristics of complex systems is the use of conceptual models that integrate and diagrammatically represent the three basic *kinds* of system components: elements (attributes), their states, and the relationships that affect attribute states.

This document presents a provisional list of natural ecological attributes and indicators of the ecosystems of this watershed for use in the context summarized above.

ECOSYSTEM TYPOLOGY

The ERP study area is divided into four ecological zones, based on similarities and differences in their respective attributes. The ecological zone designations follow:

- Upland River-Floodplain Ecological Zone
- Alluvial River-Floodplain Ecological Zone
- Delta Ecological Zone
- Greater San Francisco Bay Ecological Zone

Tables 2-5 display the attributes and indicators related to each ecological zone which were developed by the Indicators Workgroup. Table 6 offers an alternative view of the ecological attributes of alluvial river ecosystem (McBain and Trush 1999).

Table 2: Ecological Zone: Upland River-Floodplain Ecosystem.

Ecosystem Geographic Scope: Upland river-floodplain ecosystems are defined as rivers, streams, and associated riparian corridors that extend from headwaters elevations in the Coast Ranges, Cascade Range, and Sierra Nevada to the point near the floor of the Central Valley where they merge with alluvial river-floodplain ecosystems (in most cases near the 300 foot (91.4 m) elevation contour). The Sacramento River above Red Bluff is included in the upland river-riparian ecosystem. Most rivers and streams in this ecosystem correspond with the A2410 (fishless low-order tributaries) to A2430 (salmon-steelhead streams) series in the habitat classification system of Moyle and Ellison (1991) and Moyle (1996).

INDICATOR TYPE	ATTRIBUTE	INDICATORS
Hydrologic/ Hydrodynamic	Variable streamflows	■ Minimum base flows ■ Seasonal shifts in stream level ■ Measures of variability
	Floods	■ Minimum surface area of floodplain inundated at least once every 2 years ■ Flood duration (mean and variability)
	Ground water	■ Depth of water table ■ Soil moisture levels, laterally from banks. ■ Characteristic plant communities ■ Width of riparian corridor
Geomorphic	Dynamic Channels	■ Bedload movement ■ Sediment particle size and distribution ■ Pool-to-riffle ratio ■ Inter-annual comparison of fluvial geomorphic features
	Sediment budget	■ Net change in depth per unit time of unconsolidated sediment
Habitat	Habitat mosaic and connectivity	■ Extent and distribution of patches of all natural habitat types ■ Presence and distribution of species requiring multiple habitats ■ Presence and distribution of native and migratory fish species ■ Length of river channel obstructed by artificial barriers ■ Length of riparian corridor unobstructed by artificial barriers
	Water/sediment quality	■ Toxicity -- concentrations in water and sediment -- tissue concentrations -- bioassays -- biomarkers -- bioindicators -- contaminant loading ■ Dissolved oxygen ■ Turbidity-suspended solids ■ Temperature ■ Nutrients (N, P, C)
	Instream habitat complexity	■ Pool-to-riffle ratio ■ Abundance, distribution, and recruitment rate of large woody debris ■ Shaded riverine aquatic habitat ■ Diversity of flow velocity

Table 2: Ecological Zone: Upland River-Floodplain Ecosystem.		
Biological Communities	Community Structure	■ Trends in the abundance, diversity, composition, and distribution of riparian insect assemblages, by functional group ■ Trends in the abundance, diversity, composition, and distribution of benthic invertebrate assemblages, by functional group ■ Trends in abundance, reproductive success, diversity, composition, and distribution of native resident and migratory birds ■ Trends in the abundance, diversity, composition, and distribution of native mammals ■ Trends in distribution, diversity, and structural complexity of native plant associations ■ Trends in abundance, diversity, composition, distribution and trophic structure of natives fishes ■ Invasive introduced species -- measures of new invasions -- abundance, spatial extent and distribution of selected species -- number of selected species eradicated or exhibiting no net increase in distribution ■ Population trends of selected listed species ■ Fish and wildlife health
Community Energetics/ Nutrient Cycling	Nutrient loading	■ Nutrients from salmon carcasses ■ Organic input from grazing animals ■ Ratios of natural to anthropogenic sources of nutrients

Table 3: Ecological Zone: Alluvial River-Floodplain Ecosystem.

Ecosystem Geographic Scope: Lowland rivers, as defined herein, constitute those waterways and their floodplains that traverse the alluvial deposits of the Central Valley. The actual geomorphic "dividing line" between "upland" and "lowland" river-floodplain systems (as defined in this document) generally occurs at about the 300 ft. elevation contour. Lowland river-floodplain systems of the Central Valley are distributed across a vast area, covering thousands of square miles. This does not include the Redding Basin, which is considered part of the upland mountain river-floodplain ecosystem described in the previous section.

INDICATOR TYPE	ATTRIBUTE	INDICATORS
Hydrologic/ Hydrodynamic	Variable streamflows	■ Minimum base flows ■ Seasonal shifts in river level ■ Measures of variability ■ Geographic distribution of flows
	Floods	■ Minimum surface area of floodplain inundated at least once every 2 years and every 10 years ■ Flood duration (mean and variability) ■ Mean annual frequency
	Ground water	■ Depth of water table ■ Soil moisture levels, laterally from banks. ■ Characteristic plant communities ■ Width of riparian corridor
Geomorphic	Topography	■ Mean width of available meander corridor ■ Percent of river length not constrained by constructed levees ■ Distribution and extent of floodplain habitats ■ Distribution and extent of littoral zone
	River meander	■ Percent of river miles exhibiting naturalistic meandering
	Sediment supply, delivery, and movement processes	■ Net change in depth per unit time of unconsolidated sediment ■ Amount of coarse sediment delivered (as a proportion of pre-dam) ■ Lateral exchange: river to floodplain ■ Inter-annual comparison of fluvial geomorphic features ■ Sediment particle size and distribution ■ Pool-to-riffle ratio
Habitat	Habitat mosaic and connectivity	■ Extent and distribution of patches of all natural habitat types ■ presence and distribution of species requiring multiple habitats ■ Presence and distribution of migratory fish species ■ Number of unnatural barriers interfering with natural movements of native species, water flow, sediment transport and supply, and nutrient transport

Table 3: Ecological Zone: Alluvial River-Floodplain Ecosystem.		
Habitat (continued)	Water/sediment quality	■ Toxicity -- concentrations in water and sediment -- tissue concentrations -- bioassays -- biomarkers -- bioindicators -- contaminant loading ■ Dissolved oxygen ■ Turbidity-suspended solids ■ Temperature ■ Nutrients (N, P, C)
Biological Communities	Community Structure	■ Trends in the abundance, diversity, composition, and distribution of riparian insect assemblages, by functional group ■ Trends in the abundance, diversity, composition, and distribution of benthic invertebrate assemblages by functional group ■ Trends in abundance, reproductive success, diversity, composition, and distribution of native resident and migratory birds ■ Trends in the abundance, diversity, composition, and distribution of native mammals ■ Trends in distribution, diversity, and structural complexity of native plant associations ■ Trends in abundance, diversity, composition, distribution and trophic structure of natives fishes ■ Invasive introduced species -- measures of new invasions -- abundance, spatial extent and distribution of selected species -- number of selected species eradicated or exhibiting no net increase in distribution ■ Population trends of selected listed species ■ Fish and wildlife health
Community Energetics/ Nutrient Cycling	Nutrient and energy supply	■ Ratio of floodplain to river production ■ Export of organic materials from floodplain to river channel ■ Percent increase in dissolved N and P after overbank flows ■ Concentrations of dissolved N and P in groundwater at selected sites

Table 4. Ecological Zone: Delta

Ecosystem Geographic Scope: The Delta is the easternmost (upstream) portion of the estuary, and today is clearly delimited by a legal boundary that includes areas that historically were intertidal, along with supra-tidal portions of the floodplains of the Sacramento and San Joaquin Rivers. Today's legal Delta extends between the upper extent of the tidewater (near the city of Sacramento on the Sacramento River and Mossdale on the San Joaquin River) and Chipps Island to the west, and encompasses the lower portions of the Sacramento and San Joaquin river-floodplain systems as well as those of some lesser tributaries (Mokelumne and Calaveras rivers). The Sacramento and San Joaquin Rivers enter the Delta from the north and south respectively, where they join and together discharge their contents near the western margin of the Delta.

INDICATOR TYPE	ATTRIBUTE	INDICATORS
Hydrologic/ Hydrodynamic	Positive seaward flow	■ Delta outflow
	Spatial and temporal salinity patterns	■ Salinity at selected locations throughout the Delta
	Water circulation	■ Composite measures -- freshwater flow rates -- water residence time -- flow direction for selected channels ■ Flows of tributaries mimic pattern of unimpaired flow
Geomorphic	Flat topography	■ Difference in percent of area flooded during MHHW versus MLLW
	Dendritic distributary channel patterns	■ Linear distance of channels per unit area ■ Proportion of first, second, and third order channels per unit area
	Channel morphology	■ Bank slope
	Physical connectivity	■ Connectivity of riverine channels to wetlands
	Sediment production and acquisition	■ Marsh plain elevation relative to sea level ■ Change in area of Delta islands and islets
Habitat	Habitat mosaic and connectivity	■ Extent and distribution of patches of all natural habitat types ■ presence and distribution of species requiring multiple habitats ■ Presence and distribution of migratory fish species ■ Number of unnatural barriers interfering with natural movements of native species, water flow, sediment transport and supply, and nutrient transport

Table 4. Ecological Zone: Delta		
Habitat (continued)	Water/sediment quality	■ Toxicity ■ Concentrations in water and sediment -- tissue concentrations -- bioassays -- biomarkers -- bioindicators -- contaminant loading ■ Dissolved oxygen ■ Turbidity-suspended solids ■ Temperature ■ Nutrients (N, P, C) ■ Salinity/TDS
Biological Communities	Community Structure	■ Trends in abundance, diversity, composition, and distribution of native phytoplankton and zooplankton assemblages ■ Trends in the abundance, diversity, composition, and distribution of benthic invertebrate assemblages ■ Trends in abundance, reproductive success, diversity, composition, and distribution of native resident and migratory birds ■ Trends in the abundance, diversity, composition, and distribution of native mammals ■ Trends in distribution, diversity, and structural complexity of native plant associations ■ Trends in abundance, diversity, composition, distribution and trophic structure of native resident and anadromous fishes ■ Cohort replacement and survival rates of selected life stages of certain fish ■ Invasive introduced species -- measures of new invasions -- abundance, spatial extent and distribution of selected species -- number of selected species eradicated or exhibiting no net increase in distribution ■ Population trends of selected listed species ■ Fish and wildlife health
Community Energetics/ Nutrient Cycling	Plankton productivity	■ Primary production rates ■ Abundance of zooplankton
	Benthic invertebrate production	■ Secondary production of zoobenthos
	Net transport/export of detrital organic matter from marshes to other habitats	■ Flux of detrital organic matter
	Variable sources of nutrient loading to the Bay	■ Nutrient loading

Table 5. Ecological Zone: Greater San Francisco Bay.

Ecosystem Geographic Scope: Greater San Francisco Bay, as defined here, is that part of the estuary between Chipps Island and the Golden Gate. It includes four major embayments: Suisun Bay and Marsh, San Pablo Bay, and central and south San Francisco Bay.

INDICATOR TYPE	ATTRIBUTE	INDICATORS
Hydrologic/ Hydrodynamic	Freshwater inflow	■ X2 location ■ Salinity at selected locations throughout Bay
	Spatial and temporal salinity patterns	■ Salinity at selected locations throughout Bay ■ X2 location
	Hydrodynamics	■ Water movement and vertical mixing at select locations throughout Bay
Geomorphic	Sediment supply	■ Net sediment accretion rate relative to rate of sea-level rise at subtidal and intertidal sites ■ Elevation at appropriate fixed sites in marshes and mudflats throughout Bay. Compare to sea level
Habitat	Habitat mosaic and connectivity	■ Extent and distribution of patches of all natural habitat types ■ Presence and distribution of species requiring multiple habitats ■ Presence and distribution of migratory fish species ■ Number of unnatural barriers interfering with natural movements of native species, water flow, sediment transport and supply, and nutrient transport
	Water/sediment quality	■ Toxicity -- concentrations in water and sediment -- tissue concentrations -- bioassays -- biomarkers -- bioindicators -- contaminant loading ■ Dissolved oxygen ■ Turbidity-suspended solids ■ Nutrients (N, P, C) ■ Salinity/TDS

Table 5. Ecological Zone: Greater San Francisco Bay.

Biological Communities	Community Structure	■ Trends in abundance, diversity, composition, and distribution of native phytoplankton and zooplankton assemblages ■ Trends in the abundance, diversity, composition, and distribution of benthic invertebrate assemblages ■ Trends in abundance, reproductive success, diversity, composition, and distribution of native resident and migratory birds ■ Trends in distribution, diversity, and structural complexity of native plant associations ■ Trends in abundance, diversity, composition, distribution and trophic structure of native resident and anadromous fishes ■ Invasive introduced species -- measures of new invasions -- abundance, spatial extent and distribution of selected species -- number of selected species eradicated or exhibiting no net increase in distribution ■ Population trends of selected listed species ■ Fish and wildlife health
Community Energetics/ Nutrient Cycling	Plankton productivity	■ Phytoplankton productivity ■ Zooplankton productivity
	Benthic invertebrate production	■ Benthic invertebrate productivity
	Net transport/export of detrital organic matter from marshes to other habitats	■ Flux of detrital organic matter

Table 6. Attributes of Alluvial River Ecosystems	
Attribute	**Rationale**
Spatially Complex Channel Morphology	No single segment of channelbed provides habitat for all species, but the sum of all channel segments provides high-quality habitat for native species. A wide range of structurally complex physical environments supports diverse and productive biological communities.
Flow and Water Quality are Predictably Variable	Inter-annual and seasonal flow regimes are broadly predictable, but specific flow magnitudes, timing, duration, and frequencies are unpredictable because of runoff patterns produced by storms and droughts. Seasonal water quality characteristics, especially water temperature, turbidity, and suspended sediment concentration, are similar to those of regional unregulated rivers and fluctuate seasonally. This temporal "predictable unpredictability" is a foundation of river ecosystem integrity.
Frequently Mobilized Channelbed Surface	Channelbed framework particles of coarse alluvial surfaces are mobilized by the bankfull discharge which occurs on average every 1 to 2 years.
Channelbed Scour and Fill	Alternate bars are scoured deeper than their coarse surface layers by floods exceeding 3- to 5-year annual maximum flood recurrences. This scour is typically accompanied by re-deposition, such that net change in channelbed topography following a scouring flood usually is minimal.
Balanced Fine and Coarse Sediment Budgets	River reaches export fine and coarse sediment at rates approximately equal to sediment inputs. The amount and mode of sediment storage within a given river reach fluctuates, but channel morphology is sustained in dynamic quasi-equilibrium when averaged over many years.
Periodic Channel Migration	The channel migrates at variable rates and establishes meander wavelengths consistent with regional rivers with similar flow regimes, valley slopes, confinement, sediment supply, and sediment caliber.
A Functional Floodplain	On average, floodplains are inundated once annually by high flows equaling or exceeding bankfull stage. Lower terraces are inundated by less frequent floods, with their expected inundation frequencies dependent on norms exhibited by similar, but unregulated river channels. These floods also deposit finer sediment onto the floodplain and low terraces.
Infrequent Channel-Resetting Floods	Single large floods (e.g., exceeding 10- to 20-year recurrences) cause channel avulsions, widespread rejuvenation of mature riparian stands to early-successional stages, side channel formation and maintenance, and off-channel wetlands (e.g., oxbows). Resetting floods are as critical for creating and maintaining channel complexity as are lesser magnitude floods.
Self-Sustaining Riparian Plant Communities	Natural woody riparian plant establishment and mortality; based on species life history strategies, culminate in early- and late-successional stand structures and species diversities (canopy and understory) characteristic of self-sustaining riparian communities common to regional unregulated river corridors.
Naturally-Fluctuating Groundwater Table	Inter-annual and seasonal groundwater fluctuations in floodplains, terraces, sloughs, and adjacent wetlands occur in a manner similar to that in regional unregulated river corridors.

Source: B. Trush and S. McBain. 1999. McBain & Trush. Attributes of alluvial ecosystems. Appendix H in: Trinity River Flow Evaluation Final Report. A report to the Secretary of the Interior. U.S. Fish and Wildlife Service. June 1999.

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◆ Visions for Ecosystem Elements

The Strategic Plan for Ecosystem Restoration provides the scientific and practical framework for restoring the Bay-Delta watershed. The Strategic Plan guides the planning by providing 6 Strategic Goals which bound the scope of ecosystem restoration and numerous Strategic Objectives which provide more detailed direction and a basis by which to determine whether or not progress is being made toward achieving the respective goal. The majority of the goals are presented in terms of management or restoration actions designed to have a favorable impact on the Bay-Delta ecosystem and watershed.

This section provides the species designations which are consistent with the MSCS. The section also provides an ERP vision for each of the ecosystem elements (ecological processes, habitats, species, and stressors). Each vision is a snapshot of what the ERP intends to accomplish during the long-term implementation program.

Species Designations

The Multi-Species Conservation Strategy (MSCS) addresses all federally and State listed, proposed, and candidate species that may be affected by the CALFED Program; other species identified by CALFED that may be affected by the Program and for which adequate information is available also are addressed in the MSCS. The term "evaluated species" is used to refer to all of the species addressed by the MSCS. Please refer to the MSCS appendix (Multi-Species Conservation Strategy 1999) for more information and for a complete list of evaluated species.

The MSCS also identifies 18 NCCP habitat types. These are broad habitat categories, each of which includes a number of habitat or vegetation types. The NCCP habitats are as follow:

- Tidal perennial aquatic
- valley riverine aquatic
- montane riverine aquatic
- lacustrine
- saline emergent
- tidal freshwater emergent
- nontidal freshwater emergent
- natural seasonal wetland
- managed seasonal wetland
- valley/foothill riparian
- montane riparian
- grassland
- inland dune scrub
- upland scrub
- valley/foothill woodland and forest
- montane woodland and forest
- upland cropland, and
- seasonally flooded agricultural land.

The following is a discussion and definition of each of the five species designations used in the ERP. These designations have evolved during the development of the ERP. The present set of designations differs from designation previously presented in the ERP. Table 7, following the designation descriptions, provides a crosswalk of previous designations and how they are related to the present designations.

Recover

Recovery "R": For species designated "R," the CALFED Program has established a goal to recover the species within the CALFED ERP Ecological Management Zones. A goal of "recovery" was assigned to those species whose recovery is dependent on restoration of the Delta and Suisun Bay/Marsh ecosystems and for which CALFED could reasonably be expected to undertake all or most of the actions necessary to recover the species. Recovery is achieved when the decline of a species is arrested or revered, threats to the species are neutralized, and the species; long-term survival in nature is assured.

Recovery is equivalent, at a minimum, to the requirements of delisting a species under FESA and CESA. Certain species, such as anadromous fish, have threats outside the geographic scope or purview of CALFED (e.g., harvest regulated under the Magnuson-Stevens Act). Therefore, in some instances CALFED may not be able to complete all actions potentially necessary to recover the species; however, CALFED will implement all necessary recovery actions within the ERP Ecological Management Zones. For other species, CALFED may choose a goal that aims to achieve more than would be required for delisting (e.g., restoration of a species and/or its habitat to a level beyond delisting requirements). The effort required to achieve the goal of "recovery" may be highly variable between species. In sum, a goal of "recovery" implies that CALFED is expected to undertake all actions within the ERP Ecological Management Zones and Program scope necessary to recover the species.

Contribute to Recovery

Contribute to Recovery ("r"): For species designated "r," the CALFED Program will make specific contributions toward the recovery of the species. The goal "contribute to recovery" was assigned to species for which CALFED actions affect only a limited portion of the species range and/or CALFED actions have limited effects on the species.

To achieve the goal of contributing to a species' recovery, CALFED is expected to undertake some of the actions under its control and within its scope that are necessary to recover the species. When a species has a recovery plan, CALFED may implement both plan measures that are within the CALFED Problem Area, and some measures that are outside the Problem Area. For species without a recovery plan, CALFED will need to implement specific measures that will benefit the species.

Maintain

Maintain ("m"): For species designated "m," the CALFED will undertake actions to maintain the species. This category is less rigorous that "contribute to recovery." The goal "maintain" was assigned to species expected to be minimally affected by CALFED actions. For this category, CALFED will avoid, minimize, and compensate for any adverse effects to the species commensurate with the level of effect on the species. Actions may not actually contribute to the recovery of the species; however, at a minimum, they will be expected to not contribute to the need to list a species or degrade the status of a listed species. CALFED will also, to the extent practicable, improve habitat conditions for these species.

Enhance and/or Conserve Biotic Communities

Enhance and/or Conserve Biotic Communities ("E"): For those communities designated "E," the ERP will undertake actions to conserve and enhance their diversity, abundance and distribution in a manner that contributes to their long-term sustainability without adversely affecting efforts to improve conditions for other at-risk species.

Maintain and/or Enhance Harvested Species

Maintain and/or Enhance Harvested Species ("H"): For those species designated "H" the CALFED Program will undertake actions to maintain the species at levels which support or enhance sustainable harvest rates. The goal "maintain harvested species" was generally assigned to species which are harvested for recreational or commercial purposes and which are not already covered under one of the four previous designations. A key to maintaining harvestable surplus levels is to recognize the need to recover, contribute to recovery, or maintain other species. Thus, species interactions such as competition and predation and habitat needs for space and flow need to be balanced in favor of species designated for recovery, contribute to recovery and maintain. Those three designations apply only to native species and assemblages while the "maintain harvested surplus" species include some native species and non-native species. Thus, actions implemented to maintain harvestable surplus would be expected, *at a minimum*, to not contribute to the need to list an unlisted species, degrade the status of an already listed species, or impair in any way efforts to recover, contribute to recovery, or maintain native species.

MSCS Conservation Measures

The MSCS defines "conserve, conserving, and conservation" as the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to ESA and CESA are no longer necessary. These methods and procedures include, but are not limited to, all activities associated with scientific resources management, such as research, census, law enforcement, habitat acquisition, restoration and maintenance, propagation, live trapping and transplantation, and, in the extraordinary case where population pressures within a given ecosystem cannot be otherwise relieved, may include regulated taking (Multi-Species Conservation Strategy 2000).

Two types of conservation measures were developed under the MSCS: 1) measures designed to avoid, minimize, and compensate for CALFED's adverse effects on NCCP communities and evaluated species (applicable to species with "R," "r," and "m" conservation goals; and 2) measures to enhance NCCP communities and evaluated species that are not directly linked to CALFED's adverse impacts. The majority of measures designed to enhance NCCP communities and evaluated species incorporate and refine existing ERP and other CALFED actions. The scope, location, and timing of a particular CALFED Program action or group of actions, as well as the current status, distribution, and needs of the affected species, will determine which conservation measures would be necessary to compensate for adverse impacts. NCCP habitat conservation measures are primarily directed at conserving the quality and quantity of natural habitats.

Generally, measures to avoid, minimize and compensate adverse effects are addressed early in site-specific project development and are specific components of the project. The identification of additional enhancement measures are more global in nature and developed to provide additional detail to ERP programmatic actions.

An important addition to this version of the ERP is the inclusion of specific conservation measures that provide additional levels of detail to ERP programmatic actions. These conservation measures were designed specifically for MSCS evaluated species. This version of the ERP displays throughout Volumes I and II where the conservation measures fit and support existing programmatic actions.

Volume I of the ERP is structured by 1) ecological process, 2) habitat, 3) species, and 4) stressors. Generally, few conservation measures were developed specifically for ecological processes, some habitats and stressors were emphasized in the conservation measures, and most species are directly addressed in one or more conservation measures.

The conservation measures that add detail to ERP programmatic actions are from Attachment 5 of the MSCS.

Table 7. List of Species Comparing Strategic Plan/ERP Classification, MSCS Designation, and Revised ERP Designation.

Species or Biotic Community	Previous Strategic Plan/ERP Classification	MSCS Designation [a/]	Revised ERP Designation
Delta smelt	Priority Group I	Recover	Recover
Longfin smelt	Priority Group I	Recover	Recover
Green sturgeon	Priority Group I	Recover	Recover
Sacramento splittail	Priority Group I	Recover	Recover
Winter-run chinook salmon	Priority Group I	Recover	Recover
Spring-run chinook salmon	Priority Group I	Recover	Recover
Central Valley fall-run chinook salmon	Priority Group I	Recover	Recover
Central Valley steelhead	Priority Group I	Recover	Recover
Mason's lilaeopsis	Priority Group II	Recover	Recover
Suisun Marsh aster	Priority Group II	Recover	Recover
Suisun thistle	Priority Group II	Recover	Recover
Soft bird's-beak	Priority Group II	Recover	Recover
Antioch Dunes evening-primrose	Priority Group II	Recover	Recover
Contra Costa wallflower	Priority Group II	Recover	Recover
Lange's metalmark butterfly	Priority Group III	Recover	Recover
Valley elderberry longhorn beetle	Priority Group II	Recover	Recover
Suisun ornate shrew	Priority Group II	Recover	Recover
Suisun song sparrow	Priority Group II	Recover	Recover
San Pablo song sparrow	New to ERP	Recover	Recover
California clapper rail	Priority Group II	Contribute to Recovery	Contribute to Recovery
California black rail	Priority Group II	Contribute to Recovery	Contribute to Recovery
Swainson's hawk	Priority Group II	Contribute to Recovery	Contribute to Recovery
Salt marsh harvest mouse	Priority Group II	Contribute to Recovery	Contribute to Recovery
San Pablo California vole	Priority Group II	Contribute to Recovery	Contribute to Recovery
Sacramento perch	Priority Group III	Contribute to Recovery	Contribute to Recovery
Riparian brush rabbit	Priority Group III	Contribute to Recovery	Contribute to Recovery
San Joaquin Valley woodrat	Priority Group III	Contribute to Recovery	Contribute to Recovery
Greater sandhill crane	Priority Group III	Contribute to Recovery	Contribute to Recovery
California yellow warbler	Priority Group III	Contribute to Recovery	Contribute to Recovery
Least Bell's vireo	Priority Group III	Contribute to Recovery	Contribute to Recovery
Western yellow-billed cuckoo	Priority Group III	Contribute to Recovery	Contribute to Recovery
Bank swallow	Priority Group III	Contribute to Recovery	Contribute to Recovery
Little willow flycatcher	Priority Group III	Contribute to Recovery	Contribute to Recovery
Giant garter snake	Priority Group III	Contribute to Recovery	Contribute to Recovery
Delta green ground beetle	Priority Group III	Contribute to Recovery	Contribute to Recovery
Saltmarsh common yellowthroat	New to ERP	Contribute to Recovery	Contribute to Recovery
Bristly sedge	Priority Group II	Contribute to Recovery	Contribute to Recovery
Point Reyes bird's-beak	New to ERP	Contribute to Recovery	Contribute to Recovery
Crampton's tuctoria	Priority Group II	Contribute to Recovery	Contribute to Recovery
Delta tule pea	Priority Group II	Contribute to Recovery	Contribute to Recovery

Table 7. List of Species Comparing Strategic Plan/ERP Classification, MSCS Designation, and Revised ERP Designation (continued).

Species or Biotic Community	Previous Strategic Plan/ERP Classification	MSCS Designation [a/]	Revised ERP Designation
Delta mudwort	Priority Group II	Contribute to Recovery	Contribute to Recovery
Alkali milk-vetch	Priority Group II	Contribute to Recovery	Contribute to Recovery
Delta coyote-thistle	New to ERP	Contribute to Recovery	Contribute to Recovery
Northern California black walnut	Not in ERP	Contribute to Recovery	Contribute to Recovery
Mad-dog skullcap	Priority Group II	Maintain	Maintain
Rose-mallow	Priority Group II	Maintain	Maintain
Eel-grass pondweed	Priority Group II	Maintain	Maintain
Colusa grass	Priority Group II	Maintain	Maintain
Boggs Lake hedge-hyssop	Priority Group II	Maintain	Maintain
Contra Costa goldfields	Priority Group II	Maintain	Maintain
Greene's legenere	Priority Group II	Maintain	Maintain
Recurved larkspur	Priority Group II	Maintain	Maintain
Heartscale	Priority Group II	Maintain	Maintain
California freshwater shrimp	Priority Group III	Maintain	Maintain
Hardhead	Priority Group III	Maintain	Maintain
Western Least bittern	Priority Group III	Maintain	Maintain
California red-legged frog	Priority Group III	Maintain	Maintain
California tiger salamander	Priority Group III	Maintain	Maintain
Western pond turtle	Priority Group III	Maintain	Maintain
Western spadefoot toad	Priority Group IV	Maintain	Maintain
Lamprey family	Priority Group II	Not Evaluated [b]	Enhance and/or Conserve
Native resident fishes	Priority Group III	Not Evaluated as a group [c]	Enhance and/or Conserve
Native anuran amphibians	Priority Group III	Not Evaluated	Enhance and/or Conserve
Migratory waterfowl	Priority Group IV	Not Evaluated as a group	Enhance and/or Conserve
Shorebird guild	Priority Group IV	Not Evaluated as a group	Enhance and/or Conserve
Wading bird guild	Priority Group IV	Not Evaluated as a group	Enhance and/or Conserve
Neotropical migratory birds	Priority Group IV	Not Evaluated as a group	Enhance and/or Conserve
Planktonic (foodweb) organisms	Priority Group IV	Not Considered [d]	Enhance and/or Conserve
Aquatic habitat plant community	Priority Group IV	NCCP Habitat equivalent [e]	Enhance and/or Conserve
Tidal brackish and freshwater marsh habitat plant community	Priority Group IV	NCCP Habitat equivalent	Enhance and/or Conserve
Seasonal wetland habitat plant community	Priority Group IV	NCCP Habitat equivalent	Enhance and/or Conserve
Inland dune habitat plant community	Priority Group IV	NCCP Habitat equivalent	Enhance and/or Conserve
White sturgeon	Harvestable Species	Not Considered	Maintain Harvest
Striped bass	Harvestable Species	Excluded [f]	Maintain Harvest
American shad	Harvestable Species	Excluded	Maintain Harvest
Non-native warmwater gamefish	Harvestable Species	Excluded	Maintain Harvest
Pacific herring	Harvestable Species	Not Considered	Maintain Harvest
Grass shrimp	Harvestable Species	Not Considered	Maintain Harvest

Table 7. List of Species Comparing Strategic Plan/ERP Classification, MSCS Designation, and Revised ERP Designation (continued).

Species or Biotic Community	Previous Strategic Plan/ERP Classification	MSCS Designation [a/]	Revised ERP Designation
Signal crayfish	Harvestable Species	Excluded	Maintain Harvest
Upland game	Priority Group IV	Not Considered	Maintain Harvest

Footnotes for Table 7.

a/: Recover, contribute to recovery, maintain, enhance and/or conserve, and maintain and/or enhance harvested species are defined in the text.

b: Not Evaluated species are species initially considered for inclusion in the MSCS but not evaluated (e.g., Kern brook lamprey, river lamprey, and Pacific lamprey were considered but not evaluated).

c: Not Evaluated as a Group includes species assemblages described in the ERP but not evaluated as a group in the MSCS. Individual species, however, may have been considered or evaluated (e.g., native resident fishes were not evaluated as a group in the MSCS but Sacramento perch and hardhead were considered and evaluated in the MSCS).

d: Not Considered species are native species that were screened from consideration by not being on any list of special status species.

e: NCCP Habitat equivalent denotes an ERP plant community that is analogous to one or more of the 18 NCCP habitats which are broad categories, each of which includes a number of habitat or vegetation types recognized in frequently used habitat classification systems.

f: Excluded species are non-native organisms not eligible for consideration under the State or federal endangered species acts and thus excluded from consideration or evaluation under the MSCS.

Table 8. Summary of Visions for Ecosystem Elements.

Ecosystem Element	Vision Summary
Ecosystem Processes	
Hydrology and Hydraulics	
Central Valley Streamflows	The vision for Central Valley streamflows is to protect and enhance the ecological functions that are achieved through the physical and biological processes that operate within the stream channel and associated riparian and floodplain areas in order to to assist in the recovery of at-risk species, harvested species, biotic communities, and the overall health of the Bay-Delta.
Bay-Delta Hydraulics	The vision for hydraulic processes in the Sacramento-San Joaquin Delta is to restore channel hydraulics to conditions more like those that occurred during the mid-1960s to provide migratory cues for aquatic species; transport flows for eggs, larvae, and juvenile fish; and transport of sediments and nutrients.
Channel Forming Processes	
Stream Meander	The vision for stream meander is to conserve and reestablish areas of active stream meander, where feasible, by implementing stream conservation programs, setting levees back, and reestablishing natural sediment supply to restore riverine and floodplain habitats for fish, wildlife, and plant communities.
Natural Floodplains and Flood Processes	The vision for natural floodplains and flood processes is to conserve existing intact floodplains and modify or remove barriers to overbank flooding to reestablish aquatic, wetland, and riparian floodplain habitats.
Coarse Sediment Supply	The vision for coarse sediment supply is to provide a sustained supply of alluvial sediments that are transported by rivers and streams and distributed to riverine bed deposits, floodplains, channel bars, riffles, shallow shoals, and mudflats, throughout the Sacramento-San Joaquin Valley, Delta, and Bay regions to contribute to habitat structure, function, and foodweb production throughout the ecosystem.
Cycling and Transport of Nutrients, Detritus, and Organisms	
Bay-Delta Aquatic Foodweb	The vision for the Bay-Delta aquatic foodweb is to restore primary and secondary production to levels comparable to those during the 1960s and early 1970s by enhancing productivity and reducing loss of productivity as a result of water exports from the system, and in seeking to reduce or eliminate the adverse effects of introduced aquatic species.
Water Quality	
Central Valley Stream Temperatures	The vision for Central Valley stream temperatures is to restore natural seasonal patterns of water temperature in streams, rivers, and the Delta to benefit aquatic species by protecting and improving ecological processes that regulate water temperature and reducing stressors that change water temperature.

Table 8. Summary of Visions for Ecosystem Elements (continued).

Ecosystem Element	Vision Summary
Habitats	
Tidal Perennial Aquatic Habitat	The vision for tidal perennial aquatic habitats is to increase the area and improve the quality of existing connecting waters associated with tidal emergent wetlands and their supporting ecosystem processes. Achieving this vision will assist in the recovery of special-status fish and plant populations and provide high-quality aquatic habitat for other fish, wildlife, and plant communities dependent on the Bay-Delta. Restoring tidal perennial aquatic habitat would also result in higher water quality and increase the amount of shallow-water and mudflat habitats; foraging and resting habitats and escape cover for water birds; and rearing and foraging habitats, and escape cover for fish.
Nontidal Perennial Aquatic Habitat	The vision for nontidal perennial aquatic habitat is to increase the area and improve the quality of existing open-water areas to provide high-quality habitat for waterfowl and other water birds. This vision can be achieved as a component of saline and freshwater emergent wetland restorations.
Delta Sloughs	The vision for Delta sloughs is to increase the area and improve the quality of interconnected dead-end and open-ended Delta sloughs. Achieving this vision will assist in the recovery of special-status fish and wildlife populations, provide shallow-water habitats for fish spawning and rearing, and provide aquatic, wetland, and riparian habitat for wildlife. Existing sloughs would be protected and enhanced and the area of tidal slough habitat would be increased.
Midchannel Islands and Shoals	The vision for midchannel islands and shoals is to increase and enhance the area and protect the quality of existing habitat for fish and wildlife dependent on the Bay-Delta.
Saline Emergent Wetland	The vision is to increase the area and protect the quality of existing saline emergent wetlands from degradation or loss. Wetland habitat will be increased to assist in the recovery of special-status plant, fish, and wildlife populations. Restoration will provide high-quality habitat for other fish and wildlife dependent on the Bay-Delta.
Fresh Emergent Wetland	The vision is to increase the area and improve the quality of existing fresh emergent wetlands from degradation or loss and increase wetland habitat. Achieving this vision will assist in the recovery of special-status plant, fish, and wildlife populations, and provide high-quality habitat for other fish and wildlife dependent on the Bay-Delta.
Seasonal Wetlands	The vision is to increase the area and improve the quality of seasonal wetlands by restoring ecosystem processes that sustain them and reduce the effect of stressors that can degrade the quality of seasonal wetlands in order to assist in the recovery of special-status plant and animal populations and provide high-quality habitat for waterfowl, water birds, and other wildlife dependent on the Bay-Delta.

Table 8. Summary of Visions for Ecosystem Elements (continued).

Ecosystem Element	Vision Summary
Riparian and Riverine Aquatic Habitats	The vision for riparian and riverine aquatic habitats is to increase their area and protect and improve their quality. Achieving this vision will assist in the recovery of special-status fish and wildlife populations and provide high-quality habitat for other fish and wildlife dependent on the Bay-Delta. The vision includes restoring native riparian communities ranging from valley oak woodland associated with higher, less frequently inundated floodplain elevations to willow scrub associated with low, frequently inundated floodplain elevation sites such as streambanks, point bars, and inchannel bars.
Freshwater Fish Habitats	The vision for freshwater fish habitats is to protect existing habitat from degradation or loss, to restore degraded habitats, and restore areas to a more natural state. Freshwater fish habitat will be increased to assist in the recovery of special-status plant, fish, and wildlife populations. Restoration will provide high-quality habitat for other fish and wildlife dependent on the Bay-Delta.
Essential Fish Habitats	The vision for essential fish habitats is to maintain and improve the quality of existing habitats and to restore former habitats in order to support self-sustaining populations of chinook salmon.
Inland Dune Scrub Habitat	The vision for inland dune scrub habitat is to protect and enhance existing areas and restore former habitat areas. Achieving this vision will provide high-quality habitat for associated special-status plant and animal populations.
Perennial Grassland	The vision is to protect and improve existing perennial grasslands and increase perennial grassland area. This vision is a component of restoring wetland and riparian habitats. Achieving this vision will provide high-quality habitat for special-status plant and wildlife populations and other wildlife dependent on the Bay-Delta.
Agricultural Lands	The vision for agricultural lands is to improve associated wildlife habitat values to support special-status wildlife populations and other wildlife dependent on the Bay-Delta. Protecting and enhancing agricultural lands for wildlife would focus on encouraging production of crop types that provide high wildlife habitat value, agricultural land and water management practices that increase wildlife habitat value, and discouraging development of ecologically important agricultural lands for urban or industrial uses in the Sacramento-San Joaquin Delta and Suisun Marsh/North San Francisco Bay Ecological Management Zones.
Species and Species Groups	
RECOVERY "R": For those species designated "R," CALFED has established a goal to recover the species within the CALFED ERP Ecological Management Zones.	
Species	Vision Summary
Delta Smelt	The vision for delta smelt is to recover this State and Federally listed threatened species in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.

Table 8. Summary of Visions for Ecosystem Elements (continued).

Ecosystem Element	Vision Summary
Longfin Smelt	The vision for longfin smelt is to recover this California species of special concern and restore population distribution and abundance in the Bay-Delta estuary so that it resumes its historical levels of abundance and its role as an important prey species in the Bay-Delta aquatic foodweb.
Green Sturgeon	The vision for green sturgeon is to recover this California species of special concern and restore population distribution and abundance to historical levels.
Splittail	The vision for splittail is to recover this Federally listed threatened species in order to contribute to the overall species richness and diversity and to reduce conflict between protection for this species and other beneficial uses of water in the Bay-Delta.
Winter-run Chinook Salmon ESU	The vision for the winter-run chinook salmon evolutionarily significant unit (ESU) is to recover this State and Federally listed endangered species, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that fully uses existing and restored habitats.
Spring-run Chinook Salmon ESU	The vision for spring-run chinook salmon is to recover this stock which is listed as threatened under the ESA and CESA, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that fully use existing and restored habitats.
Late-fall-run Chinook Salmon	The vision for late-fall-run chinook salmon is to recover this stock which is presently proposed for listing under the ESA (it is included in the fall-run chinook salmon ESU), achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that fully use existing and restored habitats.
Fall-run Chinook Salmon ESU	The vision for the fall-run chinook salmon ESU is to recover all stocks presently proposed for listing under the ESA, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that fully use existing and restored habitats.
Central Valley Steelhead Trout ESU	The vision for the Central Valley steelhead trout ESU is to recover this species listed as threatened under the ESA and achieve naturally spawning populations of sufficient size to support inland recreational fishing and that fully uses existing and restored habitat areas.
Mason's Lilaeopsis	The vision for Mason's lilaeopsis is to recover this State listed rare plant by protecting and preserving important habitat sites within the Bay-Delta.
Suisun Marsh Aster	The vision for Suisun Marsh aster is to recover this California Native Plant Society List 1B plant species in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.

Table 8. Summary of Visions for Ecosystem Elements (continued).

Ecosystem Element	Vision Summary
Suisun Thistle	The vision for Suisun thistle is to recover this Federally listed endangered species by protecting and preserving important habitat sites within the Bay-Delta in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Soft Bird's Beak	The vision for soft bird's beak is to recover this Federally listed endangered species by protecting and preserving important habitat sites within the Bay-Delta in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Antioch Dunes Evening-primrose	The vision for Antioch Dunes evening-primrose is to recover this Federally and State listed endangered species in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Contra Costa Wallflower	The vision for Contra Costa wallflower is to recover this Federally and State listed endangered species in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Lange's Metalmark Butterfly	The vision for the Lange's metalmark butterfly is to recover this Federally listed endangered species by increasing the existing Lange's metalmark population distribution and by increasing its abundance in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Valley Elderberry Longhorn Beetle	The vision for the valley elderberry longhorn beetle is to recover this Federally listed threatened species by increasing their populations and abundance through habitat restoration in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Suisun Ornate Shrew	The vision for the Suisun ornate shrew is to recover this California species of special concern and contribute to the overall species richness and diversity in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Suisun Song Sparrow	The vision for the Suisun song sparrow is to recover this California species of special concern in Suisun Marsh and the western Delta and contribute to the overall species richness and diversity in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
San Pablo Song Sparrow	The vision for the San Pablo song sparrow is to recover this California species of special concern in the North Bay in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.

Table 8. Summary of Visions for Ecosystem Elements (continued).

Ecosystem Element	Vision Summary
CONTRIBUTE TO RECOVERY ("r"): For species designated "r," the CALFED Program will make specific contributions toward the recovery of the species. The goal "contribute to recovery" was assigned to species for which CALFED Program actions affect only a limited portion of the species range and/or CALFED Program actions have limited effects on the species.	
California Clapper Rail	The vision for the California clapper rail is to contribute to the recovery of this State and Federally listed endangered species in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
California Black Rail	The vision for the California black rail is to contribute to the recovery of this State listed threatened species in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Swainson's Hawk	The vision for the Swainson's hawk is to contribute to the recovery of this State listed threatened species in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Salt Marsh Harvest Mouse	The vision for the salt marsh harvest mouse is to contribute to the recovery of this State and Federally listed endangered species through restoring salt marsh habitat in San Pablo and Suisun bays and adjacent marshes in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
San Pablo California Vole	The vision for the San Pablo California vole is to contribute to the recovery of this California species of special concern in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Riparian Brush Rabbit	The vision for the riparian brush rabbit is to contribute to the recovery of this Federally proposed and State listed endangered species in the Bay-Delta through improvements in riparian habitat and reintroduction to its former habitat in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
San Joaquin Valley Woodrat	The vision for the San Joaquin Valley woodrat is to contribute to the recovery of this Federally proposed endangered species through improvement in its habitat in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Sacramento Perch	The vision for the Sacramento perch is to contribute to the recovery of this California species of special concern in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Giant Garter Snake	The vision for the giant garter snake is to contribute to the recovery of this State and Federally listed threatened species in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.

Table 8. Summary of Visions for Ecosystem Elements (continued).

Ecosystem Element	Vision Summary
Greater Sandhill Crane	The vision for the greater sandhill crane is to contribute to the recovery of this State listed threatened species in the Bay-Delta in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
California Yellow Warbler	The vision for the California yellow warbler is to contribute to the recovery of this California species of special concern in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Little Willow Flycatcher	The vision for the little willow flycatcher is to contribute to the recovery of this State listed endangered species in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Western Yellow-Billed Cuckoo	The vision for the western yellow-billed cuckoo is to contribute to the recovery of this State listed endangered species. Recovery of this species would contribute to overall species richness and diversity.
Bank Swallow	The vision for the bank swallow is to contribute to the recovery of this State listed threatened species in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Least Bell's Vireo	The vision for the Least Bell's vireo is to contribute to the recovery of this State and Federally listed endangered species in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Saltmarsh Common Yellowthroat	The vision for saltmarsh common yellowthroat is to contribute to their recovery by maintaining self-sustaining populations and their habitat in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Delta Green Ground Beetle	The vision for the delta green ground beetle is to contribute to the recovery of this Federally listed threatened species by increasing their populations and abundance through habitat restoration in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Bristly Sedge	The vision for bristly sedge is to contribute to the recovery of this California Native Plant Society List 2 plant species in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Delta Tule Pea	The vision for delta tule pea is to contribute to the recovery of this California Native Plant Society List 1B plant species in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.

Table 8. Summary of Visions for Ecosystem Elements (continued).

Ecosystem Element	Vision Summary
Delta Mudwort	The vision for delta mudwort is to contribute to the recovery of this California Native Plant Society List 2 plant species in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Crampton's Tuctoria	The vision for Crampton's tuctoria is to contribute to the recovery of this Federally and State listed endangered species in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Alkali Milkvetch	The vision for alkali milkvetch is to contribute to the recovery of this California Native Plant Society List 1B plant species in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Point Reyes Bird's-Beak	The vision for Point Reyes bird'-beak is to contribute to contribute to the recovery of this California Native Plant Society List 1B plant species in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Delta Coyote-Thistle	The vision for the Delta coyote-thistle is to contribute to the recovery of the State listed endangered species and California Native Plant Society List 1B plant species in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
MAINTAIN ("M"): For species designated "m," the CALFED will undertake actions to maintain the species. This category is less rigorous that "contribute to recovery." The goal "maintain" was assigned to species expected to be minimally affected by CALFED actions.	
Western Least Bittern	The vision for the Western least bittern is to contribute to the recovery of this California species of special concern to contribute to the overall species richness and diversity. Achieving this vision will reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta.
California Tiger Salamander	The vision for the California tiger salamander is to maintain existing populations of this Federal candidate species in the Bay-Delta.
Western Spadefoot Toad	The vision for the western spadefoot toad is to maintain this California species of special concern in the Bay-Delta.
California Red-Legged Frog	The vision for the California red-legged frog is to maintain populations of this Federally listed threatened species. Achieving this vision will contribute to the overall species richness and diversity and to reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta.
Native Anuran Amphibians	The vision for native anuran amphibians is to contribute to their restoration in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system. Note: western spadefoot and California red-legged frog are discussed individually.

Table 8. Summary of Visions for Ecosystem Elements (continued).

Ecosystem Element	Vision Summary
Western Pond Turtle	The vision for the western pond turtle is to maintain the abundance and distribution of this California species of special concern in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Hardhead	The vision for hardhead is to maintain and abundance and distribution of this California species of special concern in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
California Freshwater Shrimp	The vision for the California freshwater shrimp is to maintain populations of this Federally listed endangered species by maintaining its existing distribution and abundance in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Recurved Larkspur	The vision for recurved larkspur is to maintain populations of this California Native Plant Society List 1B plant species in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Mad-dog Skullcap	The vision for mad-dog skullcap is to maintain populations of this California Native Plant Society List 2 plant species in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Rose-mallow	The vision for rose-mallow is to maintain populations of this California Native Plant Society List 2 plant species in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Eel-grass Pondweed	The vision for eel-grass pondweed is to maintain populations of this California Native Plant Society List 2 plant species in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Colusa Grass	The vision for Colusa grass is to maintain populations of this Federally listed threatened and State listed endangered species in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Boggs Lake Hedge-hyssop	The vision for Boggs Lake hedge-hyssop is to maintain populations of this State listed endangered species in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Contra Costa Goldfields	The vision for Contra Costa goldfields is to maintain populations of this Federally listed endangered species in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.

Table 8. Summary of Visions for Ecosystem Elements (continued).

Ecosystem Element	Vision Summary
Greene's Legenere	The vision for Greene's Legenere is to maintain populations of this California Native Plant Society List 1B plant species in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Heartscale	The vision for heartscale is to maintain populations of this California Native Plant Society List 2 plant species in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
ENHANCE AND/OR CONSERVE BIOTIC COMMUNITIES "E": For those species designated "E," the CALFED Program will undertake actions to maintain the diversity, distribution and abundance of native biotic communities in the estuary and watershed.	
Native Resident Fish Species	The vision for resident fish species is to maintain and restore the distribution and abundance of native species, such as Sacramento blackfish, hardhead, hitch, and tule perch in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Bay-Delta Aquatic Foodweb Organisms	The vision for the Bay-Delta aquatic foodweb organisms is to maintain and restore the Bay-Delta estuary's once-productive food base of aquatic algae, organic matter, microbes, and zooplankton communities in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Shorebird and Wading Bird Guild	The vision for the shorebird and wading bird guild is to maintain and restore healthy populations of shorebirds and wading birds through habitat protection and restoration and reduction in stressors in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Migratory Waterfowl	The vision for waterfowl is to maintain and restore healthy populations at levels that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses consistent with the goals and objectives of the Central Valley Habitat Joint Venture as part of the North American Waterfowl Management Plan in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
Neotropical Migratory Bird Guild	The vision for the neotropical migratory bird guild is to maintain and restore healthy populations of neotropical migratory birds through restoring habitats on which they depend in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system. Note: several neotropical species are discussed individually.
Anadromous Lampreys	The vision for anadromous lampreys is to maintain and restore population distribution and abundance to higher levels than at present, to better understand life history, and identify factors which influence abundance in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.

Table 8. Summary of Visions for Ecosystem Elements (continued).

Ecosystem Element	Vision Summary
Upland Game	The vision for upland game is to maintain and restore healthy populations of native upland game species at levels that can support both consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses, through protection and improvement of habitats and reduction in stressors.
Plant Community Groups	The vision for plant community groups is to maintain and restore existing and rehabilitate degraded habitats that support the diverse assemblages of plants in the Bay-Delta in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
MAINTAIN AND/OR ENHANCE HARVESTED SPECIES ("H"): For those species designated "H" the CALFED Program will undertake actions to maintain the species at levels which support or enhance sustainable harvest rates. The goal "maintain harvest" was generally assigned to species which are harvested for recreational or commercial purposes and which may be covered under one of the four previous designations.	
Striped Bass	The vision for striped bass is to restore populations to levels of abundance consistent with the Fish and Game Commission's striped bass policy in order to support a sport fishery in the Bay, Delta, and tributary rivers, and to reduce the conflict between protection of striped bass and other beneficial uses of water in the Bay-Delta.
White Sturgeon	The vision for white sturgeon is to maintain and restore population distribution and abundance to historical levels to support a sport fishery in order to contribute to the overall species richness and diversity and improve water management for beneficial uses of the Bay-Delta system.
American Shad	The vision for American shad is to maintain a naturally spawning population, consistent with restoring native species, that supports a sport fishery similar to the fishery that existed in the 1960s and 1970s.
Chinook Salmon	The vision for all chinook salmon evolutionarily significant unit is to recover all stocks presently proposed for listing under the ESA, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that fully use existing and restored habitats.
Native Cyprinid Fishes	The vision for native cyprinid fishes is to maintain self-sustaining populations in order to provide opportunities for consumptive uses consistent with recovery of at-risk species.
Non-native Warmwater Gamefish	The vision for non-native warmwater gamefish is to maintain self-sustaining populations in order to provide opportunities for consumptive use such as fishing.
Pacific Herring	The vision for Pacific herring is to maintain self-sustaining populations in order to support commercial fishing.
Grass Shrimp	The vision for grass shrimp is to maintain self-sustaining populations in order to support existing commercial fisheries.
Signal Crayfish	The vision for signal crayfish is to maintain self-sustaining populations in order to support recreational and commercial fishing.

Table 8. Summary of Visions for Ecosystem Elements (continued).

Ecosystem Element	Vision Summary
Stressors	
Water Diversions	The vision for water diversions is to reduce the adverse effects of water diversions, including entrainment of all life stages of aquatic species, by installing fish screens, consolidating or moving diversions to less sensitive locations, removing diversions, or reducing the volume of water diverted. Achieving this vision will assist in the recovery of State and/or Federally listed fish species, improve important sport fisheries, and improve the Bay-Delta aquatic foodweb.
Dams and Other Structures	The vision for dams and other structures is to reduce their adverse effects by improving fish passage and enhancing downstream fish to assist in the recovery of State and/or Federally listed fish species and contribute to sustainable sport and commercial fisheries.
Levees, Bridges, and Bank Protection	The vision for levees, bridges, and bank protection is to reduce the adverse effects of these structures in order to improve riverine and floodplain habitat conditions to assist in the recovery of State and/or Federally listed fish species, and other fish and wildlife.
Dredging and Sediment Disposal	The vision for dredging and sediment disposal in the Bay-Delta is to maintain adequate channel depth for navigation, flood control, and water conveyance while reducing the adverse effects of dredging activities on the Bay-Delta ecosystem.
Gravel Mining	The vision for gravel mining is to improve gravel transport and cleansing by reducing the adverse effects of instream gravel mining in order to maintain or restore flood, floodplain, and streamflow processes that govern gravel supply to improve fish spawning and floodplain habitats.
Invasive Aquatic Plants	The vision for invasive aquatic plants is to reduce their adverse effects on native species and ecological processes, water quality and conveyance systems, and major rivers and their tributaries.
Invasive Aquatic Organisms	The vision for invasive aquatic organisms is to reduce their adverse effects on the foodweb and on native species resulting from competition for food and habitat and direct predation. This vision can be accomplished through enforcement of State laws regulating ballast water dumping and other measures designed to reduce the number of new, potentially harmful species introduced accidentally into the Bay-Delta estuary. Habitat changes or direct control measures may reduce their effects in specific cases.
Invasive Riparian and Marsh Plants	The vision for invasive riparian and salt marsh plant species is to reduce their adverse effects on native species and ecological processes, water quality and water conveyance systems, and major rivers and their tributaries.
Zebra Mussel	The vison for zebra mussel is to establish procedures to prevent or delay their introduction and to set up protocols to swiftly treat and eliminate any introduction.
Non-Native Wildlife	The vision for non-native wildlife species is to implement a program to reduce the numbers of harmful non-native wildlife species (i.e., those that threaten the diversity or abundance of native species or the ecological stability of an area).

Table 8. Summary of Visions for Ecosystem Elements (continued).

Ecosystem Element	Vision Summary
Predation and Competition	The vision for predation and competition is to reduce unnatural levels to restore fish populations by removing, redesigning, or reoperating in-water structures, diversion dams, and hatchery practices.
Contaminants	The vision for contaminants is to ensure that all waters of mainstem rivers and tributaries entering the Bay-Delta, and all waters of the Bay-Delta, are free of deleterious concentrations of toxic substances
Fish and Wildlife Harvest	The vision for fish and wildlife harvest is to support strategies that maintain a sustainable commercial and recreational chinook salmon fishery in a manner consistent with the recovery of individual stocks; steelhead trout harvest strategies that fully protect naturally spawning stocks while redirecting harvest to hatchery-produced stocks; the continued legal harvest of striped bass and reduction of illegal harvest; and the present white sturgeon harvest strategy, which protects the species from overexploitation while providing a sustainable trophy fishery.
Artificial Fish Propagation	The vision for the artificial propagation of fish is to modify existing hatcheries and hatchery practices in ways to augment salmon and steelhead populations without having detrimental effects on naturally spawning populations of salmon and steelhead.
Stranding	The vision for stranding is to reduce the magnitude of the number of aquatic organisms lost when rivers recede or overflow into flood bypasses and to reconnect areas that become isolated with flowing water and to reduce the frequency by which low-lying areas are inundated.
Disturbance	The vision for disturbance is to reduce the adverse effects of boating and other recreational activities, temporary habitat disturbances, and other human activities on wildlife and their habitats in the Bay-Delta.

REFERENCE

Multi-Species Conservation Strategy. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

◆ Ecological Process Visions

Introduction

This section presents visions for ecological processes. Ecological processes act directly, indirectly, or in combination, to shape and form the ecosystem. These include streamflow, stream channel, floodplain, and foodweb processes. Stream channel processes include stream meander, gravel recruitment and transport, water temperature, and hydraulic conditions. Floodplain processes include overbank flooding and sediment retention and deposition. Physical and biological processes addressed are those that have a strong effect in shaping and influencing the Bay-Delta ecosystem. These processes can also be managed to improve the health of the Bay-Delta ecosystem and its resources. Table 9 identifies important ecological processes and the related Strategic Plan objective. Table 10 presents the basis for their selection as an ecosystem element.

Visions describe the role and importance of each process in maintaining the health of the Bay-Delta, and a description of how the process currently operates in the ecosystem, stressors and changes to other processes that have altered how the process operates in the ecosystem. The Strategic Plan objectives, targets, programmatic actions, and conservation measures are presented here and more fully described in Volume II: Ecological Management Zone Visions. Table 11 presents the ecological management zone in which Strategic Plan objectives, targets, programmatic actions, and conservation measures have been proposed to accomplish each ecological process vision.

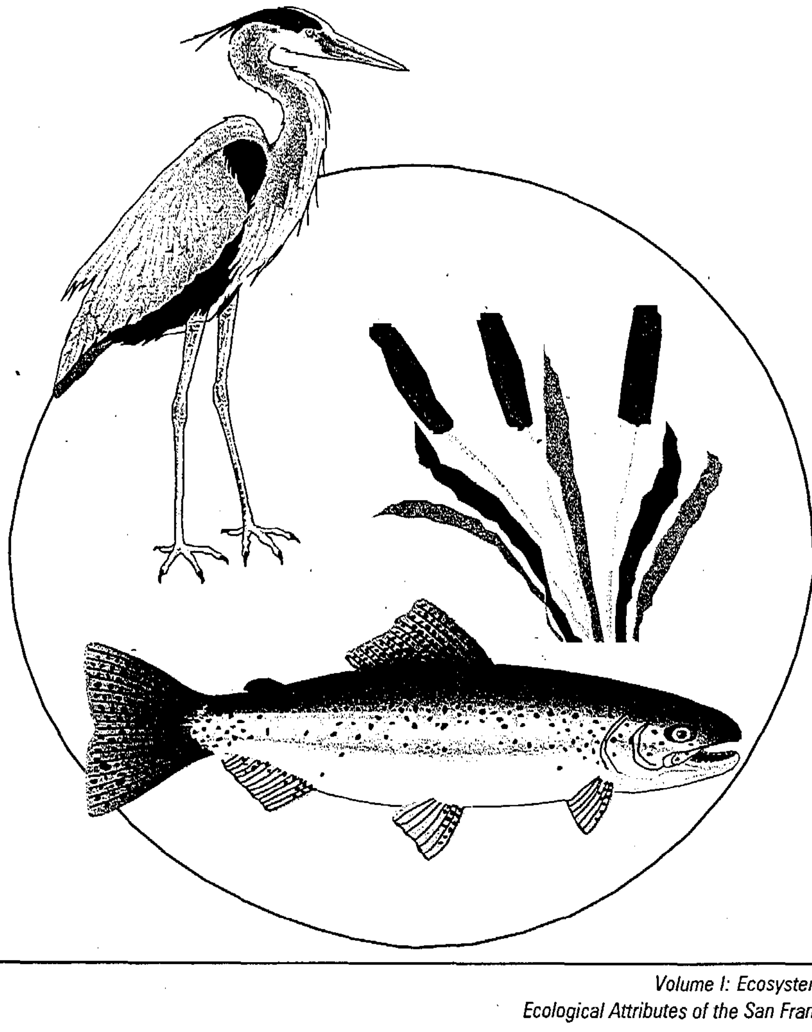


Table 9. Strategic Plan Goal and Objectives for Ecological Processes.

Goal 2. Rehabilitate natural processes in the Bay-Delta estuary and its watershed to fully support, with minimal ongoing human intervention, natural aquatic and associated terrestrial biotic communities and habitats, in ways that favor native members of those communities.

Ecological Process	Strategic Plan Objective
Central Valley Streamflows and Central Valley Stream Temperatures	Establish and maintain hydrologic and hydrodynamic regimes for the Bay and Delta that support the recovery and restoration of native species and biotic communities, support the restoration and maintenance of functional natural habitats, and maintain harvestable species. Establish hydrologic regimes in streams, including sufficient flow timing, magnitude, duration, and high flow frequency, to maintain channel and sediment conditions supporting the recovery and restoration of native aquatic and riparian species and biotic communities. Create and/or maintain flow and temperature regimes in rivers that support the recovery and restoration of native aquatic species.
Coarse Sediment Supply	Restore coarse sediment supplies to sediment-starved rivers downstream of reservoirs to support the restoration and maintenance of functional natural riverine habitats.
Stream Meander	Increase the extent of freely meandering reaches and other pre-1850 river channel forms to support the restoration and maintenance of functional natural riverine, riparian, and floodplain habitats.
Natural Floodplains and Flood Processes	Re-establish floodplain inundation and channel-floodplain connectivity of sufficient frequency, timing, duration, and magnitude to support the restoration and maintenance of functional natural floodplain, riparian and, riverine habitats.
Bay-Delta Hydrodynamics	Establish and maintain hydrologic and hydrodynamic regimes for the Bay and Delta that support the recovery and restoration of native species and biotic communities, support the restoration and maintenance of functional natural habitats, and maintain harvestable species.
Bay-Delta Aquatic Foodweb	Increase estuarine productivity and rehabilitate estuarine food web processes to support the recovery and restoration of native estuarine species and biotic communities.

Table 10. Basis for Selection of Ecological Process Ecosystem Elements.

Ecological Process	Basis for Selection as an Ecosystem Element
Central Valley Streamflows and Central Valley Stream Temperatures	Virtually all streams in the region are regulated to a greater or lesser degree and the regulated flow regimes frequently favor non-native fishes. The native fish assemblages (including those with anadromous fishes) are increasingly uncommon. Recent studies in Putah Creek, the Stanislaus River, and the Tuolumne River demonstrate that native fish assemblages can be restored to sections of streams if flow (and temperature) regimes are manipulated in ways that favor their spawning and survival, usually by having flow regimes that mimic natural patterns and increasing flows during summer months. Native invertebrates and riparian plants may also respond positively to these flow regimes. Achievement of this objective will require additional experimentation with flows below dams (or the re-regulation of existing flow regimes) to determine the optimal flow/habitat conditions for native organisms, as part of the short term goal. Part of the studies should be to determine if the objective can be achieved without 'new' water, by just altering the timing of releases or by developing conjunctive use agreements that allow more water to flow down the stream channel. These findings can then be applied opportunistically to achieve the long-term goal.
	Native aquatic and riparian organisms in the Central Valley evolved under a flow regime with pronounced seasonal and year to year variability. Frequent (annual or biannual) high flows mobilized gravel beds, drove channel migration, inundated floodplains, maintained sediment quality for native fishes and invertebrates, and maintained complex channel and floodplain habitats. By deliberately releasing such flows from reservoirs, at least some of these physical and ecological functions can probably be recreated. A program of such high flow releases (commonly termed 'flushing flows') lends itself well to adaptive management, because the flows can easily be adjusted to determine the level needed to achieve specific objectives. However, it should be recognized that channel adjustments may lag behind hydrologic changes by years or decades, which requires that monitoring be long-term. Also, on most rivers, reservoirs are not large enough to eliminate extremely large, infrequent events so these will continue to affect channel form at irregular intervals; artificial high flow events may be needed to maintain desirable channel configurations created during the natural events. This objective is similar to the previous one, but differs in its focus on high flow events that are likely to be higher than those needed to maintain most native fish species but important for maintaining in-channel and riparian habitats for other species (invertebrates, birds, mammals, etc.).

Table 10. Basis for Selection of Ecological Process Ecosystem Elements (continued).

Ecological Process	Basis for Selection as an Ecosystem Element
Coarse Sediment Supply	One of the major negative effects of dams is the capture of coarse sediments that naturally would pass on to downstream areas. As a result, the downstream reaches can become sediment starved, producing 'armoring' of streambeds in many (but not all) rivers to the point where they provide greatly reduced habitat for fish and aquatic organisms and are largely unsuitable for spawning salmon and other anadromous fish. Accomplishing this objective can be done by a wide variety of means, but most obviously through artificial importation of gravel and sand. Other possible actions include: (1) explore the feasibility of passing sediment through small reservoirs; (2) remove nonessential or low-value dams; (3) eliminate instream gravel mining on channels downstream of reservoirs, and limit extraction on unregulated channels to 50 percent of estimated bedload supply or less (or levels determined not to negatively impact fish and other ecological resources); (4) develop incentives to discourage mining of gravel from river channels and adjacent floodplain sites; and (5) develop programs for comprehensive sediment management in each watershed, accounting for sediment trapped by reservoirs, availability of sediment from tributaries down stream of reservoirs, loss of reservoir capacity, release of sediment-starved water downstream, channel incision and related effects, and the need for sources of construction aggregate.
Stream Meander	Freely migrating rivers have the highest riparian and aquatic habitat diversity of all riverine systems. Through the process of meandering, eroding concave banks and building convex banks, the channel creates and maintains a diversity of surfaces that support a diversity of habitats, from pioneer riparian plants on newly deposited point bars to gallery riparian forest on high banks built of overbank silt deposits. Similarly, wandering or braided rivers support distinct habitat types and thus are beneficial to maintain. Flood plain restoration can also increase flood protection for urban areas and increase the reliability of stored water supplies in reservoirs (because reservoirs can be maintained at higher levels because of reduced need to catch flood waters).
Natural Floodplains and Flood Processes	Frequent (usually annual or biannual) flood plain inundation was an important attribute of the original aquatic systems in the Central Valley and was important for maintaining diverse riverine and riparian habitats. Important interactions between channel and floodplain include overflow onto the floodplain, which (1) limits shear stress exerted on the bed, reducing channel incision, (2) acts as a "pressure relief valve," permitting a larger range of sediment grain sizes to remain on the channel bed, (3) increases the complexity and diversity of instream and riparian habitats, and (4) stores flood water (thereby decreasing flooding downstream). The floodplain also provides shading, food organisms, and large woody debris to the channel. Floodplain forests serve as filters to improve the quality of water reaching the stream channel by both surface flow and groundwater. The actions necessary to re-establish active inundation will probably require major land purchases or easements, and financial incentives to move existing floodplain uses elsewhere, as has been done in the Midwest since the severe floods of the Mississippi River and its tributaries in 1993.

Table 10. Basis for Selection of Ecological Process Ecosystem Elements (continued).

Ecological Process	Basis for Selection as an Ecosystem Element
Bay-Delta Hydrodynamics	Bay-Delta hydrodynamics refers to the direction and velocity of flows in the Bay-Delta channels on a temporal, tidal, and seasonal basis for a given hydrologic condition. The direction and velocity of flows and their distribution in time and location help define the extent to which the Bay-Delta can support important ecological functions such as sustaining a productive food web, providing spawning, rearing, and feeding habitat for estuarine and anadromous fish, and supporting migration of adult and juvenile fish. Human activities such as reduced Delta inflow, exports from the Delta, and conversion of tidal wetlands have had a large influence on the natural hydraulic regime of the Bay-Delta. There are opportunities to restore or simulate, where and when appropriate, a more natural hydraulic regime that sustains ecological functions and meets the life requirements of the fish and wildlife in or dependent on the Bay-Delta.
Bay-Delta Aquatic Foodweb	The abundance of many species in the estuary may be limited by low productivity at the base of the food web in the estuarine ecosystem. The causes of this are complex and not well understood, but may include a shortage of productive shallow-water regions such as marshes, high turbidity in open-water regions of the estuary, and consumption and sequestering of available organic carbon by the Asiatic clam. Solving the problem directly is difficult but presumably other actions taken as part of the ERP, such as increasing the acreage of tidal or seasonally flooded marshlands, will contribute to the solution. A major obstacle to solving problems of estuarine productivity is our poor understanding so solutions will have to come from research and monitoring of effects of various ecosystem restoration projects.

Table 11. Distribution of Targets and Programmatic Actions for Ecological Processes by Ecological Management Zone.

[Note: Refer to Volume II: Ecological Management Zone Visions for more information regarding the specific targets and programmatic actions.]

Ecological Process Vision	Ecological Management Zone[1]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Central Valley Streamflows and Temperatures	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Coarse Sediment Supply	●	●	●	●	●	●	●	●	●	●	●	●	●	
Stream Meander			●	●	●		●	●	●			●	●	
Natural Floodplains and Flood Processes	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Bay-Delta Hydrodynamics	●	●												
Bay-Delta Aquatic Foodweb	●	●												

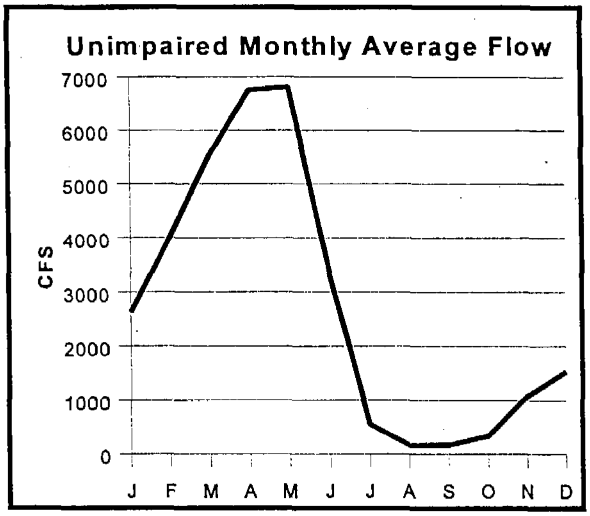
[1] *Ecological Management Zones*

1 = Sacramento-San Joaquin Delta
2 = Suisun Marsh/North San Francisco Bay
3 = Sacramento River
4 = North Sacramento Valley
5 = Cottonwood Creek
6 = Colusa Basin
7 = Butte Basin

8 = Feather River/Sutter Basin
9 = American River Basin
10 = Yolo Basin
11 = Eastside Delta Tributaries
12 = San Joaquin River
13 = East San Joaquin Basin
14 = West San Joaquin Basin

INTRODUCTION

Streamflow refers to the amount of fresh water flowing in rivers and Bay-Delta channels. Central Valley streamflows are a combination of natural discharges from surface water and groundwater and managed releases from reservoirs. Streamflow varies seasonally and annually with rainfall, run-off, and water-supply management. The volume and distribution of water in the Bay-Delta and its watersheds support important ecological processes and functions. Human activities have had a significant influence on the natural streamflow pattern of the Bay-Delta and its watershed.



Unimpaired Median Monthly Average Flow in the American River below Nimbus Dam, 1962-1992

RESOURCE DESCRIPTION

California is divided into hydrologic regions which reflect runoff and drainage basins. Three major hydrologic regions are contained within the ERPP Study Area: Sacramento River, San Joaquin River, and San Francisco Bay.

The Sacramento River Region contains the entire drainage of the Sacramento Valley and its adjacent watersheds and extends from Collinsville in the Sacramento-San Joaquin Delta almost 300 miles upstream to the Oregon border.

Characteristics of the Sacramento River Region

Average annual precipitation: 36 inches
Average annual runoff: 22,389,700 AF
Land area: 26,960 square miles
Population: 2,208,900

(Source: DWR 1994)

The San Joaquin River Region is located in the heart of California and is bordered by the Sierra Nevada on the east and the coastal range on the west.

Characteristics of the San Joaquin River Region

Average annual precipitation: 13 inches
Average annual runoff: 7,933,300 AF
Land area: 15,950 square miles
Population: 1,430,200

(Source: DWR 1994)

The San Francisco Bay Region extends from Pescadero Creek in southern San Mateo County to the mouth of Tomales Bay in the north and inland to the confluence of the Sacramento and San Joaquin rivers near Collinsville.

Characteristics of the San Francisco Bay Region

Average annual precipitation: 31 inches
Average annual runoff: 1,245,500 AF
Land area: 4,400 square miles
Population: 5,484,000

(Source: DWR 1994)

The total streamflow that would occur without upstream reservoirs and diversions is called the unimpaired flow. Data on unimpaired flows provide a record of natural streamflow patterns and a benchmark for judging the effects of water management and allocation of the available runoff. Unimpaired streamflows are also influenced by the condition of the upper watersheds and their ability to moderate or intensify runoff patterns.

Streamflows in Central Valley watersheds are extremely variable. Total annual unimpaired streamflow into and through the Central Valley varies from a low of about 5 million acre-feet (MAF) to a high of about 38 MAF. Most of the flow occurs December through June. A large part of the total flow volume occurs during relatively short periods of time, caused either by rainfall or snowmelt.

Construction and operation of dams on major rivers and streams has reduced peak winter and spring flows and increased summer and fall flows. Dry year flows are higher in some streams from release of carryover storage from reservoirs. In other streams, flow may be lower because of water diversions.

Winter and spring peak flows and summer and fall base flows are important to maintain ecological processes such as sediment transport, stream meandering, and riparian habitat regeneration. Native fish and wildlife species evolved with these flow patterns. Spawning and migrating fish depend on the natural streamflow patterns. For example, Sacramento splittail spawn during the late winter in flooded areas provided by high flows.

The ability to restore natural streamflows is limited. Constraints include water management practices, upper watershed conditions, and previous water supply allocation (water rights and contracts). Emulating natural runoff patterns will provide the greatest potential for improving the ecological functions that are dependent on streamflow.

ECOLOGICAL FUNCTIONS OF STREAMFLOW

Streamflow can be thought of as the life-blood of the tributary watersheds that link together to form the Sacramento and San Joaquin rivers. Groundwater and surface runoff generate flows into the stream networks in each tributary basin. Streamflow provides the geomorphic forces (energy and materials) needed to create and maintain stream channels and riparian corridors (floodplains). Streamflow controls the erosion, transport, and deposition of sediment in the stream channel and floodplain. Streamflow also transports and cleanses river gravels that support invertebrate production and fish spawning.

Natural flow patterns maintain natural sediment erosion, deposition, transport, and cleansing patterns, and thus natural stream channel and floodplain configurations. Reduced streamflow can lead to excessive sediment deposition in gravelbeds and armoring the channel with cobble.

Streamflows transport nutrients as well as dissolved and particulate organic material from rivers upstream to the Delta and estuary. These materials are important to planktonic and benthic foodweb organisms. Streamflows maintain soil moisture and transport seeds which contribute to the regeneration of riparian and riverine aquatic habitats.

Streamflow is needed to flood stream channel pools and riffles and riparian wetlands that provide habitat for fish and other wildlife. Flows transport fish eggs and larvae (e.g., striped bass, delta smelt) from spawning to nursery areas and may assist in the movement of juveniles from upstream spawning and rearing areas to the Delta (e.g., young splittail and chinook salmon).

Streamflow through the Delta to San Francisco Bay is referred to as Delta outflow. Delta outflow is simply the net flow at Chipps Island. Conceptually, it is estimated as the sum of Delta inflow and precipitation in the Delta minus water use in the Delta and exports from the Delta. Delta outflow has a major influence on the tidal mixing processes and the amount of saltwater that reaches upstream into the Delta. Delta outflow controls the location of the "zone of low salinity" (the area where freshwater mixes with saline water) and transports planktonic organisms, particulate organic materials, and nutrients from the rivers to the Delta and San Francisco Bay.

Following are general ecological processes and functions sustained with natural streamflow patterns:

- Channel-forming processes create and sustain the pools, riffles, meanders, sand and gravel deposits, banks, side channels, and floodplain areas. These elements are the physical framework for the stream, wetland, riparian corridor, and floodplain habitats.
- Streamflow transports nutrients and organic materials to downstream aquatic habitats where they provide the necessary components for primary (plant) and secondary (bacterial and

invertebrate) foodweb production. Transport processes also move larval and juvenile fish and other aquatic organisms to downstream rearing habitats.

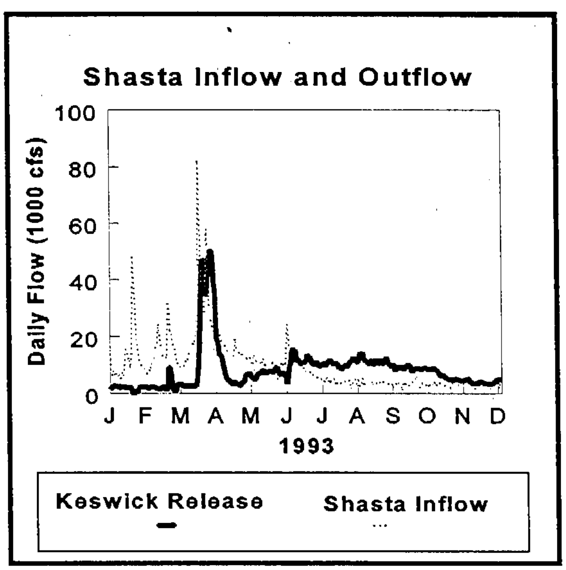
- Filling and flooding of channel and floodplain areas at high streamflows provide aquatic, wetland, and riparian habitat and sustain botanical processes (i.e., seed dispersal, soil moisture replenishment) within the floodplain, flood bypass, and riparian stream corridor.

HYDROLOGIC VARIATIONS

Water supplies in the Central Valley are categorized by "water-year classes" (wet, above normal, below normal, dry, and critical). This natural year-to-year hydrologic variability is used to establish water management plans. Facility operations are generally estimated using monthly rainfall and natural, unimpaired runoff conditions. Runoff is estimated from measured flows for 1922 to the present.

Seasonal variability results from rainfall events and snowmelt runoff. Rainfall events occur mainly during the "wet" season (between November and June). Substantial runoff from Sierra Nevada snowmelt extends into the summer and fall. This runoff pattern allows substantial diversion of water from Sacramento and San Joaquin river tributaries from May through September.

Central Valley reservoirs have been constructed during the last century to manage seasonal variability. Reservoirs capture winter floods and



spring snowmelt (while reserving sufficient flood control storage space and maintaining minimum instream flows). This storage provides an increased water supply during summer and fall for diversions and instream flows.

MULTIPURPOSE WATER MANAGEMENT

Seasonal and annual runoff fluctuation complicates control and allocation of the available water supply. Water is allocated for various beneficial uses including flood control, water supply, power generation, and instream and other environmental flows. Priorities for streamflow management are established according to the available water supply.

Almost all major Central Valley streams are regulated by large multipurpose reservoirs (as well as smaller diversion dams) and confined by flood control levees. Many rules govern the operation of these dams and affect the overall operation of water-management systems. As the effects from these facilities on the natural runoff, sediment transport, riparian regeneration, and fish migration patterns are observed, an increased understanding of the needs for instream flows is emerging.

Recognition of the importance of streamflows to protect and promote habitat conditions for fish and wildlife populations has created conflicts between existing beneficial uses of water supply, industry, and flood control.

Several agencies may be involved in the operation of each major reservoir or diversion facility. The many rules governing facility operations have an incremental and interdependent effect on overall operation of water management systems.

WATER RIGHTS AND INSTREAM FLOW

California water rights govern streamflow allocation for beneficial uses. Both riparian and appropriative water rights exist in California. These rights are administered and monitored by the State Water Resources Control Board (SWRCB). Riparian rights support specific beneficial uses on lands immediately adjacent to the stream. Appropriative water rights allow direct diversion or storage and may be obtained for beneficial use.

Water rights are incremental, with a specific priority scheme that controls water allocation during periods of shortage. Federal courts have assigned the jurisdiction over several California streams that are used for single-purpose hydropower projects to the Federal Energy Regulatory Commission (FERC). Additional "exchange contracts" between water-rights holders and water districts or government agencies, such as the U.S. Bureau of Reclamation (Reclamation) or California Department of Water Resources (DWR) further complicate the allocation of California water supplies.

Instream flow levels are sometimes required as conditions for water quality standards, water-rights permits, and FERC licenses. Negotiated agreements between water and fisheries agencies govern minimum flows downstream of major water projects. Some streams or stream segments, such as a portion of Butte Creek, are formally managed by State watermaster agreements.

The SWRCB has included instream spring flow requirements for both Delta outflow (i.e., X2 location objectives) and the San Joaquin River at Vernalis in the 1995 Water Quality Control Plan. Instream flow requirements govern the minimum flows at specific points below diversions and are often dependent on the available water supply (e.g., water-year type). Average annual instream and spring flow requirements are generally a small fraction of natural unimpaired flow and winter releases from storage reservoirs may be much less than unimpaired flows.

Many streams have no instream flow requirements. On some streams, riparian and appropriative water rights diversions may be restricted only by an amount necessary to supply downstream users having a higher priority water right. Some Central Valley streamflows are totally depleted downstream of the major diversions during the irrigation season.

ISSUES AND OPPORTUNITIES

NATURAL FLOW REGIMES. Native habitats and species in the Bay-Delta ecosystem evolved in the context of a highly variable flow regime punctuated by extreme seasonal and inter-annual changes in flow. The construction of dams and the diversion of water from Bay-Delta tributaries and the Delta have reduced the variability of the flow regime, especially by reducing peak flows and altering Bay-Delta hydrodynamics. The decrease in the variability of the flow regime is one factor that may be contributing to the explosion of exotic and invasive species, so it is hypothesized that restoring variable flows will help create habitat conditions that favor native species. However, a completely natural flow regime for a river reach below a dam is not possible (because of human water demand) and may not even be desirable since the pre-dam sediment supply has been cut off. The desired conditions below every major dam are likely to be different, suggesting a need for experimental manipulations of flows, including moderate annual floodflows, and habitat to find the right combination of factors that will maximize ecosystem benefits or assist endangered species in ways that are compatible with other uses of water and river corridors (Strategic Plan 2000).

OPPORTUNITIES: Mimic natural flow regimes through innovative methods to manage reservoir releases. There is underutilized potential to modify reservoir operations rules to create more dynamic, natural high-flow regimes in regulated rivers without seriously impinging on the water storage purposes for which the reservoir was constructed. Water release operating rules could be changed to ensure greater variability of flow, provide adequate spring flows for riparian vegetation establishment, simulate effects of natural floods in scouring riverbeds and creating point bars, and increase the frequency and duration of overflow onto adjacent floodplains. In some cases, downstream infrastructure of river floodways may require upgrading to accommodate safely a more desirable natural variability and peak discharge magnitude associated with moderate floodflows (e.g., strengthen or set levees back) (Strategic Plan 2000).

VISION

The vision for Central Valley streamflows is to protect and enhance the ecological functions that are achieved through the physical and biological processes that operate within the stream channel and associated riparian and floodplain areas in order to assist in the recovery of at-risk species, biotic communities, and overall health of the Bay-Delta.

To achieve maximum potential ecological functions and benefits from streamflows will require restoring and protecting the stream channel and floodplain process and in developing and implementing watershed management strategies and programs to protect the health of upper watersheds.

Opportunities to protect, enhance, and restore natural streamflow patterns and processes depend on stream channel and floodplain conditions, as well as existing impoundments and diversions.

Opportunities for adjusting seasonal streamflow patterns to benefit fish and wildlife while maintaining other beneficial water uses will be explored. Opportunities may include acquiring water rights from willing sellers or developing supplemental supplies (e.g., recycled water programs). Individual water rights are established according to California law, and this vision does not propose any adjudication or involuntary reallocation of water rights.

Many environmental factors and functions controlled by streamflow dynamics are only partially understood at this time. Therefore, the vision for Central Valley streamflow includes a substantial commitment to continued monitoring and evaluation of physical, chemical, and biological processes and ecological functions that are sustained and governed by streamflow.

Although the historical pattern of natural streamflows can be used as a guideline for establishing streamflow targets, the actual management of flows for each tributary or river segment will require coordination with all agencies and stakeholders. Conflicting interests and priorities will most likely be the rule rather than the exception. Streamflow targets will be developed within the existing multipurpose water resource management framework for each watershed.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

The vision for streamflow is intended to complement existing streamflow management programs. Several agencies are directly or indirectly responsible for streamflow management.

Agencies with important streamflow management responsibilities and programs include:

- U.S. Army Corps of Engineers' flood control operations of reservoirs and management of flood control facilities (e.g., levees, overflow channels and bypass weirs);
- DWR programs to provide water supplies (State Water Project), flood protection facilities, water quality monitoring, and multipurpose management of California water resources;
- Reclamation's operation of the Central Valley Project (and several other independent water projects in the Central Valley) to provide for multiple beneficial water uses, including fish and wildlife protection and habitat restoration (e.g., Central Valley Project Improvement Act);
- FERC regulation of minimum flows below hydropower projects;
- SWRCB administration of water rights for storage and diversions, including decisions about required instream flows for fish, water quality, and public trust resource protection;
- California Department of Fish and Game responsibility to study and recommend streamflows and temperature requirements for fish protection and propagation in streams and at hatcheries;
- U.S. Fish and Wildlife Service and National Marine Fisheries Service programs to recommend flows and other measures needed for mitigating impacts from federal projects and protecting endangered species, including the Anadromous Fish Restoration Program and the Water Management Program; and
- U.S. Geological Survey water resources division programs to measure streamflow and water quality, providing the information necessary for adaptive management of streamflows. Their monitoring and modeling activities for Central Valley groundwater and Bay-Delta hydrodynamics are also important contributions to water resources management.

Streamflows in Central Valley streams are being addressed under the Central Valley Improvement Act (CVPIA) subsection 3406(b)(2) and (b)(3) programs being administered by the USFWS. Under 3406(b)(2) 800 TAF of CVP water is to be allocated for fish and wildlife purposes. Under 3406(b)(3) additional water is to be acquired from willing sellers.

The combined sources of water are to be managed under a Water Management Plan being developed for selected individual rivers under FERC licensing requirements, negotiated settlements between stakeholders and agencies, State Water Resources Control Board water rights and water quality plans, and court ordered settlements such as that for the American River (Water Forum).

LINKAGE TO MULTI-SPECIES CONSERVATION STRATEGY

The interdependence of stream hydrology, fluvial geomorphology, and riparian habitats is of great relevance to the protection, restoration, maintenance, and recovery of MSCS evaluated species. Virtually all aquatic species, many riparian species, and some terrestrial species are dependent on habitats created, formed, or maintained by streamflow for nursery, forage, resting, or reproductive areas.

The basis of the ERP, and the key to the recovery of MSCS evaluated species, is the restoration of natural ecological processes. In highly altered or developed hydrologic units, understanding the role of altered streamflow patterns on existing habitats and species is critical to developing viable and effective restoration measures.

After decades of cumulative impacts, the majority of Central Valley rivers have been transformed from dynamic alluvial systems capable of forming their own stream beds and bank configurations to fossilized systems confined between berms, dikes, and levees or fossilized as a result of vegetation that has encroached into the low flow channel. The loss of coarse sediments captured behind the large dams has reduced or eliminated an essential ecological ingredient required for the creation of alternate bar features and in-stream and floodplain habitat structure. This, when combined with the significant reduction in natural stream flow patterns, especially high flows, has prevented regenerative fluvial processes from promoting river recovery. Not only are the components necessary for healthy river ecosystems no longer available (sediment supplies), the natural processes are impaired or lacking (high flow regimes).

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Streamflow is a primary ecosystem process and is integrally linked with other processes, habitats, and species. In addition, the effects of many ecological stressors are influenced by streamflow.

In all cases, the ecological value of streamflows will be incorporated into a comprehensive adaptive management program. (The Strategic Plan for Ecosystem Restoration, 2000, contains additional information regarding CALFED's approach to adaptive management.) This program for Central Valley streamflows will necessarily focus on the relationship of flow to the health of closely related ecological processes, habitats, and species.

Processes influenced by streamflow include:

- Central Valley water temperatures,
- coarse sediment supply,
- stream meander corridors,
- Bay-Delta aquatic foodweb,
- floodplain and flood processes,
- groundwater/surface water interactions, and
- dilution of contaminants.

Habitats that depend on streamflow include:

- riparian,
- aquatic, and
- wetlands.

Species directly linked to streamflow include:

- anadromous fish,
- delta smelt,
- resident fish,
- riparian dependent species,
- riparian plant communities
- shorebirds, and
- waterfowl.

Each of these processes, habitats, and species is adversely affected by stressors which restrict their full function, extent, distribution, or survival. Therefore, the full ecological benefit to be derived from streamflows also depends on reduction or elimination of stressors which impair other closely related ecosystem elements. Streamflow is an important ingredient for ecological health, but cannot provide full benefit without improvement in other areas.

OBJECTIVES, TARGETS, ACTIONS, AND MEASURES

Streamflows are addressed by two strategic objectives.

> One Strategic Objective for streamflow is to establish hydrologic regimes in streams, including sufficient flow timing, magnitude, duration, and high flow frequency, to maintain channel and sediment conditions supporting the recovery and restoration of native aquatic and riparian species and biotic communities.

LONG-TERM OBJECTIVE: For regulated rivers in the region, establish scientifically based high-flow events necessary to maintain dynamic channel processes, channel complexity, bed sediment quality, and natural riparian habitats where feasible.

SHORT-TERM OBJECTIVE: Through management of the reservoir pool or deliberate reservoir releases, provide a series of experimental high-flow events in regulated rivers to observe flow effects on bed mobility, bed sediment quality, channel migration, invertebrate assemblages, fish abundance, and riparian habitats over a period of years. Use the findings of these studies to reestablish natural stream processes where feasible, including restoration of periodic inundation of remaining undeveloped floodplains.

RATIONALE: Native aquatic and riparian organisms in the Central Valley evolved under a flow regime with pronounced seasonal and year-to-year variability. Frequent (annual or longer term) high flows mobilized gravel beds, drove channel migration, inundated floodplains, maintained sediment quality for native fishes and invertebrates, and maintained complex channel and floodplain habitats. By deliberately releasing such flows from reservoirs, at least some of these physical and ecological functions can probably be recreated. A program of such high-flow releases, in conjunction with natural high-flow events, lends itself well to adaptive management because the flows can easily be adjusted to the level needed to achieve specific objectives. However, it should be recognized that channel adjustments may lag behind hydrologic changes by years or decades, requiring long-term monitoring. Also, on most rivers, reservoirs are not large enough to eliminate extremely large, infrequent events so these will continue to affect channel form at irregular, often long, intervals; artificial high-flow events may be needed to maintain desirable channel configurations created during the natural events. This objective focuses on flows that are likely to be higher than those needed to maintain most native fish species but that are important for maintaining in-channel and riparian habitats for fish as well as other species (e.g., invertebrates, birds, mammals). Experimental flow releases also will have to be carefully monitored for negative effects, such as encouraging the invasion of unwanted non-native species.

STAGE 1 EXPECTATIONS: Studies should be conducted on five to 10 regulated rivers in the Central Valley to determine the effects of high-flow releases. Natural floodplains should be identified that can be inundated with minimal disruption of human activity. Where positive benefits are shown, flow recommendations should be developed and instituted where feasible.

> A second Strategic Objective for streamflow is to create and/or maintain flow and temperature regimes in rivers that support the recovery and restoration of native aquatic species.

LONG-TERM OBJECTIVE: Native fish and invertebrate assemblages will be restored to regulated streams where feasible, using methods developed during the short-term objective phase.

SHORT-TERM OBJECTIVE: Provide adequate flows, temperatures, and other conditions to double the number of miles (as of 1998) of regulated streams that are dominated (>75% by numbers and biomass) by assemblages with four or more native fish species.

RATIONALE: Virtually all streams in the region are regulated to some degree, and the regulated flow regimes frequently favor non-native fishes. The native fish assemblages (including those with anadromous fishes) are increasingly uncommon. Recent studies in Putah Creek, the Stanislaus River, and the Tuolumne

River demonstrate that native fish assemblages can be restored to sections of streams if flow (and temperature) regimes are manipulated in ways that favor their spawning and survival, usually by having flow regimes that mimic natural patterns in winter and spring but that increase flows during summer and fall months (to make up for loss of upstream summer habitats). Native invertebrates and riparian plants may also respond positively to these flow regimes. Achievement of this objective will require additional systematic manipulations of flows below dams (or the re-regulation of existing flow regimes) to determine the optimal flow and habitat conditions for native organisms, as part of the short-term goal. Part of the studies should be to determine if the objective can be achieved without "new" water, by just altering the timing of releases or by developing conjunctive use agreements that allow more water to flow down the stream channel. Ways to restore native fish communities that do not involve changed flows should be developed (where feasible) to be used in place of or synergistically with changed flows. These findings can then be applied opportunistically to achieve the long-term goal of restoring native fish communities.

STAGE 1 EXPECTATIONS: Surveys will have been completed to determine the status of native fishes in all regulated streams of the Central Valley and flow recommendations made to restore native fishes where feasible. During negotiations for relicensing of dams, agency personnel should evaluate and consider flow regimes favorable for native fishes.

RESTORATION ACTIONS

The general target for streams with large water storage reservoirs is to provide a spring flow event that emulates natural spring pulse flows in dry and normal years. For all streams provide sufficient year-round base flows to sustain important ecological processes, habitats, and species.

Actions that will contribute to restoring the ecological values of stream flow include maintaining spring flows and sustaining summer-fall base flows are the two major streamflow restoration activities considered in this vision. The following three programmatic actions will help to achieve streamflow objectives:

- Provide sufficient high flows during spring (March-May) to sustain high-flow dependent ecological functions. This can be accomplished by allowing a portion of the natural inflow to pass through large Central Valley reservoirs in spring of all but the driest years. In extreme cases, this may be accompanied by reductions in high summer storage releases.
- Maintain sufficient year round base flows to sustain aquatic streamflow dependent ecological processes, habitat, and species.
- Provide sufficient flow during the first yearly significant rain event to sustain habitat and species dependent on such flow. This can be accomplished by allowing a portion of the natural inflow to pass through large Central Valley reservoirs in all but the driest years.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets. Although the measures focus on at-risk species, some have direct connections to the manner in which streamflows in the Central Valley influence species or their habitats.

- Improve January and February flows for the longfin smelt during the second and subsequent years of drought periods.
- Consistent with CALFED objectives, mobilize organic carbon in the Yolo Bypass to improve food supplies by ensuring flow through the bypass at least every other year.
- Provide sufficient Delta outflows for the longfin smelt from December through March.
- For green sturgeon, provide inflows to the Delta from the Sacramento River greater than 25,000 cfs during the March to May spawning period in at least 2 of every 5 years.
- To the extent consistent with CALFED objectives, manage export flows from the San Joaquin River to improve conditions for

upstream migration of adult fall-run chinook salmon (i.e., attraction flows).

- Minimize changes in the timing and volume of freshwater flows in the rivers to the Bay-Delta.
- To the extent consistent with CALFED objectives, provide unrestricted access of adult splittail to spawning habitats from December to July by maintaining adequate flow and water quality, and minimizing disturbance and flow disruptions.
- To the extent consistent with CALFED objectives, reduce the effects on splittail from changes in reservoir operations and ramping rates for flood control.
- To the extent consistent with CALFED objectives, ensure that the Yolo and Sutter Bypasses are flooded during the spawning season at least once every 5 years.
- To the extent consistent with CALFED objectives, increase the frequency of flood bypass flooding in non-wet years to improve splittail spawning and early rearing habitat.

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◆ Central Valley Stream Temperatures

Introduction

Water temperatures in Central Valley rivers and streams and in the Bay-Delta are determined by the natural heating and cooling process of water bodies. Water temperature is controlled by water source (i.e., dam releases, runoff, and discharges), surface water and groundwater inflow, geomorphology (e.g., depth), tides, riparian shading, water clarity, and, most often, ambient air temperature. Water temperature is a major factor in habitat suitability for aquatic organisms. Unnaturally high water temperature can become a stressor to many aquatic organisms.

Major factors that limit water temperature contributions to the health of the Bay-Delta are disruption of historical streamflow patterns, loss of riparian vegetation, stored water releases from reservoirs, and discharges from agricultural drains.

Resource Description

Natural biochemical processes, as well as aquatic organism physiology and behavior (e.g., respiration, feeding, growth), are partially controlled by water temperatures. Many native aquatic organisms, such as chinook salmon, depend on cool water for spawning, rearing, and migrating. For example, adult salmon migrating upstream through the Delta and into the rivers are stressed when water temperatures reach into the 58 to 65° Fahrenheit (F) range, which may delay migration and spawning, which in turn may affect egg quality and potential production of juvenile salmon.

High fall water temperatures in the Delta may delay upstream migration of fall-run chinook salmon from the Bay into and through the Delta. High spring water temperatures in the rivers and Delta may stress young chinook salmon migrating downstream to the ocean. High summer water temperatures in the Sacramento River near Redding may stress the eggs and fry of winter-run chinook salmon. Unusually high water temperatures in periods of drought were primary factors in historical declines of salmon and other fish species.

Although stream temperatures fluctuate daily, seasonally and in response to meteorological conditions (e.g., air temperature and the amount of sunshine), many important ecological functions are dependent on a relatively narrow temperature range. For example, salmon and steelhead require 54°F to 57°F to spawn and egg development requires water temperatures below 57°F. Growth of young salmon and steelhead is generally optimal in the 50-60°F range.

Stream temperatures regulate important ecosystem functions including:

- Algae blooms,
- Aquatic invertebrate reproduction and growth,
- Fish migration,
- Fish spawning,
- Fish development and growth,
- General well-being of aquatic organisms,
- Metabolism and behavioral cues of aquatic organisms,
- The amount of dissolved oxygen (DO) available in the water body, and
- Rates of organic material decay and nutrient recycling in aquatic habitats.

The ability to control water temperature in rivers and the Delta is limited because water temperature is most strongly influenced by air temperature. Some temperature regulation is available through control over streamflows, discharges of warm water into rivers and the Delta, and the extent of inundation and shading of floodplains. Temperature can be controlled to some extent below major Central Valley reservoirs by the selective release of warm or cold water from different depths behind the dams.

Construction and operation of Shasta Dam dramatically altered the flow regime and thermal characteristics of the Sacramento River (Hallock 1987). Hallock observed that water released in the spring was often too cold for rapid growth of juvenile fall- and late-fall-run chinook salmon, and that water released in August and September was often too warm for successful spawning and incubation of spring- and winter-run chinook salmon eggs and alevins.

The recently completed Shasta Dam Temperature Control Device allows operators to release water from different depths or combinations of depths to regulate the temperature in upper portions of the lower Sacramento River. Intake shutters on Folsom Dam allow water to be released from three different layers into the lower American River. Most large reservoirs have only one deep water intake in the cold water zone of the reservoir. The amount of cold water that can be released from Central Valley reservoirs is limited, especially in drought years.

Temperatures in Central Valley streams follow a seasonal pattern. Water temperatures are controlled primarily by meteorological conditions (indicated by air temperature fluctuations). Although Central Valley air temperatures range from 30°F to over 100°F, stream temperatures generally range from about 40°F to 80°F. Coolwater fish generally require stream temperatures lower than 65°F. Lower temperatures are easily achieved in high mountain streams but are more difficult to maintain in streams at lower elevations and along the valley floor. Releases from major reservoirs and groundwater (e.g., springs) are two important seasonal sources of cool water.

Maintaining cool water below reservoirs is especially important because salmon and steelhead are blocked from reaching their historic spawning and rearing grounds in headwaters in these rivers.

The water from many Central Valley streams is impounded by large multipurpose reservoirs (as well as by smaller diversion dams) that limit the upstream migration of anadromous fish into higher elevation tributaries historically used for spawning and rearing. The operations of these reservoirs can be used to maintain adequate stream temperatures in the segments immediately downstream of the reservoirs, but these temperature control operations must be integrated with other water management objectives.

Stream temperature is a major habitat condition that exerts a strong influence on many biochemical processes. Temperature controls the maximum concentration of dissolved oxygen (DO) in water. Fish and other aquatic organisms require adequate amounts of DO in water to survive. The maximum DO concentration is higher at 50°F than at 70°F. Higher temperatures also increase the decay of oxygen-consuming organic materials further reducing total DO concentration.

Many fish behavioral and physiological functions, such as spawning, are controlled in part by temperature. Fall-run salmon begin to spawn when stream temperatures fall to 60°F. Salmon-egg survival is a strong function of temperature, declining to near zero at temperatures greater than 62°F. Successful holding of adult winter-run and spring-run salmon until spawning requires temperatures below about 60°F. Temperatures below 65°F are considered necessary for successful steelhead rearing.

Controlling water temperatures on regulated streams is complex. The Sacramento River Winter-run Chinook Salmon Recovery Team reported that water temperatures in the upper Sacramento River result from the complex interactions of: (1) ambient air temperature, (2) volume of water, (3) water temperature at release from Shasta and Trinity dams, (4) total reservoir storage, (5) location of reservoir thermocline, (6) ratio of Spring Creek Powerplant releases to Shasta Dam release, and (7) tributary inflows (NMFS 1997).

Wang (1986) reported that delta smelt spawn in fresh water at temperatures of 44 to 59°F. In recent years, ripe delta smelt and recently hatched larvae have been collected at temperatures of 59 to 72°F, so it is likely that spawning can take place over the entire 44 to 72°F range (U.S. Fish and Wildlife Service 1996).

Splittail trawl catches in Suisun Marsh are highest in summer when salinities are 6 to 10 parts per thousand and water temperatures are 59 to 73 °F (U.S. Fish and Wildlife Service 1996).

Cool temperatures also affect the growth rate of fish. For example, at 50°F, about 100 days are needed for rearing juvenile fall-run salmon to reach a size suitable for outmigration (3 inches). Rearing at 45°F would require about 140 days; rearing at 55°F would shorten the growth period to about 80 days. Fish spawning in different streams with differing temperature regimes will, therefore, have different timing and duration for spawning, growth, and migration.

Hatchery temperature objectives are often targeted to provide maximum growth without increasing mortality from excessive rates of respiration and diseases that are more prevalent at higher temperatures. Coldwater virus disease (IHN) is often a substantial problem at temperatures below 50°F. Salmonid temperature objectives in hatcheries are therefore generally within the 50-60°F range, which is much lower than the full range of Central Valley water temperatures.

VISION

The vision for Central Valley stream temperatures is to restore natural seasonal patterns of water temperature in streams, rivers, and the Delta to benefit aquatic species by protecting and improving ecological processes that regulate water temperature and reducing stressors that change water temperature.

Appropriate water temperatures will provide suitable fish spawning, holding, and rearing habitat conditions and contribute to the recovery of species and overall health of the Bay-Delta.

Natural temperature conditions in Central Valley streams vary along a continuum on a "longitudinal gradient" from the mountain headwaters to meandering lowland rivers, and on to the Delta. Therefore, restoration needs for stream temperatures vary for different streams and stream segments. These needs will vary by stream and stream segment, depending on existing conditions. The needs and opportunities to protect and manage Central Valley stream temperatures will depend on the conditions of the stream channel and riparian corridor, as well as the existing water supply (i.e., reservoir storage) of each tributary stream.

A primary restoration need will be to maintain relatively low water temperatures in summer and fall for anadromous fish populations in the upstream portion of each major tributary to the Delta, especially those tributaries with larger foothill reservoirs and impassable dams. These low water temperatures are particularly important for the survival of juvenile steelhead. In relatively wet years, with full reservoirs and high reservoir releases for downstream diversions, water temperatures below the major Central Valley reservoirs are maintained within the 50-60°F target range. However, as available water supply declines (i.e., in drier years), the ability to maintain sufficient carryover storage to sustain the release of cool water and to release sufficient flows to control downstream temperatures for salmon and steelhead rearing is substantially reduced. Sustaining adequate temperatures below reservoirs and power diversion dams is needed to provide coolwater anadromous fish habitat within the existing Central Valley multipurpose water resources management framework. Flexibility in managing stream temperatures will be an important ingredient in the successful restoration of Central Valley natural resources.

Particular attention has been given to water temperatures below Keswick Dam because this area is the only remaining spawning habitat on the Sacramento River for winter-run chinook salmon. Extremely warm water in 1976 and 1977 was likely a major cause of the decline in winter-run chinook salmon. Red Bluff Diversion Dam likely contributed to the sustained low population of winter-run chinook throughout the period following the 1976-77 drought, even when water temperature impacts were moderated. Only very low populations of winter-run salmon have been maintained since this drought event, during which Shasta Reservoir storage declined to less than 1 million acre-feet. The California Department of Fish and Game (DFG) and the Anadromous Fish Restoration Program (AFRP) suggest that Shasta Reservoir carryover storage should not drop below 1.9 million acre-feet to ensure an adequate supply of cold water for release in summer and fall. The Temperature Control Device, completed in 1997, provides additional flexibility in temperature control and conserving cooler reservoir waters through the summer and fall.

The State Water Resources Control Board (SWRCB) has added water temperature requirements below Keswick Dam (and in the Trinity River below Lewiston Dam) to the water rights for Shasta and Clair Engle Reservoirs. A multiagency Sacramento River Temperature Task Force is responsible for the adaptive management of Sacramento River water temperatures. It reports to SWRCB on the effects of its temperature management and the resulting winter-run chinook spawning and rearing success each year. These water management decisions are more difficult in years with limited water supply.

Whiskeytown Reservoir releases of water into Clear Creek, a tributary to the Sacramento River, are sufficiently cool to support salmon and steelhead. However, since 1965, insufficient streamflows and fish-passage problems have prevented this potential habitat from supporting many fish. Low-level outlets can be used for releases to Clear Creek. Efforts to manage temperatures in Clear Creek could be implemented as on the Sacramento River.

The temperature of Lake Oroville releases to the Feather River is controlled (e.g., temperature control panels) for the Feather River Hatchery and the "low-flow" channel. The objective is to maintain temperature for natural spawning and holding of spring-run salmon and steelhead. Carryover storage, sufficient to maintain low fall water temperatures, is limited during droughts. The California Department of Water Resources (DWR) is exploring operations of the Oroville-Thermalito complex to determine whether improved stream temperature controls can be achieved. As at Shasta Dam, additional means for controlling temperature are needed for these adaptive management efforts to provide optimal water temperatures within the overall water management framework. One such means would be additional storage water dedicated to temperature control in the Feather River below Lake Oroville and Thermalito Reservoir.

Yuba River water temperatures are considered well suited for salmon and steelhead below Englebright Dam (the first impassable dam), but flows and riparian vegetation have been insufficient to maintain target temperatures below the Daguerre Dam, the major water diversion dam on the lower Yuba below Englebright Dam. The Yuba County Water Agency is evaluating the temperature control potential of New Bullards Bar Reservoir (a major storage reservoir upstream of Englebright Lake on the North Fork of the Yuba River) and is working with AFRP and DFG to develop an adaptive management strategy for Yuba River flows and temperatures. Again, like at Shasta and Oroville, additional storage dedicated to water temperature control and possibly the addition of temperature control devices on major storage reservoirs could improve the water temperature conditions on the lower Yuba River.

Many of the upper Sacramento River tributaries are largely nonregulated. Water temperatures on these stream and in the Sacramento River at their confluence could be improved by managing water diversions and improving riparian vegetation.

The U.S. Bureau of Reclamation (Reclamation) has recently modified the Folsom Dam temperature control panels to provide some additional temperature management potential; however, the relatively low storage capacity of Folsom Reservoir limits the ability to control temperatures at the Nimbus Hatchery and in the lower American River. Additional storage dedicated for water temperature and potential improvements to temperature controls at Nimbus Dam could improve water temperatures in the lower American River.

Temperatures in the San Joaquin River tributaries (Mokelumne, Stanislaus, Tuolumne, and Merced rivers) are controlled by a combination of cold-water reservoir releases and streamflow management. Although initial efforts to monitor and control water temperatures on these rivers have begun, the upstream segment of each may require additional reservoir and flow management actions. Unlike other most other dams in the Central Valley, New Exchequer Dam on the Merced River draws water from the bottom of the reservoir in the hypolimnion and water temperature management is complicated by the presence of three additional reservoirs downstream of New Exchequer that influence temperatures in the lower Merced River. Merced Irrigation District plans to investigate which option, if any, may exist to improve the water temperature regime in the lower river. Long-term agreements to adaptively manage reservoirs on these San Joaquin River tributaries are needed to provide the best possible flow and temperature conditions for fish habitat while also protecting the other existing beneficial water uses.

Another primary restoration need will be to maintain cool temperatures through the spring and again in the fall in the Delta and lower rivers to provide for upstream migrating adult and downstream migrating and rearing juvenile anadromous fish. Low flows either naturally occurring or caused by water storage or diversions are the problem in these areas. Although control of water temperature is limited in the lower rivers and the Delta, restoring natural flows, riparian vegetation, connecting marsh-sloughs, and reducing warm water discharges should benefit water temperatures in small but significant ways. Shallow water habitats with adequate shade will not locally warm to intolerable levels for species dependent on them. Dead-end sloughs will maintain slightly lower water temperatures with adequate shading. Minimizing discharges of warm water such as agricultural drains into rivers and Delta will help sustain cooler temperatures further into the spring and earlier into the fall. Although water temperature changes would be small, possibly less than an degree or two, such changes are significant when overall water temperatures are stressful or approach lethal levels for some species.

Although historical stream temperatures can be used as a guideline for establishing stream temperature targets, the actual management of temperatures for each tributary or river segment will require coordination with all agencies and stakeholders. Therefore, stream temperature targets should be developed within the existing multipurpose water resource management framework for each watershed. The relative ecological value of streamflow and temperature should be estimated for each tributary stream. Streamflow and temperature should be accurately monitored and rapidly evaluated for both short-term and long-term management decisions. This basic streamflow information will then allow for flexible management of streamflows. Flexible management will allow temperatures to become a major element in the restoration of ecological functions and benefits throughout the Sacramento and San Joaquin River basins.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Water temperature in Central Valley streams is being addressed under the Central Valley Improvement Act (CVPIA) subsection 3406(b) programs being administered by the USFWS. Water temperature is also addressed in various biological opinions and recovery plans (e.g., winter-run chinook salmon) for threatened and endangered species. Water temperature is also a common criteria in water quality standards for various rivers and the Delta.

There are several important ongoing programs that attempt to improve the multipurpose water management of Central Valley streamflows and temperature conditions. The vision for stream temperature management is to complement and coordinate (where conflicts exist) these existing streamflow and temperature management programs. Several agencies are directly or indirectly responsible for stream temperature management. ERPP supports the policies and decisions of these individual agencies and could provide resources to implement stream-temperature management actions and mediate conflicts between water management goals of individual agencies.

Important stream-temperature management responsibilities and programs of agencies include:

- DWR's operation of Lake Oroville to satisfy DFG hatchery and stream temperature objectives;
- Reclamation's operation of Central Valley Project reservoirs to achieve specific temperature criteria or objectives for salmon and steelhead habitat conditions;
- Federal Energy Regulatory Commission's regulation of minimum flows below hydropower projects throughout California (e.g., Butte Creek temperatures below Centerville Diversion Dam);
- SWRCB's administration of water rights and water quality objectives (in coordination with Regional Water Quality Control Boards) necessary for beneficial uses and for fish protection below reservoirs and dams;
- DFG's responsibility to study and recommend stream temperature requirements for fish protection and propagation in streams and at hatcheries;
- USFWS's and the National Marine Fisheries Service's programs to recommend temperatures needed for mitigation of impacts from federal projects (e.g., hatcheries) and protection of endangered species (the biological opinion for winter-run chinook salmon and the AFRP each have specific temperature recommendations and requirements); and
- USGS's water resources division programs to measure streamflow and temperature to provide the information necessary for adaptive management of stream temperatures.

LINKAGE TO MULTI-SPECIES CONSERVATION STRATEGY

Although the ERP treats water temperature as a separate ecological attribute, it is closely tied to a watershed's hydrologic pattern and is an important attribute of flowing water. The recovery of many aquatic species evaluated in the MSCS will be dependent on the ability or opportunity to provide not only the appropriate quantities of water at the appropriate time, but also provide water within certain specific temperature ranges. In many instances, the contemporary recommended flows and temperatures diverge greatly from historic unimpaired flow and temperature regimes. Regardless, stream temperature is an essential component of a healthy ecosystem that in many instances is closely tied to flow and storage patterns. The recovery of many species, particularly chinook salmon and steelhead stocks, is greatly dependent on stream temperature regimes that naturally fall or are managed within tight boundaries.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Water temperature is a primary ecological process closely linked with other processes, habitats, and species. Water temperatures are dependent on streamflow and riparian vegetation. Stressors including water diversions and agricultural drainage discharges affect water temperature.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

The Strategic Objective for Central Valley stream temperature is to create and/or maintain flow and temperature regimes in rivers that support the recovery and restoration of native aquatic species.

LONG-TERM OBJECTIVE: Native fish and invertebrate assemblages will be restored to regulated streams where feasible, using methods developed during the short-term objective phase.

SHORT-TERM OBJECTIVE: Provide adequate flows, temperatures, and other conditions to double the number of miles (as of 1998) of regulated streams that are dominated (>75% by numbers and biomass) by assemblages with four or more native fish species.

RATIONALE: Virtually all streams in the region are regulated to some degree, and the regulated flow regimes frequently favor non-native fishes. The native fish assemblages (including those with anadromous fishes) are increasingly uncommon. Recent studies in Putah Creek, the Stanislaus River, and the Tuolumne River demonstrate that native fish assemblages can be restored to sections of streams if flow (and temperature) regimes are manipulated in ways that favor their spawning and survival, usually by having flow regimes that mimic natural patterns in winter and spring but that increase flows during summer and fall months (to make up for loss of upstream summer habitats). Native invertebrates and riparian plants may also respond positively to these flow regimes. Achievement of this objective will require additional systematic manipulations of flows below dams (or the re-regulation of existing flow regimes) to determine the optimal flow and habitat conditions for native organisms, as part of the short-term goal. Part of the studies should be to determine if the objective can be achieved without "new" water, by just altering the timing of releases or by developing conjunctive use agreements that allow more water to flow down the stream channel. Ways to restore native fish communities that do not involve changed flows should be developed (where feasible) to be used in place of or synergistically with changed flows. These findings can then be applied opportunistically to achieve the long-term goal of restoring native fish communities.

STAGE 1 EXPECTATIONS: Surveys will have been completed to determine the status of native fishes in all regulated streams of the Central Valley and flow recommendations made to restore native fishes where feasible. During negotiations for relicensing of dams, agency personnel should evaluate and consider flow regimes favorable for native fishes.

RESTORATION ACTIONS

General targets to achieve healthy Central Valley stream temperatures include:

- Maintaining water temperature at or below 56°F in salmon and steelhead spawning areas during spawning and incubation seasons below major dams on rivers. The ability of meeting this broad target will be influenced by in some drainages by the quantity and quality of coldwater stored behind the larger dams.
- Maintaining water temperature below 58°F for rearing and out-migrating salmon and steelhead from late winter through late spring.
- Maintaining water temperature below 60°F in oversummering areas of salmon and steelhead to the extent possible. When temperature control at this level is not possible, temperatures should be maintained below 65°F to avoid significant adverse impacts.
- Maintaining water temperature below 68°F in migratory routes of anadromous fish in spring and fall. Meeting this target in the lower Sacramento River, lower San Joaquin River, and in the Delta may be difficult in many years as there is no practical, short-term means by which to reduce water temperatures.

Several stream temperature actions should be implemented immediately. There is general agreement that these actions will improve stream temperatures without having significant impacts on water supply or energy resources. Many of these actions have been recommended by DFG and by AFRP but have not been implemented because of limited financial resources. They include:

- Increasing coldwater releases from Whiskeytown Lake to Clear Creek to allow restoration of the habitat along this 18-mile stream segment for salmon and steelhead spawning and rearing; Whiskeytown Lake could be coordinated with the operation of Shasta Dam to minimize impacts on the water supply;
- Developing a long-term agreement with Pacific Gas and Electric Company (to provide appropriate compensation for energy losses) to monitor temperatures and provide bypass flows in the lower North Fork and South Fork segments of Battle Creek to maintain suitable temperatures for holding, spawning, and rearing habitat for spring-run and winter-run chinook salmon and steelhead;
- Restoring stream temperature monitoring capability at several U.S. Geological Survey stream gages and other strategic locations of Central Valley streams, combined with improving fish sampling and counting devices to provide a solid basis for adaptive stream temperature management decisions; and
- Increasing Feather River flows in the "low-flow" channel to a maximum of 2,500 cubic feet per second (cfs) and reducing the flows through Thermalito Forebay and Afterbay released to the Feather River. Thermalito releases can have a major effect on downstream temperatures; only water needed for irrigation diversions and peaking power generation should be diverted (energy from the Thermalito power plant would be reduced).

Because temperatures are an important habitat condition and can vary with changes in other factors, there should be a substantial commitment to continued monitoring and evaluation of the physical, chemical, and biological processes and ecological functions that are governed by stream temperature.

Many stream-temperature management actions will require a slightly longer implementation period because additional information is needed for careful planning decisions, or because detailed designs for new or modified facilities are required. Nevertheless, the necessary planning studies and engineering design work can be initiated on the following longer term actions:

- Establish coordinated stream-temperature management teams for each major stream. Coordinated teams could follow the approach used by the Sacramento River Water Temperature Task Force to help Reclamation allocate and schedule releases for Sacramento River temperature control. This cooperative management approach attempts to maximize streamflow and temperature benefits while maintaining other beneficial uses of water. The choice between carryover storage and increased releases for temperature control can best be made by this type of adaptive management team. Potential conflicts between different fish populations and other water uses can also be addressed using this strategy.

- Restore blocks of riparian habitat that are sufficiently large (>50-100 acres) to create air convection currents, which will cool adjacent river water temperatures.
- Restore and protect the stream channels and riparian corridors (i.e., pools, gravelbeds, and vegetation). Minimizing warming along the stream gradient and providing habitat features will allow fish to use cool water areas in deep pools and springs.
- Develop a comprehensive series of reservoir and stream temperature models. The models would be used to investigate the effects of possible modifications to reservoir facilities and stream channel and riparian corridor conditions. These calibrated models can form the basis for adaptive management of Central Valley streamflows and temperatures within the overall framework of multipurpose water management objectives and constraints.

To protect and improve Central Valley stream temperatures, a responsible balance must be achieved between water management for temperature controls and other beneficial uses of the available water supply.

To be implemented, these measures may require that water from willing sellers be purchased or water exchanges negotiated and alternative supplies explored. There are two general programmatic actions:

- Provide sufficient carryover storage and selective withdrawal facilities in major reservoirs. These measures would help optimize summer and fall release temperatures to allow spawning and rearing of winter-run and fall-run salmon. A target temperature of 56°F during spawning and egg incubation is appropriate because salmon eggs have increasingly high mortality rates as temperatures rise above 56°F and total mortality above 68°F. The Shasta Reservoir temperature device is being constructed to allow warmer water to be released in spring and early summer to reserve more of the cooler water (at greater depth) for summer and fall releases. Because some carryover storage must be maintained to provide desirable temperatures downstream, specific reservoir releases for water supply may be reduced in some dry years.
- Provide sufficient summer and fall streamflows to maintain adequate holding and rearing temperatures for spring-run, fall-run, and winter-run salmon of less that 60°F in streams supporting these populations. This may require limiting hydropower diversions or providing higher reservoir releases than would otherwise be required for downstream diversions.

MSCS Conservation Measures

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population goals. Although the measures were developed specifically for evaluated species, some measures have direct relationships to the manner in which stream temperatures influence habitat quality or have adverse effects on evaluated species.

- Initial species recovery efforts should be directed to locations where there are immediate opportunities for protection, enhancement, or restoration of suitable habitat.
- Coordinate protection, enhancement, and restoration of important habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, the Anadromous Fish Restoration Program, and USFWS recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Implement management measures in the proposed recovery plan for the Sacramento River winter-run chinook salmon (National Marine Fisheries Service 1997).
- Implement applicable management measures identified in the restoration plan for the Anadromous Fish Restoration Program (U.S. Fish and Wildlife Service 1997) and the recovery plan for the native fishes of the Sacramento-San Joaquin Delta (U.S. Fish and Wildlife Service 1996).
- Continue research to determine causes for low outmigration survival of fish from the San Joaquin River in the South Delta and identify

and implement measures to improve outmigration survival.

- Initially restore suitable valley/foothill riparian forest and woodland under the ERP along at least 10 contiguous miles in the Delta to create a riparian forest corridor at least 220 yards in width.
- Restore large contiguous blocks of suitable valley/foothill riparian forest and woodland at least 220 yards in width and 500 acres in size along reaches of the Sacramento River (Red Bluff to Colusa.

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◆ COARSE SEDIMENT SUPPLY

INTRODUCTION

Natural sediments of streams, rivers, and estuaries consist of mineral and organic silts, sands, gravel, cobble, and woody debris. These materials naturally enter, deposit, erode, and are transported through the Bay-Delta and its watershed. Sediment, like water, is one of the natural building blocks of the ecosystem. Many other ecological processes and functions, and habitats and species require specific types and amounts of sediment and the habitats sediments create. Gravel, for example, is important for maintaining spawning habitat for salmon and steelhead, and as habitat for stream invertebrates. Finer sediments are important in the natural development of riparian and wetland habitats. Major factors that influence the sediment supply in the Bay-Delta and its watersheds include many human activities such as dams, levees, and other structures, dredging, and gravel and sand mining.

River-transported sediments are an essential component of the physical structure and nutrient base of the Bay-Delta ecosystem and its riverine and tidal arteries. The size, volume, and seasonal timing of sediments entering the riverine and estuarine systems should be compatible with both natural and altered flow regimes. Sediment transport should match channel and floodplain characteristics of individual rivers, streams, and tidal sloughs. A specific sediment management objective is to redistribute sediment in the watersheds and valley components of the ecosystem. An appropriate level, rate, and size of sediment should be redistributed to match specific habitat requirements and ecological functions.

RESOURCE DESCRIPTION

The coarse sediment supply is highly variable between the streams and tidal sloughs of the Sacramento and San Joaquin Rivers and Bay-Delta ecosystems. Part of the reason is differences in soils and geofluvial morphology of the watersheds. Other factors include difference in runoff patterns and watershed characteristics. Human activities and development may be important factors. Large dams deprive most of the major rivers entering the Sacramento-San Joaquin Valley of their primary source of sediment from the upper watersheds. Upper watershed sediment supplies have been altered by increased human use and habitation in areas previously only influenced by natural processes of fire, flood, and mass wasting.

Alluvial sediment is stored in the valley floodplains along rivers, but much of this natural supply is no longer available to rivers and streams because of extensive hardening of banks (e.g., rip-rap) to protect stream-side levees, orchards, and cropland. Some individual streams have an excess of fine sediment, such as the lower Feather River that is still affected by an oversupply of sand from the hydraulic mining era. Within the Delta, rivers and sloughs appear to suffer from a net loss of channel sediment resulting in the reduction or disappearance of midchannel islands and shallow shoal habitats .This is believed to be caused by a combination of reduced sediment supply from rivers, historic loss of Delta floodplains (reclamation of formerly extensive tule islands for agricultural uses), high velocity tidal currents, wind wave and boat wake erosion of unprotected, artificially steep banks, and channel dredging to maintain shipping routes and floodway capacity.

Land use has also altered natural sediment supplies in Central Valley watersheds. During the gold rush, natural sediment supplies in the Central Valley were greatly altered by extensive hydraulic and dredge mining on the western Sierra Nevada streams (especially the Yuba, Feather, American, lower Sacramento, and San Joaquin rivers and their tributary watersheds). Sediment from mining in the late 19th Century greatly exceeded the amounts that rivers were able to transport. Rivers became overloaded with sediment, causing deposition and flooding in valley towns and farms. Fine sediments pulsed quickly through the river systems, but the coarser sediments moved more gradually. By the late 20th Century, most riverbeds had returned to pre-Gold Rush elevations because riverflows had cut through the old placer mining debris deposits stored along the banks. Some rivers and creek valleys still contain "debris dams" (e.g., Daguerre Point Dam on the Yuba River) built a century ago in an attempt to keep placer mining sediment from spreading into streambeds of the valley and causing flooding of cities and farmlands.

Natural sediment recruitment and transport in the Central Valley are tied to streamflow. Most sediment is transported and deposited during winter and spring runoff events. Typically, bars, shoals, and braided deltas form or expand as floodwaters decline and stabilize during the dry season. Flowing water rearranges and sorts sediment (sand, silt, and clay particles) and bedload (cobble and gravel) to create the structural support for many important habitats, including fish spawning gravels, growth medium (substrate) in which riparian forests germinate and establish, and loamy floodplains that support oak woodland and grasslands. Transporting heavier cobble and gravel helps rivers dissipate stream energy, and the formation of heavy cobble bars shields the riverbed from excessive erosion and incision.

Shallow shoals of fresh sediment form along Bay-Delta rivers and sloughs by replacing sediment lost to wave action and tidal currents. The fresh sediment creates new substrate for tule marsh and sustains shallow-aquatic and tidal-mudflat habitats. Fine organic particles and suspended mineral sediment also provide essential nutrients (e.g., carbon, nitrogen, phosphorus, and iron) that support algae and phytoplankton at the base of the foodweb. High concentration of suspended sediment (high turbidity) limits growth of aquatic plants and algae by reducing sunlight penetration.

Constructed features and disturbance factors that eliminate, reduce, or alter the amount, distribution, and timing of natural sediment sources include:

- reservoirs behind medium and large dams that capture the sediment supply from the watershed;
- levees that prevent deposition of fine sediments in the floodplain alongside rivers and increase sediment scour and transport within the river channel by forcing deeper, more erosive floodflows;
- sand and gravel mining in channels and active lower floodplains of rivers and smaller tributaries that deplete the natural supply to downstream sites;
- bank protection and channelization that alters sediment transport, reduce natural bar and riffle formation, and prevent natural bank erosion and gravel and sediment releases to the river; and
- dam-regulated reduction of the magnitude and duration of average peak flows during winter and spring that reduce the ability of a river to transport bedload entering the river from tributary sources.

Sediment transport and deposition processes of the ecosystem have been significantly modified. Construction of the Sacramento River, San Joaquin River, and Delta levees and bypass systems in the early 20th century allowed Central Valley settlements and California agriculture to expand. The original levee system of the Sacramento River was built to bypass excessive floodflows, maintain sufficient channel depth for river navigation, and carry the heavy loads of sediments deposited into the Central Valley by hydraulic gold mining in the mountains and foothills.

The levees isolated rivers from their natural floodplains and separated the Bay-Delta from the extensive freshwater and saline emergent wetlands and secondary sloughs that became the agricultural "islands" we know today. River flows have sufficiently sluiced most of the sediment past the river floodplains and Delta and out to San Francisco Bay. Some of the sluiced sediment was deposited in deeper channels that now require dredging.

The natural supply of gravels and sediments entering the rivers and dams and reservoirs severely reduced streams. Construction of the State and federal dam system occurred between the 1930s (e.g., Shasta Dam) and 1970s (e.g., New Melones and New Don Pedro Dams). Although dams provide water supply and flood control benefits, they drastically reduced the natural sediment supply to Central Valley river floodplains and the Bay-Delta. Dams captured all the bedload and most of the finer sediment. Many smaller dams have filled to capacity with sediment.

The absence of sediment below dams and the confinement of rivers into narrow, leveed corridors triggered channel incision and bank erosion. Incision and erosion threatened the integrity of the levee system, leading to ongoing efforts to armor riverbanks and levees with rock riprap. Implementation of these actions further reduces the natural sediment supply of rivers.

Confining rivers and hardening banks removes the major remaining supply of gravel and sediment below dams. The lack of gravel and sediment inhibits bank erosion. Preventing or reducing bank erosion also reduces the establishment of instream woody cover (a component of shaded riverine aquatic cover) because the erosion required to topple trees into the channel no longer occurs.

The sediment deficit and high transport efficiency of the primary Delta channels, combined with wave-wash erosion, are causing the progressive disappearance of remnant tule and willow midchannel islands and shoals. These conditions prevent the replenishment of deposits that support mudflat, emergent wetlands, and willow scrub habitats. Lack of sediment and high velocities are also undermining the submerged toe of levees along Delta islands.

Immediately downstream of dams, where water temperature is often cool enough to support spawning fish populations, the release or uncontrolled spills of "clean, hungry" dam water removes the spawning gravels from the channel, armors the channelbed with more resilient (larger-sized) cobble and boulders, and erodes the fine sediment that would normally support riparian trees and shrubs along the banks. Scoured and armored river beds lack spawning habitat for salmon and steelhead forced to spawn and rear below dams that have cut them off from natural upstream habitats.

Further downstream, natural sediment and erosion patterns of the floodplain have been altered by river channelization. Only the Butte basin flood overflow area and the Sutter and Yolo bypasses support physical sedimentation processes that roughly approximate a natural floodplain. However, flood conveyance capacity, intensive farming in the bypasses, and flood easement restrictions do not allow the remnant floodplains to support natural habitats. Floodplain habitats such as emergent marsh, cottonwood-willow riparian forest, or valley oak woodland thrive in the fine-textured alluvial deposits. A few notable natural habitats do exist. These include Sutter National Wildlife Refuge, the new Yolo Basin Wildlife Management Area, and some large privately managed waterfowl habitats in the Butte basin.

Gravel mining in Central Valley river channels has also interrupted natural sediment supplies of the rivers. In-channel sand and gravel mining reduces downstream physical habitat and triggers incision of the channelbed both upstream and downstream. Large in-channel and low-floodplain pits are often excavated to a depth lower than the stream channel, such as occurs on the eastside tributaries of the San Joaquin River. These pits often "capture" the river. This creates additional ecosystem disturbances by trapping bedload gravel, causing the river alignment to suddenly shift, exposing outmigrating juvenile salmon and steelhead to increased predation, and stranding of outmigrating juvenile salmon and steelhead in isolated backwater ponds when the river recedes.

ISSUES AND OPPORTUNITIES

CHANNEL DYNAMICS, SEDIMENT TRANSPORT, AND RIPARIAN VEGETATION. There is growing recognition that dynamic river channels, free to overflow onto floodplains and migrate within a meander zone, provide the best riverine habitats. The dynamic processes of flow, sediment transport, channel erosion and deposition, periodic inundation of floodplains, establishment of riparian vegetation after floods, and ecological succession create and maintain the natural channel and bank conditions favorable to salmon and other important species. These processes also provide important inputs of food and submerged woody substrates to the channel. The most sustainable approach to restoring freshwater aquatic and riparian habitats is by restoring dynamic channel processes; however, restoration of natural channel processes is now hampered by the presence of levees and bank protection along many miles of rivers. Below reservoirs, the reductions in high flows, natural seasonal flow variability, and supply of sand and gravel have further exacerbated the constraining effect on rivers with levees and rock banks. It is therefore a priority to identify which parts of the system still have (or can have) adequate flows to inundate floodplains and sufficient energy to erode and deposit, and to identify floodplain and meander zone areas for acquisition or easements to permit natural flooding and channel migration. Sediment deficits from in-channel gravel mining should also be identified and the feasibility or efficacy of augmenting the supply of sand and gravel in reaches below dams should be evaluated.

OPPORTUNITIES: Mimic natural flows of sediment and large woody debris. Dams disrupt the continuity of sediment and organic-debris transport through rivers, with consequent loss of habitat, and commonly, river incision, downstream. In some cases, such as Englebright Dam on the Yuba River, the feasibility of dam removal should be evaluated as a sustainable solution to reestablishing continuity of sediment and debris transport, as well providing access to important spawning and rearing areas. Most dams, however, cannot be removed, so methods must be sought to reestablish continuity of sediment and wood transport with the dam in place. Coarse sediment can be artificially added below dams to at least partially mitigate for sediment trapping by the dam and ameliorate the impacts of sediment-starved flows. This approach has been successfully used in Europe, using sediment from natural (landslide) and artificial sources (injected from barges).On the River Rhine, enough gravel and sand are added below the lowest dam to satisfy the present sediment transport capacity of the Rhine to prevent further incision of the bed (an average of over 200,000 cubic yards annually).On the Sacramento River, gravels have been added at a rate much below the river's transport capacity so they are vulnerable to washout at high flows. A more sustainable approach would be to add gravel (and sand) on a regular basis and at a much larger scale to better mimic natural sediment loads and therefore provide the sediment from which the river would naturally create and maintain spawning riffles. This latter approach requires a large commitment of resources and should be undertaken only in rivers where other factors (e.g., temperature regime) are favorable (or can be made favorable) for recovery of species (such as the upper Sacramento). Such opportunities will be more economical where sources of dredger tailings or reservoir Delta deposits are available nearby.

While recognizing the navigation and flood safety issues associated with large woody debris in rivers, the importance of this debris to the foodweb and structural habitat for fish should not be overlooked. There is an opportunity to investigate ways by which to pass debris safely through dams and bridges. This may require replacing some existing bridges with those less prone to trapping woody debris.

Identify and conserve remaining unregulated rivers and streams and take actions to restore natural processes of sediment and large woody debris flux, overbank flooding, and unimpaired channel migration. Most rivers in the Central Valley are regulated by large reservoirs and therefore require considerable investment to recreate the natural processes needed to sustain true ecosystem restoration; however, a few large unregulated rivers still exist, such as the Cosumnes River and Cottonwood Creek. Lowland alluvial rivers and streams with relatively intact natural hydrology should be identified and made a high priority for acquisition of conservation and flooding easements, setting back of levees, and other restoration actions because such actions on these rivers are likely to yield high returns in restoration of natural processes and habitats and, ultimately, fish populations.

Undertake fluviogeomorphic-ecological studies of each river before making large investments in restoration projects. River ecosystem health depends not only on the flow of water, but on the flow of sediment, nutrients, and coarse woody debris and on interactions between channels and riparian vegetation, variability in flow regime, and dynamic channel changes. It is only through interdisciplinary, watershed, and historical scale studies that the constraints and opportunities particular to each river can be understood. For example, it was only after a fluviogeomorphic study of Deer Creek that the impact of flood control actions on aquatic and riparian habitat was recognized, a recognition that has lead to a proposal for an alternative flood management approach designed to permit natural river processes to restore habitats along Lower Deer Creek.

VISION

The vision for coarse sediment supply is to provide a sustained supply of alluvial sediments that are transported by rivers and streams and distributed to riverine bed deposits, floodplains, channel bars, riffles, shallow shoals, and mudflats, throughout the Sacramento-San Joaquin Valley, Delta, and Bay regions to contribute to habitat structure, function, and foodweb production throughout the ecosystem.

Where supplies are adequate they should be protected. Where inadequate, natural supplies should be restored where possible. Where supplies cannot be restored naturally, a feasibility analysis of artificially maintaining sediment supplies will be conducted.

In specific cases natural sediment supply can be restored by removing barriers to sediment transport. Common barriers to sediment transport in Central Valley rivers are diversion dams (e.g., Daguerre Dam on the Yuba River). In some tributary streams, small dams that no longer serve a purpose can be modified, or possibly decommissioned and removed. Dam removal allows a larger fraction of gravel to pass downstream.

Studies will be conducted to determine whether smaller reservoirs could be modified or re-operated to allow some sediment from upstream sources to pass through to the dam outlet. Sediment deposits in the upper ends of reservoirs are potential sources of sediments for introductions below dams.

In some river reaches, bank armoring could be reduced or avoided by creating unimpeded channel meander corridors using special conservation zones (e.g., erosion easements), landowner incentive programs, and strategic levee setbacks where feasible. A natural river meandering process provides much of the sediment needed to sustain the ecological health of alluvial rivers.

Where channel hardening occurs downstream of major dams, sediments stored in armored banks, bars, and upper terraces can be moved into the active streambed to replace natural sediments blocked by the dams. Where bank and floodplain deposits along rivers below dams have become inactive from controlled flows, additional sediment can be recruited by restoring episodic floodflows. These floodflows must be of sufficient duration and magnitude (e.g., peak flows that occur every 1.5 to 2 years) to mobilize channelbed, bank, and bar sediments. This strategy would apply only to river systems that have an excess of stored channel deposits because of limited flood duration and magnitude below the dam. Such actions would be coordinated with project operations and aquatic species life-cycle requirements.

Wherever possible, the future sediment supply from the remaining nondammed tributaries should be declared a protected ecological resource of the river and Bay-Delta ecosystem. (Cottonwood Creek is a prime example of a nondammed tributary of the Sacramento River that contributes a significant proportion of the present natural sediment supply to the river). Effects on sediment supplies will be considered in evaluating potential new water supply and flood storage facilities as part of the Bay-Delta solution.

Further natural sediment supplies can be restored by expanding river access to historical floodplains during high flows. Floodplains provide fine particulate organic matter and small food particles. These particles will reenter the Delta and main rivers from overland flows that pass over and through crop stubble, grasslands, and riparian woodlands.

Levee setbacks, partial historical floodplain restoration (e.g., breaching diked tidelands) and selected Delta island levee removal strategies would provide new sources of sediment to the Central Valley floodplain. These measures, combined with increased channel roughness from marsh and riparian restoration projects, will increase the sediment-trapping efficiency of the Delta in sloughs and channels that are not essential for commercial ship and barge navigation.

Increasing the extent of the high-water floodplain of the Delta will reduce the potential for channel erosion, thereby reducing the rate of sediment loss from midchannel tule islands and shallow shoals. Larger floodplain areas along rivers would allow additional riparian vegetation to grow along the river floodways and would enhance the formation of bank and bar deposit habitats.

Appropriate reaches of the Sacramento, San Joaquin, Merced, Mokelumne, Cosumnes, Feather, and Yuba rivers and other suitable streams, such as Cottonwood and Cache creeks, will be evaluated and, where feasible, designated for eligibility as river erosion and deposition zones, or "meander belts." Meander belts will provide an area where natural erosion and sedimentation processes can occur unimpeded (within reasonable limits) to sustain a diversity of sediment-driven habitats.

In these meander belt conservation zones, some types of agricultural production could continue. Older alluvial floodplains, unlikely to be within the eroding pathway of the river within the next 20-50 years, are ideal farming lands. Farmed areas within the estimated 20-year riverbank migration corridor could be targeted for special erosion and river floodplain easements and incentive programs. Orchardists could be compensated for loss of fruit and nut trees caused by natural bank erosion, or for permanent acquisition as river floodplain conservation areas.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Protection and enhancement of sediment supplies in the rivers and Delta will involve coordination with other programs including:

- the Upper Sacramento River Fisheries and Riparian Habitat Council's efforts under the SB 1086 Program to preserve remaining riparian habitat and reestablish a continuous riparian ecosystem along the Sacramento River between Redding and Colusa,
- river corridor management plans,
- the U.S. Army Corps of Engineers Sacramento River Flood Control and Bank Protection Projects,
- San Joaquin River Riparian Habitat Restoration Program to develop and implement a plan for restoration of a continuous riparian corridor,
- gravel mine reclamation programs being initiated under the Surface Mining and Reclamation Act by the California Department of Conservation,
- the Anadromous Fish Restoration Program's gravel replenishment program (CVPIA Subsection 3406 b13),
- small dam removal and fish ladder rehabilitation projects, and
- local bank protection and levee construction projects.

LINKAGE TO MULTI-SPECIES CONSERVATION STRATEGY

After decades of cumulative impacts, the majority of Central Valley rivers have been transformed from dynamic alluvial systems capable of forming their own stream beds and bank configurations to fossilized systems confined between berms, dikes, and levees or fossilized as a result of vegetation that has encroached into the low flow channel. The loss of coarse sediments captured behind the large dams has reduced or eliminated an essential ecological ingredient required for the creation of alternate bar features and in-stream and floodplain habitat structure. This, when combined with the significant reduction in natural stream flow patterns, especially high flows, has prevented regenerative fluvial processes from promoting river recovery. Not only are the components necessary for healthy river ecosystems no longer available (sediment supplies), the natural processes are impaired or lacking (high flow regimes).

The interdependence of stream hydrology, fluvial geomorphology, coarse sediments and riparian habitats is of great relevance to protection and restoration of MSCS evaluated species. Virtually all aquatic species and many riparian species are dependent on habitats created, formed, or maintained by streamflow transport of coarse and fine sediments for nursery, foraging, resting, or reproductive areas.

The basis of the ERP, and the key to the recovery of MSCS evaluated species, is the restoration of natural ecological processes. In highly altered or developed hydrologic units, understanding the role of altered streamflow patterns and sediment availability and transport on existing habitats and species is critical to developing viable and effective restoration measures.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Maintenance of natural sediment supplies in the rivers, Delta, and San Francisco Bay is closely linked to the following:

- streamflow,
- floodplain processes,
- stream meander processes,
- riparian, wetland, and aquatic habitats,

and many stressors including:

- dams,
- levees,
- bank protection,
- dredging, and
- gravel and sand mining in the floodplain.

OBJECTIVES, TARGETS, ACTIONS, AND MEASURES

Two Strategic Objective apply to coarse sediment supply.

> The first objective for coarse sediment supply is to restore coarse sediment supplies to sediment-starved rivers downstream of reservoirs to support the restoration and maintenance of functional natural riverine habitats.

LONG-TERM OBJECTIVE: Implement a comprehensive sediment management plan for the Bay-Delta system that will minimize problems of reservoir sedimentation and sediment starvation, shift aggregate extraction from rivers to alternate sources, and restore continuity of sediment transport through the system to the extent feasible.

SHORT-TERM OBJECTIVE: Develop methods and procedures to end gravel deficits below dams and mining operations; prioritize for correcting existing streams with major deficit problems and initiate action on at least 10 streams.

RATIONALE: One of the major negative effects of dams is the capture of coarse sediments that naturally would pass on to downstream areas. As a result, the downstream reaches can become sediment starved, producing "armoring" of streambeds in many (but not all) rivers to the point where they provide greatly reduced habitat for fish and aquatic organisms and are largely unsuitable for spawning salmon and other anadromous fish.

This objective can be accomplished by a wide variety of means, but most obviously through artificial importation of gravel and sand. Other possible actions include: (1) explore the feasibility of passing sediment through small reservoirs; (2) remove nonessential or low-value dams; (3) eliminate instream gravel mining on channels downstream of reservoirs, and limit extraction on unregulated channels to 50% of estimated bedload supply or less (or to levels determined not to negatively impact fish and other ecological resources); (4) develop incentives to discourage mining of gravel from river channels and adjacent floodplain sites; and (5) develop programs for comprehensive sediment management in each watershed, accounting for sediment trapped by reservoirs, availability of sediment from tributaries down stream of reservoirs, loss of reservoir capacity, release of sediment-starved water downstream, channel incision and related effects, and the need for sources of construction aggregate.

STAGE 1 EXPECTATIONS: Sediment-starved channels in the Bay-Delta system will have been identified; strategies to mitigate sediment starvation, such as shifting mining of gravel from river channels to alternate sources, adding gravel below dams, and removing nonessential dams will have been developed; demonstration projects will have been implemented (and monitored) to mitigate sediment starvation in at least six rivers.

> The second Strategic Objective for coarse sediment supply is to establish hydrologic regimes in streams, including sufficient flow timing, magnitude, duration, and high flow frequency, to maintain channel and sediment conditions supporting the recovery and restoration of native aquatic and riparian species and biotic communities.

LONG-TERM OBJECTIVE: For regulated rivers in the region, establish scientifically based high-flow events necessary to maintain dynamic channel processes, channel complexity, bed sediment quality, and natural riparian habitats where feasible.

SHORT-TERM OBJECTIVE: Through management of the reservoir pool or deliberate reservoir releases, provide a series of experimental high-flow events in regulated rivers to observe flow effects on bed mobility, bed sediment quality, channel migration, invertebrate assemblages, fish abundance, and riparian habitats over a period of years. Use the findings of these studies to reestablish natural stream processes where feasible, including restoration of periodic inundation of remaining undeveloped floodplains.

RATIONALE: Native aquatic and riparian organisms in the Central Valley evolved under a flow regime with pronounced seasonal and year-to-year variability. Frequent (annual or longer term) high flows mobilized gravel beds, drove channel migration, inundated floodplains, maintained sediment quality for native fishes and invertebrates, and maintained complex channel and floodplain habitats. By deliberately releasing such flows from reservoirs, at least some of these physical and ecological functions can probably be recreated. A program of such high-flow releases, in conjunction with natural high-flow events, lends itself well to adaptive management because the flows can easily be adjusted to the level needed to achieve specific objectives. However, it should be recognized that channel adjustments may lag behind hydrologic changes by years or decades, requiring long-term monitoring. Also, on most rivers, reservoirs are not large enough to eliminate extremely large, infrequent events so these will continue to affect channel form at irregular, often long, intervals; artificial high-flow events may be needed to maintain desirable channel configurations created during the natural events. This objective is similar to the previous one but differs in its focus on flows that are likely to be higher than those needed to maintain most native fish species but that are important for maintaining in-channel and riparian habitats for fish as well as other species (e.g., invertebrates, birds, mammals). Experimental flow releases also will have to be carefully monitored for negative effects, such as encouraging the invasion of unwanted non-native species.

STAGE 1 EXPECTATIONS: Studies should be conducted on five to 10 regulated rivers in the Central Valley to determine the effects of high-flow releases. Natural floodplains should be identified that can be inundated with minimal disruption of human activity. Where positive benefits are shown, flow recommendations should be developed and instituted where feasible.

RESTORATION ACTIONS

The general targets are to conserve and augment the natural sediment supply by increasing the availability of upstream sediment sources on select streams, increasing the availability of sediment stored in banks and riverside floodplains, increasing the extent of natural stream bank erosion and channel migration, increasing the transport of sediment to the Delta and to spawning reaches of streams, increasing the deposition and stability of sediment within the Delta, and increasing the extent and distribution of shallow water habitats and tule-willow islands in the Delta.

In most cases the supply necessary to sustain functions and habitats for specific watersheds is not known. Preliminary targets for cubic yards of gravel needed below dams have been prescribed for selected rivers.

The following general approach includes actions that will sustain existing natural sediment sources and restore natural sources that no longer contribute to the sediment supply of rivers and the Delta.

- Protect existing natural sediment sources in river floodplains from disturbances such as bank protection, gravel mining, levees, dams, changes in streamflow, and changes to natural stream meanders.
- Artificially maintain sediment supplies below dams that block natural sediments in rivers.
- Increase the availability of sediment stored in banks and riverside floodplains by removing bank protection.
- Enhance and restore natural stream bank erosion and stream meander processes.

MSCS CONSERVATION MEASURES

The following conservation measures are included in the Multi-Species Conservation Strategy (2000) which provide additional detail to ERP actions that would help achieve species habitat or population goals. Although the measures were developed specifically for evaluated species, some measures have direct relationships to the manner in which coarse sediment supplies influence habitat quality or have adverse effects on evaluated species.

- Initial species recovery efforts should be directed to locations where there are immediate opportunities for protection, enhancement, and restoration of suitable habitats.
- Protect the Sacramento and San Joaquin river and tributary channels from physical disturbance (e.g., sand and gravel mining, diking, dredging, and levee or bank protection and maintenance) and flow disruptions (e.g., water diversion that result in entrainment and inchannel barriers or tidal gates) for the period February 1 to August 31.
- Implement management measures identified in the proposed recovery plan for the Sacramento River winter-run chinook salmon (National Marine Fisheries Service 1997).
- Implement applicable management measures identified in the restoration plan for the Anadromous Fish Restoration Program (U.S. Fish and Wildlife Service 1997) and the recovery plan for native fishes of the Sacramento-San Joaquin Delta (U.S. Fish and Wildlife Service 1996).
- Coordinate protection, enhancement, and restoration of occupied and historic habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, the Anadromous Fish Restoration Program, and USFWS recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Modify conservation measures according to the adaptive management process as more understanding is developed of recovery needs.
- Maintain processes that support the dynamic habitat distributed throughout the species range and associated with existing populations (species this measure addresses occur on eroding margins of levees).

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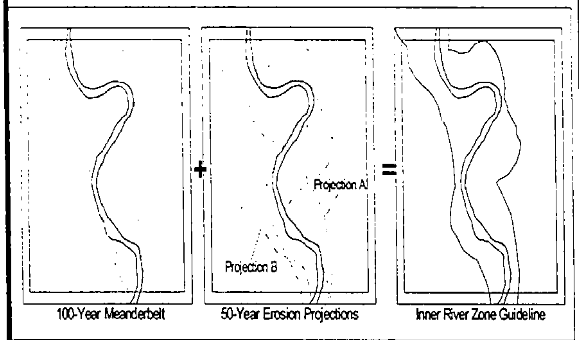

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INTRODUCTION

Stream meander is a dynamic natural process, and is also a term used to describe the shape of the river as a sinuous or bending wave form. Rivers with active stream channel meander zones generally support a greater diversity of aquatic and terrestrial habitats and biotic communities.

Major factors that limit natural stream channel migration include levees, bank riprap, channelization, upstream sediment loss from dams and levees, instream gravel mining, vegetation removal for increased floodway capacity or for reclamation of the river floodplain for agricultural uses and the storage of water, and release pattern from State Water Project, Central Valley Project, and other large water development projects within the Central Valley.

Approaches to restoring more natural stream meander corridors include conserving existing river migration zones, expanding stream meander corridors, conserving upstream and bank sediment supplies, and incorporating simulated flood peaks into dam water release schedules during wet years.

RESOURCE DESCRIPTION

The width and habitat patch size of riparian forest on meandering streams tend to be large and connected. In dynamic systems, riparian forests are always being replenished by new territory colonized by cottonwood and willow trees on recently formed point bars and floodplain deposits.

The flow velocity in meandering streams varies greatly, causing sediment and organic debris to be sorted into different sizes at different locations within the channel along a velocity gradient. Other habitat benefits from meandering streams include formation of oxbows, sloughs, and side channels that create a highly productive interaction between aquatic and terrestrial communities (e.g., canopy shading and leaf and insect drop over the riverine aquatic bed). Therefore, many species of fish, amphibians, and insects can find suitable habitat in stream meander landscapes.

Rivers that flow through their own valley alluvium (i.e., gravel, sand, and silt deposited earlier in time) have the potential to shift position. Rivers shift position when banks erode and sediment is deposited. Bank erosion and sediment deposition, form bars that block or redirect river flow. The bars also stimulate additional erosion as the river channel migrates away from the bar.

The following characteristics of a river increase the probability that it will change course during winter/spring flows:

- high average sediment or bedload source, erodible bank and bed deposits (e.g., sand and gravel),
- potential for extreme flood peaks, and
- a low density of mature vegetation along the channel.

Meandering streams typically support a wider corridor of natural habitats than channelized rivers. River flora and fauna are adapted to the changing, unstable nature of alluvial streams. Many riparian plants tolerate their stems being buried by deposits of river sediment and disperse seeds by wind and water to locations where new bars have formed. Meandering streams typically form the pool-riffle sequence that supports a range of fish habitats. The leading edge of the eroding side of the bend generates new sediment and gravel from the bank and topples riparian trees into the channel. These processes create high-quality aquatic cover and provide food and substrate for aquatic insects on which fish feed. Sediment lost at the eroding bank is transported downstream and redeposited on point bars. This process initiates the habitat colonization and bank renewal process. When pronounced bends are formed, an unimpeded river will eventually cut off the bend by eroding a "shortcut" across the inside bend during high flows. Through this process, backwater swales and oxbow lakes are formed, providing important juvenile fish rearing areas and sources of foodweb production.

Rivers with armored banks (rock riprap) or naturally stable stream channels are more likely to have urban or agricultural land use encroachment into the riparian floodplain and forest. This encroachment often leaves room for only a narrow band of trees or shrubs along the bank and results in low habitat quality for fish and wildlife. Alluvial rivers with artificially hardened banks and static channels suffer a general loss of diversity and quality at the interface of aquatic and terrestrial habitats. Unfortunately, making rivers more predictable has led to a decline in river ecosystem quality because the species and habitats that evolved on rivers are dependent on the changing, natural disturbance cycles of meandering streams.

All Central Valley streams have been affected by stressors that diminish stream meandering and associated aquatic and riparian habitats. However, significant reaches of several large rivers still support full or partial characteristics of a dynamic stream meander pattern. The best example in California is the Sacramento River between Red Bluff and Butte City. Other important examples include the San Joaquin River (from Mossdale to Merced River); the Merced, Tuolumne, Cosumnes, Feather, and Yuba rivers; and Cottonwood, Stony, and Cache creeks.

Natural meander belts tend to be the least impaired where there are no major levees or where levees are set back several hundred feet from the main channel bank; on rivers that have high flow stage during frequent flood peaks, thereby discouraging land conversion to urban or agricultural uses; and on rivers with floodplain soils that are not conducive to high-yield crops or orchards (e.g., saline hardpan soils along the lower San Joaquin River or gravelly, barren floodplains along the Yuba River).

To support a natural, dynamic stream meander system, the following important characteristics are needed, and identified stressors must be overcome or compensated for:

- A supply of gravel and sediment that matches the net transport and displacement of channel sediment and bedload. Dams interfere with the natural sediment supply from upstream, while levees, instream gravel mining, and bank protection projects deplete channel and floodplain sediment supplies. Most of the major tributaries of the Sacramento and San Joaquin rivers have large dams above an elevation of 300 feet. Most of the length of these rivers in the valley floor are being mined or have been mined for gravel, and all are confined by leveed and incised channels along substantial portions upstream of the Delta.
- A series of periodic flood peaks of sufficient magnitude and duration to remobilize and rearrange gravel and cobble deposits, transport sand and fine sediment to form new or expanded point bars, and erode banks or low bars on outside bends. Dam releases typically tame flows or eliminate flood peaks in dry or normal years. Tamed flows reduce bedload transport capacity while increasing base flows during summer. Channelization and levee confinement cause high flows to become deeper to compensate for less floodplain width, resulting in artificially increased sediment transport capacity. This reduced capacity prevents sediment capture in the off-channel floodplains and removes sediment from shallow shoal and bar deposits. The absence of frequent high-energy flows also prevents the scour of riparian vegetation, reducing the rate of natural sediment and cottonwood regeneration.
- Dense vegetation occupying the channelbanks and adjacent low floodplains to stabilize the river planform (i.e., modulate the annual rate of bank migration), reduce river flow velocities to cause new sediment to aggrade on bars, build topsoil in higher floodplains, and provide shade and instream woody cover to the aquatic zone. Narrow channels created by levees set too close to the low-flow shoreline separate the river from its floodplain and leave little room for riparian vegetation. Bank protection eliminates or

reduces vegetation on outside bends. Channel hardening discourages both erosion and point bar formation, resulting in a static, similarly-aged stand of riparian forest and a narrowing or discontinuity of the riparian cover. Artificially narrowed channels may require periodic vegetation removal to maintain minimum floodflow capacity and are more likely to require expensive bank riprap to protect the vulnerable levees during high flows.

- Adequate floodplain width to absorb and pass out-of-bank flows (i.e., the natural flood stage), capture fine sediments, store and filter woody debris, and, most importantly, make room for the progressive meander migration of the river channel within its floodplain. Loss of river floodplain functions has converted dynamic riverine ecosystems to static conveyance facilities for the transport of irrigation and drinking water and floodflow management. Urban encroachment in floodplains and meander belts usually follows river confinement and bank hardening.
- Development of innovative means to meet local or riparian water supplies without the need to install bank protection for diversion points. Creation of these hard points to protect diversions also impairs natural stream migration. In general, diversions situated within designated stream meander zones should be modular and designed to be removable to accommodate stream meander.

In general, the loss of river meander potential and functions in the Central Valley has resulted in more sterile river ecosystems upstream of the Delta, supports less habitat for anadromous and resident fish, and provides fewer nutrients and food to the Delta.

ISSUES AND OPPORTUNITIES

CHANNEL DYNAMICS, SEDIMENT TRANSPORT, AND RIPARIAN VEGETATION: There is growing recognition that dynamic river channels, free to overflow onto floodplains and migrate within a meander zone, provide the best riverine habitats. The dynamic processes of flow, sediment transport, channel erosion and deposition, periodic inundation of floodplains, establishment of riparian vegetation after floods, and ecological succession create and maintain the natural channel and bank conditions favorable to salmon and other important species. These processes also provide important sources of food and submerged woody substrates to the channel. The most sustainable approach to restoring freshwater aquatic and riparian habitats is by restoring dynamic channel processes; however, restoration of natural channel processes is now hampered by the presence of levees and bank protection along many miles of rivers. Below reservoirs, the reductions in high flows, natural seasonal flow variability, and supply of sand and gravel have further exacerbated the constraining effect on rivers with levees and rock banks. It is therefore a priority to identify which parts of the system still have (or can have) adequate flows to inundate floodplains and sufficient energy to erode and deposit, and to identify floodplain and meander zone areas for acquisition or easements to permit natural flooding and channel migration. Sediment deficits from in-channel gravel mining should also be identified and the feasibility or efficacy of augmenting the supply of sand and gravel in reaches below dams should be evaluated.

OPPORTUNITIES: Identify and conserve remaining unregulated rivers and streams and take actions to restore natural processes of sediment and large woody debris flux, overbank flooding, and unimpaired channel migration. Most rivers in the Central Valley are regulated by large reservoirs and therefore require considerable investment to recreate the natural processes needed to sustain true ecosystem restoration; however, a few large unregulated rivers still exist, such as the Cosumnes River and Cottonwood Creek. Lowland alluvial rivers and streams with relatively intact natural hydrology should be identified and made a high priority for acquisition of conservation and flooding easements, setting back of levees, and other restoration actions because such actions on these rivers are likely to yield high returns in restoration of natural processes and habitats and, ultimately, fish populations.

Undertake fluviogeomorphic-ecological studies of each river before making large investments in restoration projects. River ecosystem health depends not only on the flow of water, but on the flow of sediment, nutrients, and coarse woody debris and on interactions between channels and riparian vegetation, variability in flow regime, and dynamic channel changes. It is only through interdisciplinary, watershed, and historical scale studies that the constraints and opportunities particular to each river can be understood. For example, it was only after a fluviogeomorphic study of Deer Creek that the impact of flood control actions on aquatic and riparian habitat was recognized, a recognition that has lead to a proposal for an alternative flood management approach designed to permit natural river processes to restore habitats along Lower Deer Creek.

VISION

The vision for stream meander is to conserve and reestablish areas of active stream meander, where feasible, by implementing stream conservation programs, setting levees back, and reestablishing natural sediment supply to restore riverine and floodplain habitats for fish, wildlife, and plant communities.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Ecosystem Restoration Program Plan (ERPP) efforts may involve cooperation with other programs and organizations. These include:

- Upper Sacramento River Fisheries and Riparian Habitat Advisory Council (SB 1086) group efforts and river corridor management plans implemented for the Sacramento River (Resources Agency 1989);
- U.S. Army Corps of Engineers' proposed reevaluation of the Sacramento River Flood Control Project and ongoing Bank Protection Project, including more comprehensive floodplain management and river ecosystem restoration opportunities;
- Proposed riparian habitat restoration and floodplain management studies for the San Joaquin River, including potential new flood bypass systems and expanded river floodplains on lands recently acquired by the California Department of Parks and Recreation and U.S. Fish and Wildlife Service (USFWS);
- Anadromous Fish Restoration Program gravel replenishment programs and plans and small dam removal and/or fish ladder rehabilitation projects;
- The Nature Conservancy's ongoing Sacramento Valley conservation planning; expansion plans being made for the Sacramento River National Wildlife Refuge (USFWS) and California Department of Fish and Game's Sacramento River Wildlife Management Area;
- The Cosumnes River Preserve which is a joint project of The Nature Conservancy, Department of Interior, Department of Water Resources, Department of Fish and Game, Wildlife Conservation Board, and others.
- Plans for the San Joaquin River Parkway; plans being put into effect for all county-sponsored instream mining and reclamation ordinances and river and stream management plans; and reclamation planning assistance programs being initiated under the Surface Mining and Reclamation Act by the California Department of Conservation.
- The Riparian Habitat Joint Venture which promotes the coordinated development of riparian restoration plans with the primary purpose of conserving migrant land birds.

LINKAGE TO MULTI-SPECIES CONSERVATION STRATEGY

Stream meander is a dynamic ecological process that typifies a healthy river corridor or riverine ecosystem. A river-based ecosystem in the Central Valley extends laterally over its entire floodplain and longitudinally from its headwaters to the Delta or Bay. It may even extend beyond to hydrologically connected aquifers (California State Land Commission 1993). This view of stream meander as an essential component of a living river system is critical to the protection and restoration of aquatic, riparian, and terrestrial species addressed by the Multi-Species Conservation Strategy (2000).

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Health stream meander corridors are dependent on the following ecological processes:

- Central Valley streamflows,
- Natural sediment supplies, and
- Natural floodplains and flood processes.

Habitat supported by healthy stream meander corridors are primarily related to riparian and riverine aquatic habitats, freshwater fish habitats, and essential fish habitats (for chinook salmon).

Many fish, wildlife, plant species, and plant communities are dependent on the riparian zone associated with stream meander corridors.

Stressors that impair the health of stream meander corridors include:

- Dams, reservoirs, weirs, and other human-made structures;
- Levees, bridges, and bank protection;
- Gravel mining;
- Invasive riparian plants; and
- Wildfires in the riparian zone.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

The Strategic Objective is to increase the extent of freely meandering reaches and other pre-1850 river channel forms to support the restoration and maintenance of functional natural riverine, riparian, and floodplain habitats.

LONG-TERM OBJECTIVE: Reestablish active meander belts on all formerly meandering alluvial reaches in the Central Valley except those densely urbanized or with infrastructure whose relocation would have a high cost-to-benefit ratio.

SHORT-TERM OBJECTIVES: Inventory (at 1:1,200 scale or better) along all major river reaches bank conditions and land uses on adjacent floodplains. Prioritize for acquisition land or easements in rural areas with high potential for urbanization, especially around meander bends. Begin an acquisition program.

RATIONALE: Freely meandering rivers have the highest riparian and aquatic habitat diversity of all riverine systems. Through the process of meandering, eroding concave banks and building convex banks, the channel creates and maintains a diversity of surfaces that support a diversity of habitats, from pioneer riparian plants on newly deposited point bars to gallery riparian forest on high banks built of overbank silt deposits. Similarly, wandering or braided rivers support distinct habitat types and thus are beneficial to aquatic biota. Floodplain restoration can also increase flood protection for urban areas and increase the reliability of stored water supplies in reservoirs (because reservoirs can be maintained at higher levels because of reduced need to catch floodwaters).

STAGE 1 EXPECTATIONS: Plans for meander belts will have been developed for all major river corridors and priorities for land acquisition and easements established. Development of a meander belt will have begun on at least one river.

RESTORATION ACTIONS

The general targets and actions which will contribute to restoring healthy stream meander corridors include the following.

EXISTING RIVER MIGRATION ZONES

Appropriate reaches of the Sacramento and San Joaquin rivers and their major alluvial tributaries will be evaluated. Suitable portions will be designated as important river migration and floodplain deposition zones, or "meander belts." In these zones, natural erosion and sedimentation processes occur or could potentially occur unimpeded (within reasonable limits), sustaining a diversity of sediment-driven habitats.

These river reaches and potential meander zones will be eligible for river conservation programs and appropriate landowner incentives once they have been evaluated and ranked according to ecological process and function characteristics. Remaining Central Valley stream reaches where natural meander processes occur will be mapped and ranked according to the level of meander-system functions, the quality of dependent habitats, and the contribution to Delta species and important physical processes.

STREAM MEANDER CORRIDORS

Levees and floodplains along rivers of the Sacramento and San Joaquin valleys will be evaluated to determine if some levees can be set back to create new meander corridors or nodes of expanded floodplains and wider riparian forest. This approach also benefits flood safety and reduces flood protection maintenance costs by repositioning levees outside the primary bank migration pathway of alluvial streams, reducing the need for expensive rock riprap, and reducing the potential for levee breaches. Enlarging inadequate floodplains will increase the volume of safe floodflow, while allowing additional riparian vegetation within the channel to close gaps in the forest canopy. Riparian vegetation will tend naturally to recolonize stream meanders in areas where the channel is widened because point bar development and sediment capture will be enhanced. Vegetation removal practices, required in confined channels, are reduced with levee setbacks. The Sacramento River between Chico Landing and Colusa is an example of a partial levee setback that benefits both flood safety and habitat quality while reducing levee and channel maintenance costs.

In other areas, land use changes and land management costs in floodplains outside existing levees may no longer justify continual levee upkeep and future bank protection costs. These areas present additional potential for expanded river meander zones. Levees could be removed, breached in key locations, or allowed gradually to erode from river migration processes. An example is the floodplain of the lower San Joaquin River near Los Banos, where former livestock pasture has been acquired for wildlife management as part of the San Luis National Wildlife Refuge. Other examples are north Delta islands, where land subsidence and frequent levee failures have diminished the value of farmed lands.

UPSTREAM AND BANK SEDIMENT SUPPLY

The first step in restoring upstream and bank sediment supply is to identify and rank the sediment contribution of remaining non-dammed tributaries of alluvial rivers. These tributaries help support the dynamic equilibrium of meandering stream corridors and spawning gravel areas. River reaches where bank and floodplain gravels and sediment deposits are, or could reasonably be made, available to meandering rivers through natural erosion processes must also be identified. A variety of approaches will be needed to ensure that these remaining river sediment supply sources are conserved.

The potential ecosystem benefits of county mining ordinances which incorporate incentives and policies that promote replacing instream gravel mines with off-channel mines in high terrace deposits, abandoned dredger tailings, and reservoir delta deposits (deposits at the head of the impoundments) should be evaluated. The objective is to phase out instream gravel extraction that disrupts natural meander geomorphology and depletes annual sediment supply.

DAM RELEASE SCHEDULES DURING WET YEARS

The potential for modifying reservoir storage management during wet years will be investigated. Releases during wet years could simulate the seasonal pattern of natural, short-duration flood peaks. The magnitude and duration of major natural flood peaks cannot be restored in rivers below large reservoirs, but even short duration high flows can contribute significantly to the physical forces that support meander formation. This was demonstrated by the experimental flows released on the Colorado River below Glen Canyon Dam, which redistributed channel sediments from tributaries to create new fish habitat and substrate for riparian vegetation. Dam releases can be combined with non-regulated tributary inflow below the reservoirs to create flow spikes of sufficient magnitude to mobilize bed and bank sediments, clean spawning gravels, and form new river corridor landforms.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population goals. Although the measures were developed specifically for evaluated species, some measures have direct relationships to the manner in which stream meander influences habitat quality and quantity or have beneficial influences on evaluated species.

- Coordinate protection, enhancement, and restoration of channel meander belts and existing bank swallow colonies with other federal, state, and regional programs (e.g., the SB 1086 program, the Corp's Sacramento and San Joaquin Basin Comprehensive Study, the Anadromous Fish Restoration Program, and U.S. Fish and Wildlife Service recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Initial species recovery efforts should be directed to locations where there are immediate opportunities for protection, enhancement, or restoration of suitable habitat.
- Protect the Sacramento and San Joaquin river and tributary channels from physical disturbance (e.g., sand and gravel mining, diking, dredging, and levee or bank protection and maintenance) and flow disruptions (e.g., water diversion that result in entrainment and inchannel barriers or tidal gates) for the period February 1 to August 31.
- Implement management measures identified in the proposed recovery plan for the Sacramento River winter-run chinook salmon (National Marine Fisheries Service 1997).
- Implement applicable management measures identified in the restoration plan for the Anadromous Fish Restoration Program (U.S. Fish and Wildlife Service 1997) and the recovery plan for native fishes of the Sacramento-San Joaquin Delta (U.S. Fish and Wildlife Service 1996).
- Proposed ERP actions designed to protect or restore stream meander belts should initially be implemented along reaches of the Sacramento River and its tributaries that support nesting colonies of bank swallow or potential nesting habitat.
- Consistent with CALFED objectives, protect all known nesting bank swallow colonies from potential future changes in land use or activities that could adversely affect colonies.
- To the extent consistent with CALFED objectives, manage lands purchased or acquired under conservation easements to maintain or increase current population levels of resident evaluated species.

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◆ NATURAL FLOODPLAINS AND FLOOD PROCESSES

INTRODUCTION

Floodplains and flood processes provide important seasonal habitat for fish and wildlife, and provide sediment and nutrients to both the flooded lands and aquatic habitats of the rivers and Bay-Delta. Flooding also shapes the associated plant and animal communities. Major factors that reduce floodplain and flood processes contributions to the health of the Central Valley rivers and the Bay-Delta include construction of levees that constrict the floodplain, dams and reservoir operations that moderate flows, and activities that maintain flow capacity in major flood bypasses.

Before reclamation, Central Valley rivers and the Bay-Delta were comprised primarily of tidal and riverine floodplains in the form of vast tule islands, perennial grasslands, and riparian fringe corridors, intersected by permanent open water channels and secondary sloughs. Today only the primary open water channels remain, bordered by narrow, steep-sided floodplains sandwiched between the channel and the levee. Floodplains of the Bay-Delta provided a matrix for the interaction of secondary channel shorelines with tule marsh, riparian scrub, grasslands, and intertidal community types. Floodplains are essential to a balanced sediment budget by providing an area having lower velocity than the main channel, thereby capturing fine sediment and organic debris, and providing a more stable substrate for many vegetation types to flourish. During winter and spring flood events, floodplains provide important velocity refugia for resident and anadromous fish.

Floodplains reduce flood stages by slowing flow velocities, moderate channel incision and scour by providing a wide area for bank overflow, contribute to species diversity by creating the landforms that support different communities, contribute to the aquatic foodweb when overbank floodflows collect and transport organic matter from the floodplain back to channels and eventually the Bay-Delta estuary, provide low-velocity refuge for fish and other aquatic organisms during floods, and provide spawning habitat for fish species dependent on the Bay-Delta. Major factors that have disrupted floodplains and flood processes in the Delta and its tributaries include construction of levees that constrict the floodplain, dams and reservoir operations that moderate flow and block sediment, and activities that maintain flow capacity in major flood bypasses. Approaches to restoring more natural floodplains and flood processes include conserving existing natural floodplains and expanding confined floodplains.

RESOURCE DESCRIPTION

A natural floodplain is an important component of rivers and estuaries that allows many essential ecological functions to occur. Healthy floodplains are morphologically complex, including backwaters, wetlands, sloughs, and distributaries that carry ans store floodwater. Floodplain areas can constitute islands of biodiversity within semi-arid landscapes, especially during dry seasons and extended droughts. The term *floodplain* as used here means the generally flat area adjoining rivers and sloughs that is flooded by peak flows every 1.5-2 years and exceed the capacity of the channel ("bankfull discharge"). Peak flows in winter and spring that happen every 1.5-2 years are considered by river geomorphologists to be the "dominant discharge" that contributes the most to defining the shape and size of the channel and the distribution of sediment, bar, and bed materials. Larger flood events can cause major changes to occur, but they do not happen often enough to be the decisive factor in river geomorphology.

A more common use of the term *floodplain* refers to the 100-year floodplain as determined and mapped by the U.S. Army Corps of Engineers (Corps) and Federal Emergency Management Agency (FEMA). This definition is used to prepare land-use and flood-management plans.

Active floodplains provide many ecological benefits by:

- Slowing flow velocities
- Moderating channel incision and scour by providing area for bank overflow

- Contributing to species diversity by creating landforms that support different communities
- Contributing to the aquatic foodweb by collecting and transporting organic matter from the floodplain back to channels and eventually the Bay-Delta estuary
- Providing low-velocity refuge for fish and other aquatic organisms during floods
- Providing spawning habitat for fish species dependent on the Bay-Delta
- Providing habitats for wildlife such as shorebirds and dabbling ducks, and in high rainfall years, diving ducks.

One benefit of levees and flood control reservoirs is reducing the extent of and hazards within the 100-year floodplain and similar high-magnitude, low-probability storm events, as experienced in the January 1997 flood. The 100-year floodplain is related to a natural river floodplain but does not apply to the following discussion of ecosystem functions as supported by flood processes. A predicted 100-year floodplain covers a much larger area than a natural floodplain of a river, slough, or stream at bankfull discharge.

At higher flow, water spills out of the channel and flows over the flat-lying land near the river. River channels are not large enough to accommodate higher discharges without overflowing. This process of out-of-bank flow is a common but little recognized attribute of rivers and their floodplain.

Levees placed close to riverbanks have allowed human encroachment on river floodplains. Human encroachment on the floodplains of rivers accounts for the predominance of flood-related damage. Central Valley rivers that have little or no remaining natural floodplain, typically have the lowest ecological values and present the greatest risk of flood damage to adjacent lands. Large-scale reclamation and separation of low-lying land alongside rivers, streams, and estuaries have eliminated major habitat areas including riparian forests, marshes, and upper tidal zones.

On many tributaries, large reservoirs and diversions have also reduced the size of natural floodplains. Reservoirs and diversions reduce the frequency and duration of bankfull discharge and restrict channel flow to the low-flow channel most of the time, including during the wet season. In this case, a stream no longer comes into contact with its floodplain except during high-magnitude, low-frequency flood events. These types of streams may experience channel straightening and incision. The reduction of flood frequency on the lower floodplain often encourages encroachment of agricultural land uses and even recreational development on the area that once supported diverse floodplain habitats.

Floodplains reduce flood stages in the Delta, rivers, and streams by increasing the cross-sectional area of the channel and slowing flow velocities. Under overbank flow conditions, the river merges with its floodplain, increasing the capacity of the river to move and temporarily store large volumes of storm flow. Slow-moving water covering large riverine floodplains and adjacent basins naturally detains the volume of floodwaters entering the Delta and leveed reaches of the lower Sacramento and San Joaquin Rivers. Temporary floodplain storage thereby reduces the peak stage of flood events in the Delta region and other sectors of the levee system, and gradually releases the storm water as flood waters recede. The prolonged inundation of floodplains, such as can be observed in the Yolo and Sutter Bypasses and Stone Lakes basin, is highly compatible with the natural flood tolerance of seasonal wetland and riparian vegetation and animal life.

Floodplains capture and store sediment, build soil, and reduce the need for dredging channels downstream and in the Delta. The overbank flow across a floodplain is wider and more shallow than in the channel. The flow often encounters more resistance from vegetation along the outer banks, which causes the river to lose energy in the floodplain areas and, in turn, causes sand and fine sediment to be deposited. Natural levee mounds parallel the channel banks are created by the deposited sediment. The sediment also builds soil to support forests and grasslands. Natural floodplains are thus able to capture and store enormous volumes of fine sediment spread over large areas, balancing the river's sediment budget and preventing the clogging of channels and estuaries downstream.

Floodplain overflow moderates channel incision and bank scour. The term *stream power* refers to the ability of riverflow to erode the bed and bank by the shear stress created by deep, high-velocity, turbulent water. Rivers and streams confined to a narrow channel by bedrock canyon walls or constructed levees have greater stream power than alluvial rivers with unconfined adjoining floodplains. Energy and flood volume diverted into the overbank floodplain regulate the stream power acting on the channelbed and banks and, in concert with the binding effect of shoreline vegetation, prevent channel instability. Stream meander moderates the rate of change. Although many rivers and streams tend to experience some bed incision during high winter flows, the floodplain overflow capacity moderates stage increases and channel velocities that would otherwise cause excessive channel incision and widespread loss of riparian vegetation and riverine bed habitats during major storm events. Wide floodplains also reduce the scour effects on levees and bridge piers during high flows.

Floodplains contribute to habitat, and therefore, species diversity. During bankfull discharge, a flow/energy gradient exists from the channelbanks to the outermost extent of the natural floodplain. The flow/energy gradient results in a corresponding gradient from larger to smaller particle deposition and greater to lesser frequency of inundation. Scour effects are also greatest nearest the channel banks. The build-up of natural levee mounds and ridges may trap floodwaters in shallow, marshy basins formed between the outermost high ground and the sediment ridge deposited alongside the channel. These physical processes combine to create highly variable vegetation community types and age classes over the floodplain surface. The variation in plant species and community structure provides a wide array of habitat types and interfaces, resulting in the notably high wildlife species diversity found in riverine and estuarine corridors.

Floodplains are a major source of nutrients and organic matter for the aquatic zone. Floodwater passing over flat-lying lands captures organic material, carbon and nutrient-rich soil particles, insects, and fallen trees. These materials are transported at high flow stage to backwater basins, estuaries, and secondary channels that may then return the organic "cargo" to the river and Delta aquatic zone. These organic components provide microhabitats, prey items, and nutrients that sustain zooplankton, aquatic invertebrates, and small fish in the rivers and Delta.

Organic debris and dislodged trees may be captured by the filtering effect of the floodplain during one year, forming debris piles as floodwaters recede, and then be resuspended or swept away by a subsequent inundation of the floodplain. Without a floodplain to cycle buoyant matter conveyed by rivers and streams at high flow, most of the organic matter generated would be flushed through the system without being fully used. By detaining floodwaters longer than in the main channels, floodplains increase the residence time of nutrients, phytoplankton, and zooplankton, which promotes greater energy use and higher productivity of the foodweb entering the Delta.

Floodplains provide safe haven and spawning areas for native Delta and valley fish species. Fish, especially juveniles, seek lower velocity refuge from turbid, turbulent floodflows in rivers and streams. Vegetated floodplains adjoining channels provide ideal velocity refuge and overhead and instream cover during high-flow events. Here, small juvenile salmon, steelhead, and resident native fish can avoid excessive predation and weather the inhospitable stormflows in the main channel. Some fish species important to the Delta, such as splittail, will disperse from the rivers and sloughs into shallow, vegetated floodplains to spawn. Splittail recruitment is highest during wet years when the floodplains of the Delta and rivers, such as the lower Yolo basin, are flooded for a long time. In some areas, or under specific hydrologic events, poor drainage from floodplain and flood overflow areas can pose a hazard to aquatic organisms, primarily adult and juvenile fish, by contributing to stranding. Reconnecting rivers to their floodplains will be accomplished in ways sensitive to this risk and provide measures to reduce or eliminate it.

Floodplain function is affected by a number of common and widespread stressors, including levees and dams. Levees restrict the width and extent of floodplains in rivers and the Bay-Delta. In some areas, levees are only slightly wider than the channel at low flow, such as along the Sacramento River downstream of Colusa. Restricted floodplains typically cause deeper flow and faster channel velocity during high stage. They also restrict the amount and width of allowable or potential riparian vegetation, and have a low ratio of shallow-water habitats to deep, open water. Channels in these areas typically have a trapezoidal section, rather than a more natural compound channel with low bank angles and one or more flat-lying floodplain surfaces. Under these conditions, channels typically have a high depth-to-width ratio which is inherently unstable during high flows that can remobilize deep layers of channel bed materials. The physical processes necessary to sustain floodplain habitats may be absent or diminished. Within the Delta and Suisun and San Pablo Bays, levees restrict the extent of tidal floodplains inundated by higher high tides and storm flow surges passing through Delta sloughs and rivers.

Narrow floodplains along streams limit natural floodplain vegetation. Along rivers and streams contained within levee systems, the width of the floodplain is restricted, and much of the remaining floodplain surface has been reclaimed for orchard and cropland. Floodplain narrowing and conversion to cropland provides less inundation of vegetated areas during normal high water events, thereby reducing the input of critical nutrients and organic materials that typically come from a natural wide floodplain, and limiting rearing and spawning habitat for native fish such as splittail. In other cases, riparian vegetation is removed from the floodplain to optimize flood conveyance capacity if it is assumed that the predicted 100-year flood or "design flow"event will exceed the capacity of the channel.

Dams and reservoir operations reduce the natural peaks of a typical flood flow pattern, thereby reducing inundation of the natural floodplain. Large reservoirs on most of the Sacramento and San Joaquin Rivers tributaries capture the 1.5- to 2-year bankfull discharge. Water releases from reservoirs limit the magnitude, frequency, and duration of higher channel-forming flows that would otherwise spread into the lower floodplain areas adjoining rivers. Reservoirs also capture most of the incoming fine sediment that is needed to build soil on the floodplain. The net effect is to convert rivers and streams below dams into much smaller versions of the original channel and floodplain.

Managed reservoir releases may not be sufficient to interact with the remaining patches of floodplain except during higher magnitude stormflows. This is especially true on rivers such as the American River, where there are no major nondammed tributaries downstream of Folsom and Nimbus Dams. Channel incision that often follows dam construction and associated loss of the natural sediment supply further exacerbates the shrinkage of the floodplain alongside the lowered channel.

Flood management programs and policies affecting the Sutter and Yolo Bypasses discourage vegetation in the floodplain. Although the Yolo and Sutter Bypasses provide some of the physical functions of natural flooding and floodplain benefits, the full ecological potential of the floodplain is not realized because of the artificially uniform grade and generally sterile, nonvegetated condition of most of the bypass system. As recently as 1960, there were still hundreds of acres of natural grassland and valley oak woodland in the bypass system, most of which have been removed to improve floodway conveyance and make way for more intensive cropping patterns.

ISSUES AND OPPORTUNITIES

FLOOD MANAGEMENT AS ECOSYSTEM TOOL: The current approach is to control floods using dams, levees, bypass channels, and channel clearing. This approach is maintenance intensive, and the underlying cause of much of the habitat decline in the Bay-Delta system since 1850. Not only has flood control directly affected ecological resources, but confining flows between closely spaced levees also concentrates flow and increases flood problems downstream. Without continued maintenance or improvement of flood control infrastructure, further levee failures are likely. Emergency flood repairs are stressful to local communities and resources and often result in degraded habitat conditions. An alternative approach is to manage floods, recognizing that they will occur, they cannot be controlled entirely, and have many ecological benefits. Allowing rivers access to more of their floodplains actually reduces the danger of levee failure because it provides more flood storage and relieves pressure on remaining levees. Valley-wide solutions for comprehensive flood management are essential to ensure public safety and to restore natural, ecological functioning of river channels and floodplains. Integrating ecosystem restoration with the Army Corps of Engineers' Comprehensive Study of Central Valley flood management can help redesign flood control infrastructure to accommodate more capacity for habitat while reducing the risks of flood damage (Strategic Plan 2000).

BYPASSES AS HABITAT: The Yolo and Sutter Bypasses along the Sacramento River are remarkably successful in reducing flooding in urban areas. They are also important areas for farming. The realization of their relatively low-cost benefits to flood control is leading to the consideration of additional bypasses, especially in the San Joaquin Valley. There is also a growing realization that bypasses can be important habitat for waterfowl, for fish spawning and rearing, and possibly as a sources of food and nutrients for estuarine foodwebs. For example, when the Yolo Bypass is flooded, it effectively doubles the wetted surface area of the Delta, mostly in shallow-water habitat. Managing the bypasses for the benefit of fish and wildlife, however, may conflict with their use for flood control and farming. Therefore, there is a major need to evaluate existing bypasses as habitat to reduce management conflicts. New or expanded bypasses and managed flood basins should also be designed with the needs of fish and wildlife in mind (Strategic Plan 2000).

OPPORTUNITIES: Undertake floodplain restoration on a broad scale, where land or easements can be acquired and where the river hydrology includes (or can be made to include) sufficiently high flows to inundate floodplain surfaces. Restoration of floodplain function can produce many benefits, such as reducing stress on remaining levees, reducing excessive channel scour, and encouraging establishment of riparian vegetation over a larger area within the adjacent floodplain. A range of possible measures will need to be employed to fit local conditions, such as widening flood bypasses or creating new ones; setting levees back, creating backup levee systems, or deauthorizing specific levee reaches; constructing armored notch weirs in levees and purchasing flood easements to restore flood basin storage functions; or implementing measures described in item two above to increase the frequency and duration of overbank flow onto existing floodplains. Reactivating the historical floodplain can provide effective reliable, and cost effective flood storage while restoring important ecological processes (Strategic Plan 2000).

VISION

The vision for natural floodplains and flood processes is to conserve existing intact floodplains and modifying or removing barriers to overbank flooding to reestablish aquatic, wetland, and riparian floodplain habitats.

Measures for conserving and enhancing natural floodplains and flood processes are complimented by the visions for natural sediment supply, natural fluvial geomorphology, and stream meander corridors. If the floodplain, meander width, sediment supply, and natural or simulated flood peaks are in place, the river will respond by creating natural landforms. These natural landforms will support self-sustaining vegetation communities and aquatic and terrestrial habitats. Even partial restoration or simulation of natural physical processes and floodplains will enhance channel characteristics and resultant habitats.

Conservation and management of natural existing floodplains should be promoted. Cooperative efforts with the U.S. Army Corps of Engineers and California Department of Water Resources (DWR) should be developed to map and describe the hydrologic characteristics and conditions of all remaining natural riverine and estuarine floodplains not separated from channels by levees or irreversible stream incision. Remaining floodplains that interact with bankfull discharge and higher high tides should be maintained as active floodplains because of their ecological functions and habitat potential, as well as their flood management benefits.

Flood processes and floodplain functions can be restored to many rivers, streams, and estuaries where levees are no longer essential for flood safety or where agricultural uses are marginal or problematic because of poor drainage, high maintenance costs, or frequent sand deposition.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Attaining the vision for natural floodplains and flood processes will involve coordination with other programs and organizations, including:

- Upper Sacramento River Fisheries and Riparian Habitat Advisory Council (SB1086 group) efforts and river corridor management plans implemented for the Sacramento River;
- studies underway by the state Reclamation Board and DWR to evaluate the aftermath of the January 1997 flood damage, levee stability, and future floodplain risk assessment;

- the U.S. Army Corps of Engineers and the Reclamation Board's Sacramento and San Joaquin River Basins Comprehensive Study, including more comprehensive floodplain management and river ecosystem restoration opportunities;
- proposed riparian habitat restoration and floodplain management studies for the San Joaquin River and its major tributaries, under supervision of the State Reclamation Board and Corps of Engineers, including potential new flood bypass systems and expanded river floodplains on lands recently acquired by the California Department of Parks and Recreation and U.S. Fish and Wildlife Service (USFWS);
- the San Joaquin River Parkway Plan;
- various plans for the restoration of tidelands (i.e., tidal floodplains) in the north San Pablo Bay and Suisun Bay; and
- multiagency plans or studies to breach levees and reopen floodplains of islands of the north Delta, including Liberty and Prospect Islands, and Little Holland Tract.

LINKAGE TO MULTI-SPECIES CONSERVATION STRATEGY

Stream meander is a dynamic ecological process that typifies a healthy river corridor or riverine ecosystem. A river-based ecosystem in the Central Valley extends laterally over its entire floodplain and longitudinally from its headwaters to the Delta or Bay. It may even extend beyond to hydrologically connected aquifers (California State Land Commission 1993). This view of floodplains as essential components of a living river system is critical to the protection and restoration of aquatic, riparian, and terrestrial species addressed by the Multi-Species Conservation Strategy (2000).

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Maintenance of natural floodplain and flood processes in the rivers and Delta is closely linked with stream flow, sediment supply, and stream meander processes, riparian, wetland, and aquatic habitats, and many stressors including dams, levees, bank protection, dredging, and gravel and sand mining in the floodplain.

OBJECTIVES, TARGETS, ACTIONS, AND MEASURES

> The Strategic Objective for natural floodplains and flood processes is to reestablish floodplain inundation and channel-floodplain connectivity of sufficient frequency, timing, duration, and magnitude to support the restoration and maintenance of functional natural floodplain, riparian and, riverine habitats.

LONG-TERM OBJECTIVE: Reestablish active inundation of floodplains with area targets and inundation frequencies (1-5 years) to be set for each major alluvial river (where feasible) based on probable pre-1850 floodplain inundation regimes and on existing opportunities to modify existing land uses.

SHORT-TERM OBJECTIVE: Reestablish active inundation of at least half of all remaining unurbanized floodplains in the Central Valley, where feasible.

RATIONALE: Frequent (often annual) floodplain inundation was an important attribute of the original aquatic systems in the Central Valley and was important for maintaining diverse riverine and riparian habitats. Important interactions between channel and floodplain include overflow onto the floodplain, which (1) reduces the cutting down of the channel, (2) acts as a "pressure relief valve", permitting a larger range of sediment grain sizes to remain on the channel bed, (3) increases the complexity and diversity of instream and riparian habitats, and (4) stores floodwater (thereby decreasing flooding downstream). The floodplain also provides shading, food organisms, and large woody debris to the channel. Floodplain forests serve as filters to improve the quality of water reaching the stream channel by both surface flow and groundwater. The actions necessary to reestablish active inundation will probably require major land purchases or easements, and financial incentives to move existing floodplain uses elsewhere, as has been done in the Midwest since 1993. Obviously, artificial inundation events will have to be planned to take into account other needs for stored water, including increased summer flows.

STAGE 1 EXPECTATIONS: All existing unurbanized floodplains in the Central Valley will have been identified and a priority list for floodplain restoration projects developed. Strategies for the restoration of natural channel and floodplain dynamics will have been developed and implemented in at least two large demonstration projects. Results of initial floodplain reactivation projects will be used to increase understanding of channel-floodplain interactions and the potential for restoration of processes.

RESTORATION ACTIONS

General targets to restore health to floodplains and flood processes include:

- conserving and expanding floodplains of Central Valley rivers and Bay-Delta by augmenting the natural flood processes including increasing the average floodplain width and linear extent of low areas beyond channel banks subject to bankfull discharge;
- promoting flood detention in flood basins and, where appropriate, encouraging wetland formation;
- increasing the frequency of inundation of vegetated floodplains connected to rivers and tidal channels; increasing the extent of tidal inundation at or above mean high tide; and
- reducing the extent of trapezoidal channels within levees and floodways; and increasing the acreage and connectivity of natural habitat areas within active floodplains of rivers and estuaries.

Floodplain expansion can be implemented in one of the following ways:

- Set back levees along channels and tidal sloughs to expand the width of the river's floodplain within the levee system. This approach should be evaluated on many rivers and tributaries as part of the overall reevaluation of the valley's flood control infrastructure and floodplain management policies.
- Acquire flood easements on agricultural and natural lands to allow a greater frequency and extent of floodplain inundation.
- Breach or remove levees from channels that are confined by narrow levee corridors, where feasible. In farmed areas, much of the land could continue to be farmed, if desirable, because most flooding would occur in limited areas and only during the non-growing season. This approach may have wide applicability to the low-lying plains of the San Joaquin River and lower tributaries and should be studied together with levee upgrades.
- Modify bypass and channel vegetation management policies to allow greater vegetative cover on existing floodplains. Where needed, compensate for increased channel roughness by implementing other flood control projects upstream that reduce peak flood water surface elevations.
- Expand floodplains and bypasses and add additional flood relief structures to reduce maximum flood stage in the channels. Expanded floodplains will allow for more vegetation and habitat within the channels, as well as the potential to provide greater flood protection. The Corps of Engineers and the Governor's Flood Control Task Force will be evaluating the need for new flood relief structures for the Sacramento and Feather Rivers along the Colusa Basin and Sutter Basin and for the San Joaquin River and lower tributaries along the extensive historic river plains.
- Breach or remove levees along Delta sloughs and former diked tidelands of the Bay.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population goals. Although the measures were developed specifically for evaluated species, some measures have direct relationships to the extent to which floodplains and flood processes influence habitat quality and quantity or have beneficial effects on evaluated species.

- Coordinate protection, enhancement, and restoration of floodplains with other federal, state, and regional programs (e.g., the SB 1086 program, the Corp's Sacramento and San Joaquin Basin Comprehensive Study, the Anadromous Fish Restoration Program, and U.S. Fish and Wildlife Service recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Initial species recovery efforts should be directed to locations where there are immediate opportunities for protection, enhancement, or restoration of suitable habitat.
- To the extent consistent with Program objectives, direct ERP actions towards setting back levees in the south Delta to increase shallow water habitat.
- To the extent consistent with Program objectives, mobilize organic carbon in the Yolo Bypass to improve food supplies by ensuring flow through the bypass at least every other year.
- Identify and implement measures to eliminate stranding of green sturgeon in the Yolo Bypass or to return stranded fish to the Sacramento River.
- Implement management measures identified in the proposed recovery plan for the Sacramento River winter-run chinook salmon (National Marine Fisheries Service 1997).
- Implement applicable management measures identified in the restoration plan for the Anadromous Fish Restoration Program (U.S. Fish and Wildlife Service 1997) and the recovery plan for native fishes of the Sacramento-San Joaquin Delta (U.S. Fish and Wildlife Service 1996).
- Consistent with Program objectives, improve the frequency, duration, and extent of bypass flooding in all years.
- Develop a water management plan to allocated multiyear water supply in reservoirs to protect drought year supplies and source of winter-spring Delta inflow and outflow needed to sustain splittail and their habitats.
- Direct ERP actions proposed for the Stanislaus River towards protecting, enhancing, and restoring suitable riparian and associated flood refuge habitats in and adjacent to occupied habitat at Caswell Memorial State Park.
- Restore and protect suitable open floodplain habitat for Delta coyote-thistle along the San Joaquin River.
- To the extent consistent with CALFED objectives, manage lands purchased or acquired under conservation easements to maintain or increase current population levels of resident evaluated species.

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◆ Bay-Delta Hydrodynamics

INTRODUCTION

The Delta of today is greatly altered from its historical condition. Historically, a complex, dendritic array of channels drained extensive marsh plains. Now, theses channels have been replaced by a greatly simplified network of uniform channels.

The Delta waterways generally contain fresh water, with brief incursions of slightly brackish water into the northern and western Delta. This incursion is more pronounced during the spring and early summers of very dry years when the discharges from the Sacramento and San Joaquin rivers are low. This differs from the natural pattern in which brackish water intrusion naturally occurred in late summer and early fall.

Beginning in the mid 1800s, the Delta has been subject to the effects of alteration of the natural seasonal patterns of river discharge, Delta morphology, and tidal prism. These factors interact to determine water movement patterns and salinity distribution in the Delta. Salinity levels in Delta waters is primarily a result of tidal prism and stage, and net Delta outflow. It is also influenced by prevailing wind direction and velocity. Daily tidal cycles result in flows in the lower San Joaquin River of up to 300,000 to 400,000 cfs, and the spring-neap cycle alters water surface elevations and salinity levels on a monthly basis.

Other factors that now contribute to alteration or moderation of historic flow patterns in Delta waterways and channels include operation of the CVP/SWP pumping plants in the south Delta, the Suisun Marsh Salinity Control Structure, the Delta Cross Channel (DCC), and a temporary flow barrier on the San Joaquin River at the head of Old River. The DCC and Old River Barrier affect flow rates, direction, and water surface elevations. At times, these factors contribute to the creation of unnatural flow patterns which is particularly evident in the channels of the southern and central Delta.

Hydrodynamic processes are an extremely important aspect of the Bay-Delta system and refers to the seasonal and daily direction and velocity of flows in Bay-Delta channels. The direction and velocity of flow and their distribution in time and location are important factors in habitat preferences of Bay-Delta organisms, erosion and sedimentation processes, migratory cues for organisms, and many other ecological processes and functions in the Bay-Delta. Major factors that affect hydrodynamics of Bay-Delta channels include streamflow, sediment composition, and channel configuration.

Flow conditions in Delta channels affect foodweb production, transport of organisms through the Delta, and vulnerability to south Delta pumping plant diversions. The Bay-Delta estuary provides important fish spawning, rearing, and migrating habitats. The Bay-Delta also serves as an important link in nutrient cycling and provides for high levels of primary (plant) productivity that supplies the aquatic foodweb.

RESOURCE DESCRIPTION

Nonimpeded tidal action into tidal wetlands affects sediment and nutrient supplies into those wetlands and complements natural marsh successional processes. Tidal action associated with flows out of tidal wetlands transports nutrients and organic carbon into aquatic habitats of the Bay-Delta.

Hydrodynamic patterns in the Delta are important to the survival of delta smelt, longfin smelt, striped bass, chinook salmon, and other fish dependent on the Sacramento-San Joaquin Delta. Unfavorable hydrodynamic conditions, such as net flow moving south to Delta export facilities instead of moving west toward Suisun Bay, reduce fish survival.

Improved hydrodynamic patterns will increase residence times of Delta water; provide more natural downstream flows; and improve rearing and spawning habitat, nutrient cycling, and foodweb integrity.

Delta hydrodynamics are determined by a combination of flow parameters including Delta inflow, Delta diversions, tidal flows, and facility operations (e.g., operation of the DCC gates). Cross-Delta water flow to the south Delta pumping plants reduces residence time of water in the Delta and alters flow direction and magnitude.

Unfavorable hydrodynamic conditions decrease juvenile chinook salmon survival as they migrate from the Sacramento River through the Delta. With a high rate of north-to-south flow from the Sacramento River through the DCC and Georgiana Slough into the central Delta, young salmon may become lost or delayed within the Delta, or may become more susceptible to being drawn to the south Delta pumping plants.

Favorable hydrodynamic conditions are important for chinook salmon because the Delta is a migration corridor and also provides rearing habitat. Juvenile chinook salmon rearing in the Delta are exposed to adverse hydrodynamic conditions for approximately 1-3 months until they are ready to migrate to the ocean.

Other species, including striped bass and delta smelt, are also subject to being drawn south across the Delta to the pumping plants. Because the water has a short residence time, the food supply is generally poor for those fish drawn into or residing in the central and southern Delta.

VISION

The vision for hydrodynamic processes in the Sacramento-San Joaquin Delta is to restore channel hydrodynamics to conditions more like those that occurred during the mid-1960s to provide migratory cues for aquatic species; transport flows for eggs, larvae, and juvenile fish; and transport of sediments and nutrients.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

The objective of one current program, the Temporary Barriers Program in the south Delta, is to improve the quantity and quality of irrigation water to agricultural users in the south Delta. A secondary objective is to provide a physical barrier in spring at the head of Old River at its junction with the San Joaquin River to reroute outmigrating San Joaquin fall-run chinook salmon downstream and away from the export facilities. In fall, a partial rock barrier modifies channel hydrodynamics to reduce the risk of dissolved oxygen blocks near Stockton and to ensure that a greater percentage of attraction water from natal streams reaches the Central and West Delta Ecological Unit.

The DCC gates are required to be closed under the terms of the National Marine Fisheries Service's biological opinion on winter-run chinook salmon and the 1995 Water Quality Control Plan to reduce impacts on salmon migrating down the Sacramento River. The gates can be closed at the request of the California Department of Fish and Game for half of November, December, and January. The DCC gates are then closed from February 1 through May 15.

LINKAGE TO MULTI-SPECIES CONSERVATION STRATEGY

Hydraulic and hydrodynamic patterns in the Delta and lower bays are critical elements in the transport of nutrients, foodweb organisms, fish eggs, larval and older fishes. These flow and flood-ebb, and circulation patterns are critical to achieving the recovery of tidal perennial aquatic and saline emergent wetland dependent species evaluated in the Multi-Species Conservation Strategy (2000).

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Bay-Delta hydrodynamics are closely linked to the health of aquatic habitats in the Bay-Delta and the aquatic resources that depend on these health habitats. These include:

- tidal perennial aquatic habitat,
- Delta sloughs, and
- midchannel islands and shoals.

Species and species groups that are dependent on healthy hydrodynamic conditions in the Bay-Delta include:

- delta smelt,
- longfin smelt,
- striped bass,
- chinook salmon, and
- many other estuarine and resident aquatic species.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

The Strategic Objective for Bay-Delta hydrodynamics is to establish and maintain hydrologic and hydrodynamic regimes for the Bay and Delta that support the recovery and restoration of native species and biotic communities, support the restoration and maintenance of functional natural habitats, and maintain harvested species.

LONG-TERM OBJECTIVE: Have a hydrodynamic regime in the Delta, Suisun Bay, San Pablo Bay, and San Francisco Bay that is favorable to maintenance of large, self-sustaining populations of species and habitats treated separately under goals 1, 3 and 4.

SHORT-TERM OBJECTIVE: Develop a more favorable hydrodynamic regime during key spawning and rearing times for native species and desirable non-native species. Select and implement water project operations measures to the extent feasible to support this hydrodynamic regime. Evaluate other measures and actions designed to create favorable conditions for depleted species and implement them where feasible.

RATIONALE: The restoration to abundance of most, if not all, of the native species and habitats in the Sacramento-San Joaquin estuary depends on the restoration and maintenance of a Bay-Delta hydrodynamic regime that supports important ecological functions such as sustaining a productive food web, providing spawning, rearing, and feeding habitat for estuarine and anadromous fish, and supporting migration of adult and juvenile fish. Human activities such as reduced Delta inflow, exports from the Delta and conversion of tidal wetlands have had a large influence on the natural hydrodynamic regime of the Bay-Delta. There are opportunities to restore or simulate, where and when appropriate, a more natural hydrodynamic regime, particularly in the February through June period, that sustains ecological functions and meets the life requirements of the fish and wildlife in or dependent on the Bay-Delta. As more is learned about the hydrodynamics of the estuary, direct and indirect modifications of estuarine processes (in an adaptive management context) should continue.

STAGE 1 EXPECTATIONS: Implementation of actions to restore or simulate a more natural hydrodynamic regime in the February through June period will be underway. Actions will include modifications to Delta inflow patterns and export operations during that period as well as restoration of tidal action to areas within the Bay-Delta. Studies on the factors affecting the abundance of key organisms should be ongoing, And a basic understanding of how effective the water operations measures have been for the at-risk species with continued exports from the south Delta should be developed and used to assess the need for a dual conveyance facility and to implement other strategies for their recovery.

RESTORATION ACTIONS

The general target for restoring and maintaining healthy Bay-Delta hydrodynamics is to focus on restoring hydrodynamic patterns typical of those exhibited when the ecosystem was functioning in a healthy state (e.g., 1960s).

The general approach to attain the target include the following:

- The effects of water exports and lower riverflows can be reduced by altering Delta channel configurations to improve system hydrodynamics. The two ecological units that have the greatest need for improved hydrodynamics are the South Delta and Central and West Delta Ecological Units.
- Modify Delta inflow patterns and export operations during the February through June period to more closely mimic hydrodynamic conditions that would have occurred under conditions in the mid-1960s.
- The greatest opportunities to restore hydrodynamic processes to reference levels that occurred when the estuary was healthier are linked to the water and storage alternatives. The potential for restoration is limited by a water storage and transport component that has its only export facilities located in the South Delta Ecological Unit. Under that condition, increased storage upstream or downstream of the Delta

could reduce exports in portions of some months and improve hydrodynamics during those times. Other more limited opportunities exist that are associated with storing water in the Delta, using physical barriers in strategic locations in the Delta, broadening specific sloughs to increase their flow-bearing capacity while reducing water velocities, and restoring large acreages of tidal wetlands and tidal channels to increase the tidal volume of the estuary.

MSCS Conservation Measures

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population goals. Although the measures were developed specifically for evaluated species, some measures have a direct relationship to improving Bay-Delta hydrodynamic conditions to support the recovery and maintenance of at-risk species.

- Coordinate protection, enhancement, and restoration of occupied delta smelt habitats with other federal state, and regional programs (e.g., the San Francisco Bay Area Wetland Ecosystem Goals Project, the SB 1086 program, the Corp's Sacramento and San Joaquin Basin Comprehensive Study, the Anadromous Fish Restoration Program, and U.S. Fish and Wildlife Service recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Allow delta smelt unrestricted access to suitable spawning habitat and protect these areas from physical disturbance (e.g., heavy equipment operation) and flow disruption in the period from December to July by maintaining adequate flow and suitable water quality to attract migrating adults in the Sacramento and San Joaquin River channels and their tributaries, including Cache and Montezuma sloughs and their tributaries.
- Protect critical delta smelt rearing habitat from high salinity (>2 ppt) and high concentration of pollutants from the beginning of February to the end of August.
- To the extent consistent with CALFED objectives, protect the Sacramento and San Joaquin river and tributary channels from physical disturbance (e.g., sand and gravel mining, diking, dredging, and levee or bank protection and maintenance) and flow disruption (e.g., water diversion that result in entrainment and in-channel barriers or tidal gates) from the period February 1 to August 31.
- Improve January and February flows for the longfin smelt during the second and subsequent years of drought periods.
- Provide sufficient Delta outflows for the longfin smelt during December through March.
- Provide inflows to the Delta from the Sacramento River greater then 25,000 cfs during the March to May green sturgeon spawning period in at let 2 of every 5 years.
- Implement management measures identified in the proposed recovery plan for the Sacramento River winter-run chinook salmon (National Marine Fisheries Service 1997).
- Implement applicable management measures identified in the restoration plan for the Anadromous Fish Restoration Program (U.S. Fish and Wildlife Service 1997) and the recovery plan for native fishes of the Sacramento-San Joaquin Delta (U.S. Fish and Wildlife Service 1996).
- Modify operation of the Delta Cross Channel to minimize potential to increase exposure of splittail population in the Delta to the south Delta pumping plants.
- Modify operation of the barrier at the Head of Old River to minimize the potential for drawing splittail toward the sough Delta pumping plants.
- Consistent with CALFED objectives, design modifications to South Delta channels to improve circulation and transport of north of Delta water to the south Delta pumping plants to ensure habitat supports splittail and to not increase transport of splittail to the south Delta pumping plants.

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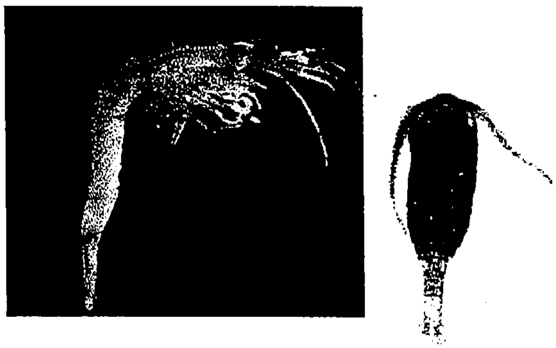
◆ Bay-Delta Aquatic Foodweb



Introduction

The aquatic foodweb of the Bay-Delta ecosystem is the web of organisms through which energy transfers up through the different trophic levels from the lower level that includes the plants to the highest level that includes the fish, water birds, and marine mammals. Each level in the web receives energy from the lower levels. The lower or primary producer level gets energy from photosynthesis or basic forms of dissolved organic compounds in the water. The second level is generally the primary consumers or herbivores (e.g., bacteria and algae-eating zooplankton) that feed on the plants or plant products. Secondary and tertiary consumers are further up the foodweb.

Total productivity of the Bay-Delta estuary is dependent primarily on the amount of plant biomass produced and the efficiency in which the energy is transferred up through the higher levels of the web. The Bay-Delta aquatic foodweb is derived from energy created by many kinds of plants, some of which are grown in the Bay-Delta waters and adjacent riparian and wetland habitat, while others are from upstream or land production.

Resource Description

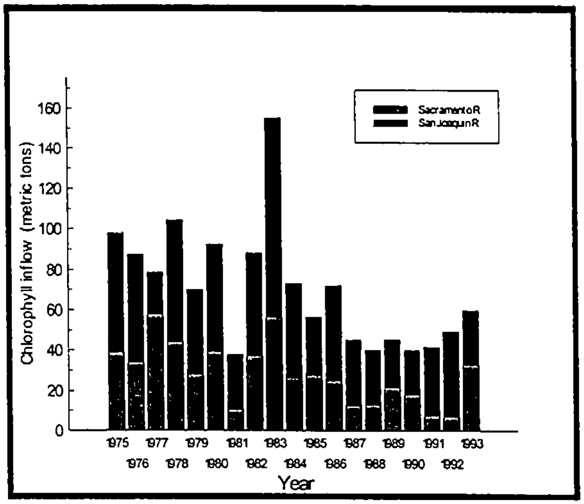
Plant contributions to the estuary foodweb consist mostly of benthic algae and phytoplankton produced in the estuary and its watershed. "Benthic" foodweb organisms are bottom dwelling, whereas plankton spend most of their time drifting in the water column. Vascular-plant debris contributed from terrestrial or wetland communities adjacent to the system also contribute to the foodweb. Algae are generally small (diameter <0.1 millimeters [mm]), easily transported, and highly nutritious; whereas most vascular-plant debris begins as coarse particulate organic matter that must be colonized and partially decomposed by bacteria before being usable by invertebrates and fish.

The Bay-Delta foodweb has undergone many changes since the 1960s. Most notably, algal abundance (as measured by chlorophyll concentrations in waters of the estuary) has declined in important fish nursery areas of Suisun Bay and the western Delta. Lowered algal abundance in Suisun Bay coincides with very low Delta outflow during drier years, particularly in the drought years, such as 1977 and 1987-1992, and with very wet years, such as 1983 and 1995. However, many species of zooplankton underwent their largest declines between 1970 and 1980, well in advance of the 1987-1992 drought (Obreski et al. 1992). Chlorophyll levels greater than 20 micrograms-per-liter (μg/l) were present in Suisun Bay only twice since 1986.

Over the past three decades, chlorophyll concentrations upstream in the western Delta have been similar to those in Suisun Bay. As in Suisun Bay, concentrations are lower in dry years and very wet years. Such levels have been achieved in only two years since 1986.

A pattern of very low chlorophyll levels in Suisun Bay and the western Delta beginning in 1987 has caused concern among many scientists. These low levels may be the result of high densities of Asian clams (*Potamocorbula amurensis*) which colonized the Bay after being accidentally introduced from the ballast waters of ships. Large numbers of the clams colonized this area of the estuary during the drought period from 1987 to 1992.

Some of the plant production appearing in the Delta and Suisun Bay is washed down from south Delta channels and the San Joaquin River. Chlorophyll levels in these channels reached an average of more than 100 μg/l in spring and summer of some years in the early 1970s. In the past two decades, productivity



May-October Chlorophyll Inflow to Delta, 1975-1993

in these channels, although remaining relatively high, has declined. Levels in 1993, 1995, and 1996 were low, possibly because of high flows (as in 1982, 1983, and 1986); however, lower than expected levels in recent dry years are a concern.

In wet years, some algae and other plant material in Suisun Bay and the Delta are transported tidally downstream into the wider expanses of San Pablo Bay and other portions of San Francisco Bay. Spring and summer chlorophyll levels in San Pablo Bay are generally low compared with those in Suisun Bay and the Delta. Peak concentrations in the past three decades in San Pablo Bay occurred in wet years (1980, 1982, 1983, 1984, 1986, and 1995).

Aquatic invertebrate population trends have varied significantly over the past three decades. Species that once dominated the aquatic invertebrate community have become relatively scarce such as *Eurytemora* and *Neomysis*, while some others have increased in relative abundance. Many native species have become less abundant or more narrowly distributed, while dozens of new non-native species have become well established and widely dispersed. Overall, the abundance of invertebrate plankton has declined, while most notably, populations of Asian clams have increased. This transition has been most evident in Suisun Bay and other traditionally important fish-rearing areas such as the western Delta and Montezuma Slough in Suisun Marsh. Also in these areas, populations of rotifers, copepods, and other relatively small species have declined substantially since monitoring began in the 1960s. This pattern is perhaps most dramatic for the mysid shrimp, which has declined to less than one-tenth of its former abundance, particularly since 1986. The continued decline from 1993 to 1995, despite the return of higher flows, is of particular concern. These declines in zooplankton abundance have roughly coincided with the decline in algae, one of the main food sources for the zooplankton.

The deterioration of the zooplankton community and its algal food supply in key habitat areas of the Bay-Delta is a serious problem because striped bass, delta smelt, chinook salmon, and other species that use Suisun Bay and the Delta as a nursery area feed almost exclusively on zooplankton during early life. Limited research indicates that survival and growth of fish larvae may improve with increased concentration of zooplankton. Declines in the production of juveniles of these fish species appear to coincide with the declines in algae and zooplankton. Modifying the Bay-Delta ecosystem in ways that will lead to increased algae and zooplankton abundance, such as increasing the residence time of water in the Delta, may be critical to restoring Bay-Delta fish populations and improving the health of its ecosystem.

Much of the plant biomass and other forms of fine particulate organic matter consumed by zooplankton in the Bay-Delta is transported from the Sacramento and San Joaquin rivers and accumulates in the western Delta and Suisun Bay. Some organic matter also comes from the lower mainstem rivers and from side channels, side sloughs, and floodplain lakes. Large amounts of organic matter and associated bacterial biomass enter the rivers, Bay, and Delta as crop residue, leaf litter, dead tule stems, and other organic debris from riparian corridors, floodplains, or other areas subject to periodic flooding by tides and high flows. Historically, considerable organic material entered the rivers and Bay-Delta from sewage and food-processing plants. These point source loadings have since been reduced as part of an overall effort to improve water quality.

The San Joaquin River contributes a disproportionately high percentage of the food resources supplied to the Delta. The river's chlorophyll levels are among the highest recorded for temperate rivers anywhere in the world. San Joaquin River water has a relatively long hydraulic residence time and high phosphorus and nitrogen levels. Under these circumstances, algae have an abundant supply of nutrients and enough time to process them before being swept downstream into the Delta. The Sacramento River, by contrast, has relatively low nutrient levels throughout most of its length and a comparatively short residence time and, therefore, low productivity.

These differences between the San Joaquin and Sacramento rivers are partly a result of natural differences in regional soils and hydrologic conditions, but are also a function of how the two rivers have been engineered and operated to meet water supply needs. The San Joaquin River is fertile and sluggish from May to October because it consists primarily of agricultural return flows. In contrast, the Sacramento River consists primarily of reservoir releases that are relatively nutrient poor. Although the San Joaquin River accounts for only 17% of Delta water inflow from May through October, it contributes 60% of the plant material flowing into the Delta.

From May through October, the amount of plant material flowing out of the Delta exceeds the amount transported in from the rivers by an average of 44%. This difference results from production of algae within the Delta. Most of the plant material transported to or produced within the Delta flows out of the Delta, either through the main channel connecting the Delta with Suisun Bay or by way of the project pumps in the southern Delta. Of the total outflow of water and plant material from the Delta (i.e., project exports plus "net Delta outflow" to Suisun Bay), on average two-thirds goes to Suisun Bay and one-third is exported by the pumps.

The proportion of the organic material in the Delta that reaches Suisun Bay varies considerably from year to year and depends, in part, on prevailing flow conditions. At higher flows, much of the organic material brought in by the rivers will travel to Suisun Bay or farther to San Pablo Bay or central San Francisco Bay. At low flows, a greater proportion remains in the Delta or is exported from the south Delta pumping plants.

In addition to serving as a critical habitat area for food production and accumulation, Suisun Bay is an area of intense food consumption. Before the prolonged drought that began in the mid-1980s, high densities of copepods, young mysid shrimp, and other planktonic grazers usually accompanied relatively high chlorophyll levels in Suisun Bay. Dozens of species of filter-feeding clams and other benthic grazers joined in the intense food consumption. Since the drought ended in 1993, chlorophyll concentrations have remained low in Suisun Bay.

The Asian clam is likely responsible for this lack of plankton recovery. This non-native marine bivalve was first detected in Carquinez Strait in 1986. Since then, it has become very abundant throughout San Pablo Bay and Suisun Bay and, in dry years, extends upstream into the western Delta. It is estimated that the clam can effectively filter the entire water column within 24 hours. Therefore, some scientists believe that these clams are effectively removing algae and other fine organic materials from the water column of Suisun Bay almost as fast as the Delta can supply it. The Asian clam is, therefore, considered an important "stressor" that will likely hamper efforts to restore the Bay-Delta foodweb; however, clam densities and the extent of their upstream distribution in the estuary have declined since 1993 with the onset of higher freshwater winter and spring inflows associated with wet years in 1993, 1995, and 1996.

The decline of plankton populations and chlorophyll concentration in the Bay-Delta may be a result, at least in part, of the effects of heavy metals, herbicides, pesticides, and other toxic substances. Low concentrations of these substances in the water column may act individually or in combination to reduce productivity of plant and animal plankton. Laboratory tests of Delta water on sensitive organisms indicate periodic toxicity of Delta water.

ISSUES AND OPPORTUNITIES

DECLINE IN PRODUCTIVITY: Productivity at the base of the foodweb has declined throughout the Delta and northern San Francisco Bay. Although some of this decline can be attributed to the introduced clam, *Potamocorbula amurensis*, or Asia clam, not all of the decline is explained. The decline at the base of the foodweb has been accompanied by declines in several (but not all) species and trophic groups, including mysids and longfin smelt. The long-term implications of this seem to be a reduction in the capacity of the system to support higher trophic levels. This implies a limit on the extent to which Bay-Delta fish populations can be restored unless creative solutions can be found to increase foodweb productivity (Strategic Plan 2000).

OPPORTUNITIES: Initiate targeted research on major restoration issues, such as: (1) how to control problem invasive species such as the Asia clam (*Potamocorbula amurensis*), which has a negative effect on foodweb dynamics in the estuary; (2) factors limiting the abundance of high-priority endangered species; and (3) design of habitats for shallow-water tidal marsh and bypasses. Use such research to address critical uncertainties and impediments to restoration discussed in the Strategic Plan (2000). Ultimately, the limited funds available for restoration will be much more effectively spent if there is a clear understanding of the relative seriousness of the diverse problems facing the estuarine and riverine ecosystems and of the ability to solve those problems. Where the research can be linked to pilot or large-scale restoration projects, the benefits will be multiplied (Strategic Plan 2000).

VISION

The vision for the Bay-Delta aquatic foodweb is to restore primary and secondary production to levels comparable to those during the 1960s and early 1970s by enhancing productivity and reducing loss of productivity as a result of water exports from the system, and in seeking to reduce or eliminate the adverse effects of introduced aquatic species.

Although zooplankton abundance has declined in Suisun Bay, herbivore productivity (i.e., productivity of Potamocorbula) in Suisun Bay is still very high. Thus, in Suisun Bay, energy from primary production flows mainly to the benthos instead of to zooplankton in the water column. The vision is also in evaluate means by which to restore primary and secondary production and increasing zooplankton biomass.

There are several means to enhance Bay-Delta productivity. One way to maintain or increase productivity is to reduce the loss of nutrients, plants, and animal plankton to water diversions. Additional improvements can be gained by increasing shallow-water habitat and tidal wetlands in the Bay and Delta, which would result in more plant production. Increasing the acreage of floodplain lakes, sloughs, and other backwaters in the Sacramento and San Joaquin Rivers will further increase organic matter inputs to the Delta. Reducing the amount of toxic substances entering the system will reduce loss of primary and secondary production. Other means of increasing productivity of the aquatic foodweb include opening leveed lands to tidal or seasonal floodflows; increasing the array of sloughs in the Delta; protecting and restoring shallows, shoals, and channel islands in the Delta; and providing for a more natural floodplain and meander belt along the rivers.

Restoring tidal action to leveed lands in San Pablo Bay, Suisun Marsh, and the Delta enhances productivity by allowing Bay-Delta waters to capture their plant production. The Yolo and Sutter bypasses offer potential opportunities to produce more permanent slough, riparian, and wetland habitats in the Sacramento River floodplain. Setback levees or improved riparian and shallow-water habitat along leveed reaches of the rivers and Delta offer additional opportunities to increase productivity of the Bay and Delta. These actions will promote aquatic and riparian plant production, which should improve the plant material base of the foodweb. With greater plant material available, the productivity of consumers like zooplankton will be greater, which in turn will increase the productivity of many important fish and wildlife species in the Bay-Delta.

There are several ways to ensure that increased plant material transported to or produced in the Delta is transported to Suisun Bay. Changes in the timing and magnitude of flows through the Delta and exports from south Delta pumping plants may increase transport of organic materials to the Bay from the Delta. Spring flow pulses in drier years from the rivers will enhance productivity in the rivers, Bay, and Delta and ensure that a greater amount of this productivity is transported through the Delta to the Bay. More of the organic material transported to or produced within the Delta would be retained in the Delta or transported to the Bay if the south Delta export pumps were relocated to the northern Delta.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore the productivity of the Bay-Delta foodweb would involve the cooperation and support from established programs underway to restore habitat and fish populations in the Bay-Delta including the following:

- The Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes calls for improving flows, reducing diversions, and increasing habitat.
- The Salt Marsh Ecosystem Recovery Plan calls for improving wetland habitat in the Bay.
- The Recovery Plan for Winter Run Chinook Salmon (NMFS) includes recommendations for habitat and foodweb restoration in the Bay-Delta and Sacramento River.
- The Recovery Plan for the Salt Marsh Harvest Mouse and California Clapper Rail includes provisions for protection and restoration of wetland habitats in the Bay.
- The Central Valley Project Improvement Act (PL 102-575) and its associated Anadromous Fish Restoration Plan includes provisions to reduce losses of organisms into water diversions, to restore aquatic habitat, to improve water quality, to improve freshwater flows, and to restore wetland and riparian habitats in the rivers and Bay-Delta.
- The Steelhead Trout, and Anadromous Fisheries Program Act of 1988 includes elements to improve freshwater flows and riparian habitats in the Sacramento and San Joaquin Rivers and their tributaries.
- The Delta Wildlife Habitat Protection and Restoration Plan include protection and improvements to riparian and wetland habitats of the Bay-Delta.
- Central Valley Habitat Joint Venture includes restoration of riparian and wetlands of the rivers, Delta, and Suisun Marsh.
- US Army Corps of Engineers Yolo Basin Wetlands Creation and Restoration Project will increase wetland acreage in the Yolo Bypass.
- California Senate Concurrent Resolution 28 has set a goal of doubling wetland acreage by the year 2000.
- San Francisco Estuary Project planning for wetland protection and restoration, and water quality protection and improvement.
- San Joaquin River Management Plan is a plan to restore riparian and wetland habitats and improve water quality in the San Joaquin River and its tributaries.
- SWRCB and RWQCB efforts to restore wetlands and improve water quality of the rivers and Bay-Delta.
- Suisun Resource Conservation District is developing wetlands restoration and management plans.
- The San Francisco Bay Joint Venture is a public/private partnership working to protect, restore, enhance and increase wetlands of all types throughout the San Francisco Bay region to benefit fish and wildlife using a non-regulatory approach.
- Riparian Habitat Joint Venture will restore riparian habitats.

LINKAGE TO MULTI-SPECIES CONSERVATION STRATEGY

The Bay-Delta aquatic foodweb is intricately linked to the protection and restoration of many aquatic species covered by the Multi-Species Conservation Strategy (2000). Estuarine dependent species such as delta smelt are particularly dependent on foodweb organisms and efforts to understand better the complex dynamics of nutrient flow and uptake in the system will contribute to the long-term goals of recovering a wide variety of estuarine dependent species.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Improvement of the aquatic foodweb of the Bay-Delta is integrally linked with wetland and riparian habitat restoration, water quality (contaminants) improvement, and Central Valley streamflow improvements.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

> The Strategic Objective for the Bay-Delta aquatic foodweb is to increase estuarine productivity and rehabilitate estuarine food web processes to support the recovery and restoration of native estuarine species and biotic communities.

LONG-TERM OBJECTIVE: Using knowledge gained in the shorter term, raise the level of ecosystem productivity to lift limits on production of desirable species of fish and invertebrates.

SHORT-TERM OBJECTIVES: Determine the limits on productivity and the major sources of organic carbon contributing to the estuarine ecosystem. Evaluate large-scale restoration projects associated with the restoration of tidal emergent, seasonal, and nontidal perennial wetlands, generate hypotheses as to the actions that might be effective at increasing productivity, and conduct pilot studies based on those findings.

RATIONALE: The abundance of many species in the estuary may be limited by low productivity at the base of the food web in the estuarine ecosystem. The causes of this are complex and not well understood, but may include a shortage of productive shallow-water regions such as marshes, high turbidity in open-water regions of the estuary, and consumption and sequestering of available organic carbon by the Asiatic clam. Solving the problem directly is difficult but presumably other actions taken as part of the ERP, such as increasing the acreage of tidal marshlands, will contribute to the solution. A major obstacle to solving problems of estuarine productivity is our poor understanding, so solutions will have to come from research and monitoring of effects of various ecosystem restoration projects.

STAGE 1 EXPECTATIONS: Studies of large-scale restoration projects associated with the restoration of tidal emergent, seasonal, and nontidal perennial wetlands will have been undertaken to assess organic carbon sources and cycling to generate and test hypotheses as to factors limiting their availability. These hypotheses (and findings generated from testing them) will be considered in setting priorities for restoration actions taken in future stages.

RESTORATION ACTIONS

The general targets for a healthy Bay-Delta aquatic foodweb include:

- Restore chlorophyll "a" abundance in San Pablo and Suisun Bays, and in the Delta to levels that occurred in the 1960s and early 1970s.
- Restore abundance of important zooplankton species in San Pablo and Suisun bays, and in the Delta to levels that occurred in the 1960s and early 1970s.

General programmatic actions to contribute to attaining targets include:

- Increase the residence time of water in the Delta.
- Restore tidal action to diked wetlands.
- Reduce concentrations and loadings of trace metals, herbicides, and other toxic substances in sediments and waters of the Central Valley.
- Reduce losses to diversions by modifying the structure and operation of Delta conveyance and pumping facilities.
- Increasing the amount and diversity of organic matter input from the Bay-Delta watershed by restoring aquatic, riparian, and wetland habitats.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population goals. Although the measures were developed specifically for evaluated species, some measures have a direct relationship to the Bay-Delta aquatic foodweb, which is of critical importance to the restoration and maintenance of at-risk species.

- To the extent consistent with CALFED objectives, mobilize organic carbon in the Yolo bypass to improve food supplies by ensuring flow through the bypass at least every other year.
- To the extent consistent with CALFED objectives, improve the frequency, duration, and extent of bypass flooding in all years.

REFERENCES

Multi-Species Conservation Strategy. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

INTRODUCTION

This section presents visions for habitat ecosystem elements. Habitats are areas occupied by plants, fish, and wildlife that provide specific conditions essential to the needs of plant and animal communities. There are no fixed boundaries for habitats, just as there are no fixed boundaries for environments, communities, or ecosystems (Goals Project 1999). Habitats will benefit markedly from restoration activities related to ecological processes and stressors. In some cases, direct action may be necessary to restore important habitats. Habitat types that are included are those that have a strong effect on an ecological process or a species that is dependent on the Bay-Delta and can be restored and managed to improve the health of the Bay-Delta ecosystem and its resources.

Many habitat classification systems have been developed to allow researchers to inventory and report abundance, distribution, and other related data for scientific, educational, or administrative purposes. For example, the classification system developed by Cowardin (1979) was designed by wetland ecologists to allow researchers to develop standard information which could be compared over large areas of the United States.

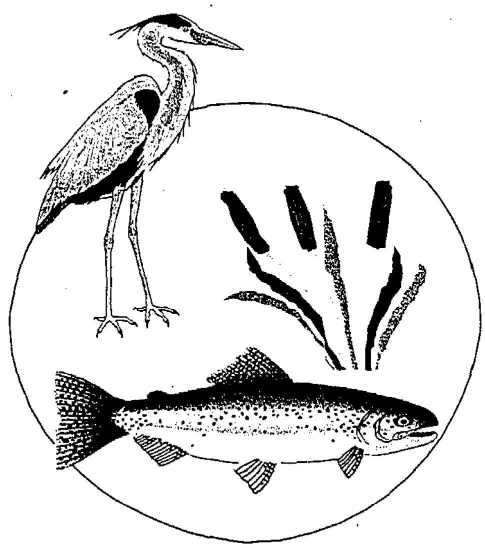
The Delta Wildlife Habitat Protection and Restoration Plan (Madrone Associates 1980) modified the habitat classifications of Cowardin (1979) to provide descriptions of habitat in the Sacramento-San Joaquin Delta. The Goals Project (1999) developed a habitat typology (hierarchical classification) in which habitat components of one level are nested within the next higher level. The Bay Institute (1998) broadly described historic habitat and changes in its ecological history of the San Francisco Bay-Delta watershed using a classification system similar to Cowardin (1979). Moyle and Ellison (1991) contributed by developing a hierarchical classification system for the inland waters of California. This system is based largely on fish distribution and endemism.

More recently, the CALFED Multi-Species Conservation Strategy (2000) provided the necessary information for a programmatic Natural Communities Conservation Plan for 20 natural communities, encompassing 18 habitat types. The MSCS NCCP habitats are consistent with the habitats described in this section. (Note: Please refer to the MSCS for additional information on NCCP communities and habitat types.)

RELATIONSHIP TO MULTI-SPECIES CONSERVATION STRATEGY

Together, the ERP and the Multi-Species Conservation Strategy (MSCS) address natural communities and the species which depend on them for the explicit purposes of recovery, contributing to recovery, or maintaining populations of listed or covered species as identified in the MSCS. The MSCS is designed to serve as the programmatic Natural Community Conservation Plan and provides a framework for compliance of the CALFED Program with the ESA, CESA and the Natural Community Conservation Planning Act.

Implementation of the CALFED Program, including the ERP, will likely result in actions that adversely affect some species or their habitats. These actions must comply with the federal ESA and state CESA where the impacts affect species listed under either endangered species acts. Therefore, it is essential that the MSCS and ERP address the habitat needs of species in a clear and consistent manner.



The MSCS identifies 18 broad types of habitat including tidal perennial aquatic, valley riverine aquatic, montane riverine aquatic, lacustrine, saline emergent, tidal freshwater emergent, nontidal freshwater permanent emergent, natural seasonal wetlands, managed seasonal wetlands, valley/foothill riparian, montane riparian, grassland, inland dune scrub, upland scrub, valley/foothill woodland and forest, montane woodland and forest, upland cropland and seasonally flooded agricultural lands (Multi-Species Conservation Strategy 2000). These classifications are consistent and contained within the designated habitats addressed by the ERP.

Table 12 identifies important habitat ecosystem elements and the related ERP Strategic Objective. Strategic objectives are fixed and will not change through time. Table 13 presents the basis for their consideration.

Visions describe the role and importance of each habitat type to dependent plants, fish, wildlife, and other organisms, a description of the current condition of habitats, stressors and changes to ecological processes that have altered habitat condition, and approaches for restoring habitats and their functions to improve the health of the Bay-Delta and its biological resources. The Ecosystem Restoration Program Plan (ERPP) objectives, targets, and actions for each habitat type are described in Volume II: Ecological Management Zone Visions. Table 14 presents the ecological management zone in which targets, programmatic actions, and MSCS conservation measures have been proposed to accomplish each habitat vision. Table 15 provides a comparison of ERP habitats with other habitat classification systems.

Table 12. Strategic Goals and Objectives for ERP Habitats.

Goal 4:	**Protect and/or restore functional habitat types in the Bay-Delta estuary and its watershed for ecological and public values such as supporting species and biotic communities, ecological processes, recreation, scientific research, and aesthetics.**
Objective 1:	Restore large expanses of all major habitat types, and sufficient connectivity among habitats, in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay to support recovery and restoration of native species and biotic communities and rehabilitation of ecological processes. These habitat types include tidal marsh (freshwater, brackish, and saline), tidal perennial aquatic (including shallow water and tide flats), nontidal perennial aquatic, tidal sloughs, midchannel island and shoal, seasonal wetlands, riparian and shaded riverine aquatic, inland dune scrub, upland scrub, and perennial grasslands.
Objective 2:	Restore large expanses of all aquatic, wetland, and riparian habitats, and sufficient connectivity among habitats, in the Central Valley and its rivers to support recovery of native species and biotic communities and rehabilitation of ecological processes. These habitat types include riparian and shaded riverine aquatic, instream, fresh emergent wetlands, seasonal wetlands, other floodplain habitats, lacustrine, and other freshwater fish habitats.
Objective 3:	Protect tract of existing high quality major aquatic, wetland, and riparian habitat types, and sufficient connectivity among habitats, in the Bay-Delta estuary and its watershed to support recovery and restoration of native species and biotic communities, rehabilitation of ecological processes, and public value functions.
Objective 4:	Minimize the conversion of agricultural land to urban and suburban uses and maintain open space buffers in areas adjacent to existing and future restored aquatic, riparian, and wetland habitats, and manage agricultural lands in ways that are favorable to birds and other wildlife.
Objective 5:	Manage the Yolo and Sutter Bypasses as major areas of seasonal shallow water habitat to enhance native fish and wildlife, consistent with CALFED Program objectives and solution principles.

Table 13. Basis for Selection of Habitat Ecosystem Elements.

Habitat	Basis for Selection as an Ecosystem Element
Tidal Perennial Aquatic Habitat	Tidal perennial aquatic habitats, particularly areas less than 9 feet deep at mean high tide, are important habitat use areas for many species of fish and wildlife in the Delta. The substantial loss of historic shallow-water areas, primarily as a result of reclamation of tidally influenced habitat and channel dredging, has reduced the available habitat area for associated fish and wildlife. Loss of shallow-water areas has also caused a reduction in primary and secondary productivity which contributed to changing the historic foodweb of the Delta.
Nontidal Perennial Aquatic Habitat	Nontidal perennial aquatic habitats, particularly areas less than 6 feet deep, are important habitat-use areas for many species of fish and wildlife in the ERPP focus area. The substantial loss or degradation of nontidal perennial aquatic habitats, primarily as a result of reclamation of wetlands and alteration of streamflows, has reduced the available habitat area for associated fish and wildlife.
Delta Sloughs (Dead-end)	Dead-end sloughs provide warmer, highly productive habitat for seasonal spawning, rearing, and foraging of important aquatic organisms, as well as important carbon production for other Bay-Delta habitats. Several smaller branches of tidal slough networks have been severed from the main slough channel by levees. For waterfowl and wildlife, dead-end sloughs have associated marsh and riparian corridors important for breeding, feeding, resting, and roosting.
Delta Sloughs (Open-ended)	Open-ended sloughs provide unique, generally low-velocity habitats and important migratory pathways for many species and important habitat for wildlife and waterfowl along the riparian corridors of the sloughs. Levee construction and channel dredging over many years has converted the gradual sideslopes supporting marsh and tideflat habitat along sloughs to steep-sided, high-velocity channels with narrow or nonexistent shoreline habitat.
Midchannel Islands and Shoals	Midchannel islands and shoals provide unique remnant shallow-water edge habitat in many Delta channels. They typically support willow scrub, tule marsh, and tidal mudflat habitats and associated wildlife and fish. Midchannel islands and shoals have been shrinking or disappearing as a result of progressive erosion. Loss of this habitat has reduced nutrient cycling, and foodweb support functions in the ERPP focus area.
Saline Emergent Wetland	Saline emergent wetland habitats, including brackish and saline wetlands, are important habitat-use areas for fish and wildlife dependent on marshes and tidal shallows in the Bay-Delta and support several special-status plant species. The loss or degradation of historic saline emergent wetlands, primarily as a result of reclamation of tidally influenced wetlands for agriculture, has substantially reduced the habitat area available for associated fish and wildlife species. Several plant and animal species closely associated with tidal saline emergent wetlands have been listed as endangered under the State and federal Endangered Species Acts, primarily as a result of the extensive loss of this habitat type. Loss of this habitat has reduced nutrient cycling, and foodweb support functions in the ERPP focus area.

Table 13. Basis for Selection of Habitat Ecosystem Elements (continued).

Habitat	Basis for Selection as an Ecosystem Element
Fresh Emergent Wetland	Tidal and nontidal fresh emergent wetland habitats are important habitat-use areas for fish and wildlife dependent on marshes and tidal shallows in the ERPP focus area and support several special-status plant species. The loss or degradation of historic fresh emergent wetlands has substantially reduced the habitat area available for associated fish and wildlife species.
Seasonal Wetlands	Seasonal wetland and aquatic habitats are important habitat-use areas for many species of fish and wildlife in the ERPP focus area. Loss or degradation of historic seasonal wetlands, primarily as a result of urban development and reclamation of wetlands for agriculture, has substantially reduced the habitat area available for waterfowl, shorebirds, and other water birds. Loss of vernal pool habitat, in particular, has directly resulted in the listing of several vernal pool-dependent species as threatened or endangered under the federal Endangered Species Act. The loss of seasonal aquatic floodplain habitat, primarily as a result of levee construction and alteration of riverflows, has substantially reduced floodplain refuge habitat for fish and spawning habitat for the Sacramento splittail. Loss of this habitat has reduced water storage, nutrient cycling, and foodweb support functions in the ERPP focus area.
Riparian and Riverine Aquatic Habitats (Shaded riverine aquatic)	Shaded riverine aquatic habitat (SRA) is a major component of the ERPP riparian and riverine aquatic habitat ecosystem element. SRA habitats are important habitat areas for one or more life stages of most fishes that inhabit the ERPP focus area. The loss or degradation of historic riparian vegetation from river and stream channelbanks and alteration of nearshore aquatic habitat have primarily been caused by channelization, stabilization of channelbanks with riprap, and construction of levees. Control of flows and diversion of water have altered the hydrologic conditions that historically supported riparian vegetation. The loss of SRA has directly contributed to declines in populations of associated native fishes and reduced an important source of nutrients and allochthonous material in streams and Delta sloughs.
Riparian and Riverine Aquatic Habitats (Riparian scrub, woodland, and forest habitat)	Riparian scrub, woodland, and forest habitat is the other major component of the riparian and riverine aquatic habitat ecosystem element. Many species of wildlife, including several species listed as threatened or endangered under the State and federal Endangered Species Acts and several special-status plant species in the ERPP focus area are dependent on or closely associated with riparian habitats. Compared with all other habitat types in California, riparian habitats support the greatest diversity of wildlife species. Degradation and loss of riparian habitat have substantially reduced the habitat area available for associated wildlife species. Loss of this habitat has reduced nutrient cycling, and foodweb support functions in the ERPP focus area. Valley oak woodland habitats are important habitat-use areas for many species of wildlife in the ERPP focus area. The loss or degradation of historic stands of valley oak woodland has substantially reduced the valley oak woodland habitat area available for associated wildlife.

Table 13. Basis for Selection of Habitat Ecosystem Elements (continued).

Habitat	Basis for Selection as an Ecosystem Element
Freshwater Fish Habitats	Freshwater fish habitats and native fishes are closely linked in the Central Valley as the health of the native fish populations is largely dependent on the health of their habitats. Generally the fish habitats include standing waters, flowing waters and artificial waters. These habitats have additional utility as this classification scheme assumes that use by fishes also is representative of use by less we-known aquatic organisms such as insects and amphibians.
Essential Fish Habitat	The designation of Essential Fish Habitat is important to allow the systematic protection of chinook salmon habitat and other related elements of biological diversity within distinct regions of the Central Valley.
Inland Dune Scrub Habitat	Coastal scrub is associated with inland sand dunes and is limited in the ERPP focus area to the vicinity of the Antioch Dunes National Wildlife Refuge. This habitat area supports two plant and one butterfly species listed as endangered under the federal Endangered Species Act.
Perennial Grassland	Grasslands are important breeding and foraging habitat areas for many species of wildlife and support several special-status plant species. Historically common throughout most of the Central Valley, most perennial grassland in the ERPP focus area has been lost or has been converted to annual grassland.
Agricultural Lands (Agricultural wetlands)	Following extensive loss of native wetland habitats in the ERPP focus area, some wetland-associated wildlife species have adapted to the artificial wetland environment created by some agricultural practices and have become dependent on agricultural wetland areas to sustain their populations at current levels. Agricultural wetlands include rice lands; fields flooded for weed, salinity, and pest control; stubble management; and tailwater circulation ponds.
Agricultural Lands (Agricultural uplands)	Following extensive loss of some native upland habitats, upland-associated wildlife species have adapted to the artificial upland environment created by some agricultural land uses and have become dependent on agricultural upland areas and fence line vegetation to sustain their populations at current levels.

Table 14. Distribution of Targets and Programmatic Actions for Habitat by Ecological Management Zone.

[Note: Refer to Volume II: Ecological Management Zone Visions for more information regarding the specific targets and programmatic actions.]

Habitat Vision	Ecological Management Zone[1]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Tidal Perennial Aquatic Habitat	●	●												
Nontidal Perennial Aquatic Habitat	●	●												
Delta Sloughs	●	●												
Midchannel Islands and Shoals	●													
Saline Emergent Wetland		●												
Fresh Emergent Wetland	●													
Seasonal Wetlands	●	●	●	●		●	●	●	●		●	●		●
Riparian and Riverine Aquatic Habitats	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Freshwater Fish Habitats	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Essential Fish Habitat	●	●	●	●	●	●	●	●	●	●	●	●	●	
Inland Dune Scrub Habitat	●													
Perennial Grassland	●	●							●					
Agricultural Lands	●					●	●	●	●	●		●		●

Ecological Management Zones

[1] 1 = Sacramento-San Joaquin Delta
2 = Suisun Marsh/North San Francisco Bay
3 = Sacramento River
4 = North Sacramento Valley
5 = Cottonwood Creek
6 = Colusa Basin
7 = Butte Basin
8 = Feather River/Sutter Basin
9 = American River Basin
10 = Yolo Basin
11 = Eastside Delta Tributaries
12 = San Joaquin River
13 = East San Joaquin Basin
14 = West San Joaquin Basin

Table 15. Comparison of Ecosystem Restoration Program Habitats with Other Community and Classifications Systems.

ERP Habitat	Equivalent Community or Habitat Type under Other Classification Systems		
	MSCS/NCCP Habitat[1]	Wildlife Habitat Relationship[2]	National Wetland Inventory[3]
Tidal perennial aquatic, Delta slough, midchannel island and shoal	Tidal perennial aquatic	Estuarine	Estuarine (aquatic subtypes only)
Riparian and riverine aquatic	Valley riverine aquatic	Riverine	Riverine (aquatic subtypes only)
Riparian and riverine aquatic	Montane riverine aquatic	Riverine	Riverine (aquatic subtypes only)
Riparian and riverine aquatic	Valley/foothill riparian	Valley foothill riparian	Estuarine/scrub-shrub, estuarine/forested, palustrine/scrub-shrub, palustrine/forested
Riparian and riverine aquatic	Montane riparian	Montane riparian	Palustrine/emergent/nontidal/permanent; lacustrine/emergent/permanent; riverine/emergent/permanent
Nontidal perennial aquatic	Lacustrine	Lacustrine	Lacustrine (aquatic subtypes only)
Saline emergent wetland	Saline emergent	Saline emergent wetland	Estuarine/emergent
Fresh emergent wetland, Delta slough, and midchannel island and shoal	Tidal freshwater emergent	Fresh emergent wetland	Palustrine/emergent/tidal
Fresh emergent wetland	Nontidal freshwater permanent emergent	Fresh emergent wetland and wet meadow	Palustrine/emergent/nontidal/permanent; lacustrine/emergent/permanent; riverine/emergent/permanent
Seasonal wetlands	Natural seasonal wetlands	Fresh emergent wetland	Palustrine/emergent/nontidal/seasonal
Seasonal wetlands	Managed seasonal wetland	Fresh emergent wetland	Palustrine/emergent/nontidal/seasonal/artificial
Perennial grassland	Grassland	Annual grassland and perennial-grassland	Upland
Inland dune scrub	Inland dune scrub	None	Upland
Agricultural lands	Upland cropland	Cropland, pasture, and orchard-vineyard	Upland
Freshwater fish habitat	None	None	None
Essential fish habitat	None	None	None

(1) Multi-Species Conservation Strategy, 2000.
(2) Mayer, K. E. and W. F. Laudenslayer. 1988.
(3) Cowardin et al. 1979,

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Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

◆ TIDAL PERENNIAL AQUATIC HABITAT

INTRODUCTION

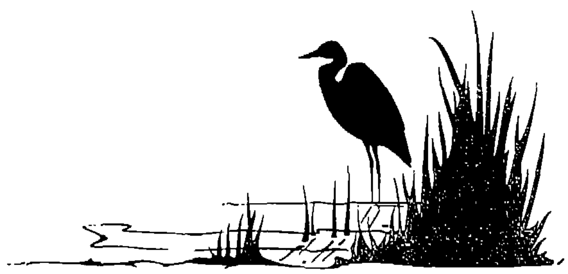
Tidal perennial aquatic habitat consists of the estuary's edge waters, mudflats and other transitional areas between open-water habitats and wetlands. Similar habitats are defined by the Goals Project (1999) as elements of tidal baylands which include mudflats, sandflats, and shellflats. These shallow waters are associated with natural wetland and riparian habitats that are important to fish and wildlife of the Bay-Delta. The substantial loss of historic shallow tidal waters, primarily as a result of reclamation and channel dredging and scouring, has led to the decline of many native fish, wildlife, and plant species in the Bay-Delta. Loss of such habitat has also reduced primary (plant) and secondary (invertebrate) productivity in the Bay-Delta estuary, and has changed important characteristics of the natural foodweb of the system.

TIDAL PERENNIAL AQUATIC HABITAT is defined as deepwater aquatic (greater than 3 meters deep from mean low low tide), shallow aquatic (less than or equal to 3 meters deep from mean low low tide), and unvegetated intertidal (i.e., tideflats) zones of estuarine bays, river channels, and sloughs. Tidal perennial aquatic includes all or portions of the ERP tidal perennial aquatic, tidal and Delta slough, and midchannel island and shoal habitats (Multi-Species Conservation Strategy 2000).

RESOURCE DESCRIPTION

Tidal perennial aquatic habitat is important for many fish, wildlife, and plants. It also supports many biological functions important to the Bay-Delta system. Many animal and plant species, identified as threatened or endangered under the California and federal Endangered Species Acts (ESAs), rely on tidal perennial aquatic habitat during some portion of their life cycle.

Bay-Delta estuary tidal wetlands and associated perennial aquatic habitat are among the most valuable natural resources in the United States. Restoring tidal perennial aquatic habitats is an important ingredient for successfully restoring the



Bay-Delta. Tidal aquatic habitats link wetlands with open-water habitats. Such habitat is used as foraging and resting habitat and escape cover for shorebirds, wading birds, and waterfowl. Resident and migratory fish use tidal perennial aquatic habitats for spawning, rearing, foraging, and escape cover. Young salmon forage in these productive waters and put on critical weight before entering the ocean. Striped bass, delta smelt, splittail, and many native resident Bay-Delta fish use this habitat, especially as rearing areas.

Tidal perennial aquatic habitat plays a primary role in the formation and maintenance of tidal wetlands. As tidal aquatic habitats accumulate sediment vegetation can increase. Over time this vegetation will become wetland and riparian habitat. As these tidal aquatic habitats accumulate sediment and vegetation, they maintain their structure and function, even with gradual rises in sea level.

Stressors that adversely affect the health of tidal perennial aquatic habitats include urban and industrial development, dredging, levees and associated land conversion, wastewater discharges, and land, urban and agricultural runoff.

VISION

The vision for tidal perennial aquatic habitat is to increase the area and improve the quality of connecting waters associated with tidal emergent wetlands and their supporting ecosystem processes to assist in the recovery of special-status fish and plant populations and provide high-quality aquatic habitat for other fish, wildlife, and plant communities dependent on the Bay-Delta.

Restoring tidal perennial aquatic habitat would also result in higher water quality and increase the amount of shallow-water and mudflat habitats; foraging and resting habitats and escape cover for water birds; and rearing and foraging habitats, and escape cover for fish.

Reducing fragmentation of existing tidal perennial aquatic habitat should be a focus of restoration efforts. Many areas of open water in the Bay-Delta are isolated by levees or deeper open-water habitat. Many open-water areas have been converted to managed marshes, saltponds, or agricultural use. Restoring historic habitats would involve reclaiming former tidal habitat by levee removal.

Initial efforts should focus on protecting existing tidal perennial aquatic habitats. These existing habitats offer functions and values that may not be possible to recreate. Former habitats should be linked with existing healthy habitats to enhance natural habitat restoration. Restored habitats should have natural gradients of open water, shallow water, wetland, riparian, and upland habitats to increase the habitat value for a greater diversity of species.

Many leveed lands in the Bay and Delta have subsided and are too low to support shallow tidal perennial aquatic habitat, and thus cannot be readily restored. The greatest subsidence has occurred in the Central and West Delta Ecological Management Unit. A comprehensive long-term program is needed to reverse subsidence. Changes in land use management, and use of suitable dredged materials or other "natural materials" should be implemented to restore land elevations to suitable ranges.

Restoration efforts should focus on those leveed lands that have not yet been subjected to severe subsidence. Prime candidates are existing managed marshes and salt ponds adjacent to San Pablo and Suisun Bays. Leveed agricultural lands and some industrial lands adjacent to Suisun Bay can be readily restored to tidal aquatic habitat. Some of the habitat would be mudflats, while deeper waters would be shallow productive bays not unlike the very productive Honker and Grizzly Bays of Suisun Bay, and much of northern San Pablo Bay.

LINK TO MSCS EVALUATED SPECIES

The MSCS has identified the following species as potentially benefitting from restoration of tidal perennial aquatic habitat in the Bay-Delta system:

MSCS SPECIES INCLUDED IN THE ERP

- steelhead
- delta smelt
- winter-run chinook salmon
- Sacramento splittail
- fall-run chinook salmon
- spring-run chinook salmon
- Sacramento perch
- longfin smelt
- green sturgeon
- California freshwater shrimp.

OTHER SPECIES EVALUATED IN THE MSCS

- California least tern
- western snowy plover
- American peregrine falcon
- bald eagle
- Aleutian Canada goose
- California brown pelican
- tidewater goby
- California gull
- long-billed curlew
- osprey.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Tidal perennial aquatic habitat used here is similar to the Goals Project (1999) descriptions of shallow bay and channel habitat, and tidal flat habitat. It also includes marine and estuarine subtidal areas that are less than 2 m deep at low water and shallow tidally influenced riverine areas (Cowardin 1979).

Many programs and projects aim to protect, restore, and enhance habitats within the San Francisco-San Joaquin Bay-Delta estuary. These include:

- Bay Area Aquatic Habitats Planning Group
- Cache Creek Corridor Restoration Plan
- California Wetland Riparian Geographic Information System Project
- Central Valley Habitat Joint Venture
- Governor's California Wetland Conservation Policy
- Inland Wetlands Conservation Program

- Montezuma Wetlands Project
- National Estuarine Reserve Research System
- North American Waterfowl Management Plan
- North Bay Initiative
- North Bay Wetlands Protection Program
- San Francisco Bay Regional Water Quality Control Board, and San Francisco Bay Conservation and Development Commission - Regional Wetlands Management Plan
- San Francisco Estuary Project
- Suisun Ecological Workgroup of the Interagency Ecological Program
- Tidal Wetlands Species Recovery Plan
- Wetlands Reserve Program
- and Yolo Basin Wetlands Project.

The Ecosystem Restoration Program Plan restoration targets and objectives reflect the goals of many of these programs. For example, the Goals Project (1999) has completed a comprehensive science-based approach to determining where, how much, and what kinds of wetlands should be restored in the Suisun Bay and San Francisco Bay areas. Contributing to each of these program would help to restore critical ecological processes, functions, and habitats and reduce or eliminate stressors.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Tidal perennial aquatic habitat is linked to the following ecosystem elements: (1) ecological processes, (2) habitats, (3) species, and (4) stressors.

Related ecological processes include Delta inflow (Central Valley streamflows) which influences the location of X2; natural sediment supply which influences the maintenance of mudflats, shallow shoals, bottom composition throughout the Delta and Bay; Bay-Delta hydraulic patterns which influence flow patterns in channels and sloughs; and Bay-Delta aquatic foodweb which depends on nutrient input, shallow water interactions, and access to tidal perennial habitat.

Habitats which are closely linked to tidal perennial aquatic habitat include tidal sloughs and channels, saline emergent wetlands, midchannel islands and shoals, and perennial grasslands. Tidal perennial aquatic habitat also provide an important ecological connection between open-water areas and shallow-water, emergent wetlands, and riparian habitats.

Species which depend on tidal perennial aquatic habitat include a large assemblage of marine, estuarine, anadromous, and resident fish, wildlife, and plant species and communities.

Stressors which adversely effect tidal perennial aquatic habitat include levee construction, contaminants, and dredging and sediment disposal.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

The Strategic Objective is to restore large expanses of all major habitat types, and sufficient connectivity among habitats, in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay to support recovery and restoration of native species and biotic communities and rehabilitation of ecological processes.

LONG-TERM OBJECTIVE: Restore tidal perennial aquatic habitats in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay to a substantial fraction of their pre-settlement areas, or to a point where all at-risk species that depend on the habitats are no longer at risk.

SHORT-TERM OBJECTIVE: Develop and begin implementation of action plans for restoring large and significant examples of tidal perennial aquatic habitat in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay.

RATIONALE: All major natural habitat types in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay have been reduced to a small fraction of the area they once occupied, resulting in a large number of at-risk plant and animal species and an increased susceptibility of the remaining areas to irreversible degradation (e.g., invasion by non-native species). The reduction trend is continuing and will have to be reversed if self-sustaining examples of these habitats, and the diverse organisms they support, are to persist into the future. This reversal will require a large number of diverse and localized actions, from levee setbacks to land acquisition to better management of existing sites. The major habitat types to be restored include tidal shallow water habitat, freshwater emergent wetland, channel islands and associated habitats, tidal sloughs, nontidal freshwater emergent wetlands, seasonal upland wetlands, vernal pools and surrounding uplands, riparian forests and associated upland areas, perennial grassland, and inland dune scrub. In order to make restoration actions systematic and cost-effective, specific objectives need to be established for each of the habitat types, as well as subsets of them that have distinctive biological characteristics, and then priorities set within each objective for protection and restoration activities.

STAGE 1 EXPECTATIONS: A classification system for Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay habitats that can be used as a basis for conservation actions will have been developed. Specific, numeric objectives should be formulated for each habitat type, with restoration objectives based on clearly stated conceptual models. Within and among habitat types, conservation and restoration activities should be prioritized. Work should begin on those projects given highest priority within a year of adoption of the strategic plan.

RESTORATION ACTIONS

The general target for restoration of tidal perennial aquatic habitat is to restore 7,000 acres in the Sacramento-San Joaquin Delta Ecological Management Zone and 1,500 acres in the Suisun Marsh/North San Francisco Bay Ecological Management Zone.

The following actions will help achieve this vision:

- restoring land elevations will allow more leveed lands to be returned to tidal shallow water habitat,
- setting backs levees would add aquatic habitat along potential margins of the Bay and Delta, and
- opening or breaching levees would also open unnaturally isolated lands to tidal flows.

MSCS CONSERVATION MEASURES

The Multi-Species Conservation Strategy recommends the following types of conservation measures for species dependant on tidal perennial aquatic habitat.

- Direct ERP actions towards setting back levees in the south Delta to increase shallow water habitat.
- Restore and enhance delta smelt habitat to provide suitable water quality (i.e., low concentrations of pollutants) and substrates for egg attachment (submerged tree roots, branches, rock, and emergent vegetation) to spawning areas in the Delta: Barker, Lindsey, Cache, Prospect, Georgiana, Beaver, Hog, and Sycamore sloughs, and the Sacramento River in the Delta and tributaries of northern Suisun Bay.
- Protect the Sacramento and San Joaquin river and tributary channels from physical disturbance (e.g., sand and gravel mining, diking, dredging, and levee or bank protection and maintenance) and flow disruption (e.g., water diversion that result in entrainment and in-channel barriers or tidal gates) for the period February 1 to August 31.
- Protect critical rearing habitat (Suisun Bay, Grizzly Bay, Honker Bay, Montezuma Slough and tributary sloughs, Sacramento River upstream to confluence with Three Mile Slough, and south along the San Joaquin river including Big Break) from high salinity (>2 ppt) and high concentration of pollutants from the beginning of February to the end of August.
- Allow delta smelt unrestricted access to suitable spawning habitat and protect these areas from physical disturbance (e.g., heavy equipment operation) and flow disruption in the period from December to July by maintaining adequate flow and suitable water quality to attract migrating adults in the Sacramento and San Joaquin River channels and their tributaries, including Cache and Montezuma sloughs and their tributaries.
- To the extent consistent with CALFED objectives, channel modification activities should

avoid channel islands, shoals, and shoreline areas with emergent vegetation.

- To the extent consistent with CALFED objectives, no dredging should be conducted within 200 feet of the shoreline and 250 feet of any water 4 feet or less (MLLW) in Suisun Bay and the western Delta (west of the confluence of the Sacramento and San Joaquin rivers.
- To the extent consistent with CALFED objectives, dredging or water side activities should not occur in shallow water (<3 m) areas of the Bay and Delta.
- To the extent consistent with CALFED objectives, construction of waterside rock berms and backfill should be avoided in critical spawning and rearing areas.

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◆ NONTIDAL PERENNIAL AQUATIC HABITAT

INTRODUCTION

Nontidal perennial aquatic habitat in the Bay-Delta estuary is present in certain low-elevation areas. Nontidal perennial aquatic habitat includes portions of permanent bodies of water that do not support emergent vegetation and that are not subject to tidal exchange, including lake, ponds, oxbows, gravel pits, and flooded islands. Such areas have permanent open water which is no longer subject to tidal influence. The size, quantity, and quality of existing nontidal perennial habitat do not equal the wildlife habitat values of sloughs and backwaters in the estuary before reclamation.

> **NONTIDAL PERENNIAL AQUATIC HABITAT** is defined as lacustrine habitat by the MSCS. This habitat includes portions of permanent bodies of water that do not support emergent vegetation and that are not subject to tidal exchange, including lake, ponds, oxbows, gravel pits, and flooded islands (Multi-Species Conservation Strategy 2000).

Nontidal perennial aquatic habitats are important for many species of wildlife in the Delta. In many places within the Delta, nontidal aquatic habitat has replaced the native tidal aquatic habitats. Outside the Delta, the substantial loss or degradation of nontidal aquatic habitats associated with Central Valley wetlands has reduced the available habitat area for many native fish and wildlife species. Land reclamation is the major factor that limits the contribution of nontidal perennial aquatic habitats to the health of the Delta.

RESOURCE DESCRIPTION

Historically, most wetlands in the Bay-Delta estuary were tidal. Nontidal perennial aquatic habitats were largely nonexistent. Some historical nontidal perennial habitat was created naturally. Shifts in river alignments occasionally isolated oxbow lakes, and drainage divide ponds in Bay area tidal wetlands were subjected to limited tidal action. Most of the remaining nontidal perennial aquatic habitat areas were established by constructing dikes and levees.

Isolating these areas allowed their conversion for other uses, primarily agricultural. Perennial aquatic habitats on converted lands are primarily located in large agricultural drains, small farm ponds, industrial ponds, ponds managed for waterfowl and other wildlife, and Delta island blowout ponds (created by levee failures that scour island interiors deeply enough to maintain permanent water through seepage).

Existing nontidal open-water areas generally have poor wildlife value. Nontidal perennial aquatic habitats have insufficient shoreline cover for nesting and protection from predators. Adjacent lands are relatively barren (e.g., farmed fields and land next to industrial ponds) and lack cover needed by nesting waterfowl and other species that require adjacent open-water and upland habitats. A notable exception is the unreclaimed blowout ponds around which native vegetation has been allowed to establish (e.g., ponds on Webb Tract).

The loss of permanent open water within historic tidal wetlands substantially reduced habitat for waterfowl, shorebirds, and other wetland wildlife species in the Bay-Delta system. Important ecosystem processes needed to restore and sustain nontidal perennial aquatic habitat include:

- the geologic and hydrologic condition, stream meander, and tidal function necessary to maintain permanent surface water;
- a range of elevations sufficient to support deep-water (greater than 3 feet in depth) and shallow-water areas; and

- adjacent wetland and riparian (streambank) vegetation.

Land use and human disturbance are stressors on nontidal perennial aquatic habitat. Insufficient buffer areas around open water reduce habitat value for wildlife species. These species require quality upland habitats connected to the aquatic habitat and increasing levels of human disturbance that adversely affects wildlife using open-water areas.

The value of open-water habitat to wildlife greatly increases if emergent vegetation is present along shorelines and in shallow-water areas. Adjacent dense upland herbaceous vegetation and riparian woodland further increase the value to wildlife.

VISION

The vision for nontidal perennial aquatic habitat is to increase the area and improve the quality of existing open-water areas to provide high-quality habitat for waterfowl and other water birds.

This vision can be achieved as a component of saline and freshwater emergent wetland restorations. Permanent open-water areas could be restored as a component of nontidal saltwater, and fresh emergent wetland habitat areas. The bottom slope ranges of restored wetland areas will provide the water flow patterns necessary to create a wide variety of permanent open-water areas. Waterfowl brood ponds can be constructed on agricultural lands next to suitable waterfowl nesting habitats.

Restoring nontidal perennial aquatic habitat would improve ecological process and functions of other habitats and wildlife. Adjacent wetland and upland habitats would then have increased ecological value. The open shallow water would provide resting and foraging habitat for waterfowl and other water birds. Wading and shore birds would feed in the open shallow water habitat. These restored habitats may improve the quantity and quality of nesting habitat. Increased nesting habitat would increase the production of waterfowl and other water birds in the estuary.

Restoring nontidal perennial aquatic habitat in sufficient quantity and quality will require reestablishing associated ecosystem processes. Restoring these processes will establish and maintain habitat, reduce or remove stressors, and help restore adjacent habitats.

Restoration efforts should be accomplished through landowners, conservation groups, and land management agencies. The focus of these efforts should be to restore open-water habitats on Delta islands and other former tidelands of the Bay-Delta.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Nontidal perennial aquatic habitat used here is similar to the Goals Project (1999) description of diked marsh, salt pond, and storage/treatment pond.

Efforts to restore nontidal perennial aquatic habitat would involve cooperation with other wetland restoration and management programs. These include:

- San Francisco Bay Area Wetlands Ecosystem Goals Project,
- Natural Resources Conservation Service's Wetland Reserve Program,
- Wildlife Conservation Board's Inland Wetlands Conservation Program,
- restoration programs administered by Ducks Unlimited and the California Waterfowl Association,
- Central Valley Habitat Joint Venture and North American Waterfowl Management Plan,
- the Suisun Marsh Protection Plan,
- and ongoing management of State and federal wildlife refuges and private duck clubs.

Cooperation will also be sought from agencies or organizations with responsibility or authority for restoring wetland and aquatic habitats, including California Department of Fish and Game, California Department of Water Resources, U.S. Fish and Wildlife Service, the U.S. Army Corps of Engineers, and the Delta Protection Commission.

Link to MSCS Evaluated Species

The MSCS has identified the following species as potentially benefitting from restoration of nontidal perennial aquatic habitat in the Bay-Delta system.

MSCS Species Included in the ERP

- California red-legged frog
- western pond turtle
- Sacramento perch
- eel-grass pondweed.

Other Species Evaluated in the MSCS

- American peregrine falcon
- bald eagle
- Aleutian Canada goose
- California gull.

Linkage with Other Ecosystem Elements

Nontidal perennial aquatic habitat is linked to the following ecosystem elements: (1) ecological processes, (2) habitats, (3) species, and (4) stressors.

Related ecological processes include:

- natural geologic and hydrologic conditions,
- stream meander corridor,
- and tidal actions that maintain permanent water.

Other areas which are closely linked to nontidal perennial aquatic habitat include:

- adjacent wetlands and upland habitats,
- and riparian and riverine aquatic habitat.

Species which depend on nontidal perennial aquatic habitat include:

- resident fish and wildlife,
- migratory birds,
- and plant species and communities.

Stressors which adversely effect nontidal perennial aquatic habitat and wildlife use include:

- levee construction,
- land use,
- loss of edge vegetation,
- and human disturbance.

Objective, Targets, Actions, and Measures

> The Strategic Objective is to restore large expanses of all major habitat types, and sufficient connectivity among habitats, in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay to support recovery and restoration of native species and biotic communities and rehabilitation of ecological processes.

Long-Term Objective: Restore nontidal perennial aquatic habitat in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay to a substantial fraction of their presettlement areas, or to a point where all at-risk species that depend on the habitats are no longer at risk.

Short-Term Objective: Develop and begin implementation of action plans for restoring large and significant examples of nontidal perennial aquatic habitat in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay.

Rationale: All major natural habitat types in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay have been reduced to a small fraction of the area they once occupied, resulting in a large number of at-risk plant and animal species and an increased susceptibility of the remaining areas to irreversible degradation (e.g., invasion by non-native species). The reduction trend is continuing and will have to be reversed if self-sustaining examples of these habitats, and the diverse organisms they support, are to persist into the future. This reversal will require a large number of diverse and localized actions, from levee setbacks to land acquisition to better management of existing sites. The major habitat types to be restored include tidal shallow water habitat, freshwater emergent wetland, channel islands and associated habitats, tidal sloughs, nontidal freshwater emergent wetlands, seasonal upland wetlands, vernal pools and surrounding uplands, riparian forests and associated upland areas, perennial grassland, and inland dune scrub. In order to make restoration actions systematic and cost-effective, specific objectives need to be and cost-effective, specific objectives need to be established for each of the habitat types, as well as subsets of them that have distinctive biological characteristics, and then priorities set within each objective for protection and restoration activities.

STAGE 1 EXPECTATIONS: A classification system for Delta, Suisun Bay, Suisun Marsh, and San Pablo Bay habitats that can be used as a basis for conservation actions will have been developed. Specific, numeric objectives should be formulated for each habitat type, with restoration objectives based on clearly stated conceptual models. Within and among habitat types, conservation and restoration activities should be prioritized. Work should begin on those projects given highest priority within a year of adoption of the strategic plan.

RESTORATION ACTIONS

The general target for restoring nontidal perennial aquatic habitat is to provide 2,600 acres in the Sacramento-San Joaquin Delta Ecological Management Zone, 1,600 acres in the Suisun Marsh/North San Francisco Bay Ecological Management Zone, and 1,000 acres in the West San Joaquin Ecological Management Zone.

The following actions would help to achieve targets for nontidal perennial aquatic habitat restoration:

- Restore nontidal perennial aquatic habitat in concert with restoration of fresh emergent wetland habitats.
- Restore permanent open-water areas by establishing elevation gradients sufficient to maintain surface water through natural groundwater or surface-water recharge, or by pumping water into lowland areas.

MSCS CONSERVATION MEASURES

The Multi-Species Conservation Strategy (2000) has developed draft recommendations identifying the types of potential conservation measures to protect non-tidal perennial aquatic habitat dependent species.

- Avoid implementing actions that would result in the loss or degradation of traditional wintering habitat use area (Aleutian Canada goose).
- Enhance or restore 1 to 2 acres of suitable natural or agricultural habitat to replace every acre of traditional wintering habitat use areas that are permanently lost or degraded as a result of implementing ERP actions (Aleutian Canada goose).
- To the extent consistent with overall ERP objectives, direct proposed actions for improving agricultural habitats for wildlife to protecting and improving traditional wintering habitat use areas (Aleutian Canada goose).
- Program actions that potentially could mobilize large quantities of toxic materials from the soil should include an analysis to determine the amount of contaminants that could be mobilized and, if released contaminant loadings could be harmful, modify actions to reduce loadings of mobilized contaminants (American peregrine falcon).
- Conduct surveys in suitable habitat areas within the species range that could be affected by ERP actions to determine the presence and distribution of the western pond turtle before implementing actions that could result in the loss or degradation of occupied habitat (western pond turtle, California red-legged frog, eel-grass pondweed).
- Avoid implementing ERP actions that could result in the substantial loss or degradation of suitable habitat in areas that support core species' populations that are essential to maintaining the viability and distribution of the species (western pond turtle, California red-legged frog, eel-grass pondweed).
- If occupied habitat would be affected by ERP actions: 1) acquire, protect and mange existing occupied habitat areas or 2) enhance or restore 1 to 3 acres of suitable habitat for every acre of occupied habitat affected by ERP actions near where impacts are incurred (western pond turtle, California red-legged frog).
- If occupied habitat would be affected by ERP actions, to the extent feasible, capture individuals from the affected area and relocate to nearby suitable existing, restored, or enhanced areas (western pond turtle).

- If occupied habitat would be affected by ERP actions, to the extent feasible, capture individuals from the affected area and relocate to nearby suitable existing, restored, or enhanced areas that do not support non-native predator populations (California red-legged frog).
- Manage lands purchased or acquired under conservation easements that are occupied by the species to maintain or increase their current population levels (western pond turtle, eel-grass pondweed).
- Coordinate protection, enhancement, and restoration of the Sacramento perch and its habitats with other federal, state, and regional programs (e.g., USFWS recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives (Sacramento perch).
- Implement reintroductions into suitable habitat areas and manage habitat areas to maintain introduced populations (Sacramento perch).

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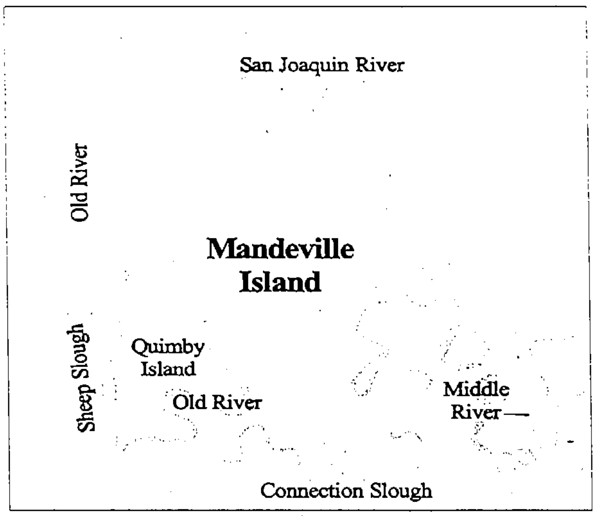

INTRODUCTION

Sloughs are a small remaining part of natural Delta habitats. Sloughs are tidal channels of the Delta that once connected rivers to the Bay through Delta marshes. These low-velocity, natural tributaries of Delta rivers vary in depth and width, have gently sloped, vegetated sides, and are connected to the Delta.

Most of the Delta sloughs were lost when the islands were reclaimed by construction of the levees. Many smaller Delta sloughs were lost in the past several decades when levees severed them from main channels. Levee construction and maintenance along sloughs has reduced the habitat value of many natural sloughs in the Delta. Boat traffic has also lead to shoreline erosion and loss of shallow water, marsh, and riparian habitat along many sloughs.

Sloughs provide warmer, highly productive habitat for seasonal spawning, rearing, and foraging for many aquatic organisms, as well as important organic carbon productivity for all habitats of the Bay-Delta. Sloughs provide shallow, low-velocity refuge habitat for many native fishes. Slough habitat also includes associated marsh and riparian corridors that are important for breeding, feeding, resting, and roosting waterfowl. Several resident species of Delta fish live in sloughs, and splittail and delta smelt may use them for spawning. Unlike leveed river channels, sloughs have marsh and riparian fringes with shallow water and natural shaded riverine aquatic habitat.

RESOURCE DESCRIPTION

Delta sloughs provide various beneficial habitats. They offer protection to plants, fish, and wildlife from wind and high-velocity flows. Delta sloughs support floating aquatic plant communities, which are otherwise found only in small, sheltered pockets along open channels. The seasonal succession of native floating plants in sloughs is a valuable link in the estuary's food chain. First to appear is duckweed, which provides primary food production for insect larvae, crustaceans, and waterfowl and other birds. The duckweed community creates conditions favorable to water fern establishment. The water fern's pores contain a bacterium that photosynthesizes and "fixes" (stores) nitrogen, which allows the water ferns to establish in nitrogen-deficient waters. Aquatic plants in sloughs provide protective cover for fish; habitats for insects, fish, and birds; and an abundance of food organisms. Wildlife use varies with the amount of open water and marsh, the extent and type of vegetation present, and surrounding land uses.

Delta sloughs provide habitat for biological functions necessary for the survival of resident and migratory fish species. These species need warm, highly productive Delta sloughs habitat for seasonal spawning, rearing, and foraging. Organic carbon created by the sloughs helps other Bay-Delta habitats.

Adjacent marsh and riparian corridors provide breeding, feeding, resting, and roosting habitat for waterfowl and wildlife. Delta sloughs and their riparian scrub, riparian forest, and open-water habitats provide the complex habitat needed by some State- and federally listed species such as the giant garter snake, splittail, and delta smelt.

DELTA SLOUGHS are defined in the MSCS as a component of tidal perennial aquatic habitat that includes deepwater slough areas (greater than 3 meters deep from mean low low tide) and shallow slough areas (less that or equal to 3 meters deep from mean low low tide) Multi-Species Conservation Strategy 2000).

Dead-end sloughs include Beaver, Hog, and Sycamore sloughs. These quiet backwaters provide essential habitat for native resident fish. Open-ended sloughs provide unique, generally low-velocity habitats and migratory pathways for many species. In addition, the adjacent riparian corridors provide habitat for wildlife and waterfowl.

Sloughs provide valuable transitional zones that link upland terrestrial habitats with open-water habitats. Historically, these transitional areas provided foraging, resting, and escape cover for shore and wading birds and other waterfowl. Resident and migratory fish use sloughs for rearing, foraging, and escape cover.

The ability of most sloughs to provide these functions has been severely degraded. Urban and industrial development has moved into areas adjacent to sloughs, destroying historic riparian habitat. Other factors that have contributed to degradation of habitat values include invasion and spread of non-native aquatic plants, such as water hyacinth, reduced water quality, and reduced freshwater outflows. In addition, levee construction and channel dredging have converted gradual sideslopes that once supported marsh and tidal flat habitat into steep-sided, high-velocity channels with narrow strips of emergent shoreline habitat.

VISION

The vision for Delta sloughs is to increase the area and improve the quality of interconnected dead-end and open-ended Delta sloughs to assist in the recovery of special-status fish and wildlife populations, provide shallow-water habitats for fish spawning and rearing, and provide aquatic, wetland, and riparian habitat for wildlife.

Existing natural sloughs require protection and habitat improvement. Additional restoration efforts would be identified by developing a thorough understanding of site-specific sediment transport, tides, hydrogeomorphology (landscape forms created by moving water), and Delta channel hydraulics (water flow patterns). Restoration of a variety of slough and adjacent terrestrial and aquatic areas would provide a wide range of complex habitats that would benefit many aquatic and terrestrial species.

Changes in tidal flows through sloughs and decreased human disturbance, e.g., reduced wake erosion, could improve slough habitats. Removing invasive, non-native aquatic plants would help restore many smaller sloughs to their natural function.

LINK TO MSCS EVALUATED SPECIES

The MSCS has identified the following species as potentially benefitting from restoration of Delta sloughs as a component of tidal perennial aquatic habitat in the Bay-Delta system.

- California least tern
- western snowy plover
- American peregrine falcon
- bald eagle
- Aleutian Canada goose
- California brown pelican
- steelhead
- delta smelt
- winter-run chinook salmon
- tidewater goby
- California freshwater shrimp
- Sacramento splittail
- fall-run chinook salmon
- spring-run chinook salmon
- California gull
- long-billed curlew
- osprey
- Sacramento perch
- longfin smelt and
- green sturgeon.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Delta sloughs as described here are related to the tidal riverine classification in Cowardin (1979), the slough and backwater designation in Moyle and Ellison (1991), and the channels and open water habitat and lakes and dead-end channels descriptions in Madrone Associates (1980).

Many projects associated with wetlands would benefit open-ended and dead-end sloughs. Some of these are sponsored by:

- San Francisco Estuary Project, Bay Area Wetlands Planning Group,
- California Wetland Riparian Geographic Information System Project,
- Governor's California Wetland Conservation Policy,
- Canal Ranch Project to develop tidally influenced areas and riparian zones in conjunction with existing agricultural practices,
- Inland Wetlands Conservation Program,
- North Bay Wetlands Protection Program,
- San Francisco Estuary Project,
- and Wetlands Reserve Program.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Delta sloughs are linked to the following ecosystem elements: (1) ecological processes, (2) habitats, (3) species, and (4) stressors. For example sloughs are an important element in Delta channel hydraulics, provide a range of aquatic habitats from deep water to tidal emergent vegetation, and support riparian vegetation. Many resident fish species, invertebrates, reptiles, and amphibians utilize these habitats, as well as resident and neotropical migratory birds, and waterfowl.

Maintenance and restoration of Delta and other tidal slough are dependent on channel hydraulics, natural sediment supply, sediment transport, erosion, deposition, and tides.

Other habitats that are interconnected to Delta and other tidal sloughs include open water areas, tidal perennial aquatic habitat, mainstem rivers, emergent wetlands, mudflats, seasonal floodplains, and riparian and riverine aquatic habitats.

Stressors to the health and quality of slough habitats include levee and channel island erosion, increased water velocities, and the removal of overhanging vegetation.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

The Strategic Objective is to restore large expanses of all major habitat types, and sufficient connectivity among habitats, in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay to support recovery and restoration of native species and biotic communities and rehabilitation of ecological processes.

LONG-TERM OBJECTIVE: Restore slough habitats in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay to a substantial fraction of their pre-settlement areas, or to a point where all at-risk species that depend on the habitats are no longer at risk.

SHORT-TERM OBJECTIVE: Develop and begin implementation of action plans for restoring large and significant examples of slough habitat in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay.

RATIONALE: All major natural habitat types in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay have been reduced to a small fraction of the area they once occupied, resulting in a large number of at-risk plant and animal species and an increased susceptibility of the remaining areas to irreversible degradation (e.g., invasion by non-native species). The reduction trend is continuing and will have to be reversed if self-sustaining examples of these habitats, and the diverse organisms they support, are to persist into the future. This reversal will require a large number of diverse and localized actions, from levee setbacks to land acquisition to better management of existing sites. The major habitat types to be restored include tidal shallow water habitat, freshwater emergent wetland, channel islands and associated habitats, tidal sloughs, nontidal freshwater emergent wetlands, seasonal upland wetlands, vernal pools and surrounding uplands, riparian forests and associated upland areas, perennial grassland, and inland dune scrub. In order to make restoration actions systematic and cost-effective, specific objectives need to be established for each of the habitat types, as well as subsets of them that have distinctive biological characteristics, and then priorities set within each objective for protection and restoration activities.

STAGE 1 EXPECTATIONS: A classification system for Delta, Suisun Bay, Suisun Marsh, and San Pablo Bay habitats that can be used as a basis for conservation actions will have been developed. Specific, numeric objectives should be formulated for each habitat type, with restoration objectives based on clearly stated conceptual models. Within and among habitat types, conservation and restoration activities should be prioritized. Work should begin on those projects given highest priority within a year of adoption of the strategic plan.

RESTORATION ACTIONS

The general target for restoration of Delta sloughs it to restore 160 miles in the Sacramento-San Joaquin Delta Ecological Management Zone and 30 miles of tidal sloughs in the Suisun Marsh/North San Francisco Bay Ecological Management Zone. The restoration of Delta sloughs will, in many instances, be closely linked to the restoration of tidal perennial habitat, and fresh and saline emergent marshes. In developing the approach to habitat restoration, a mosaic of habitats is very desirable, including provisions for increasing the overall linear mileage of Delta sloughs.

Actions that could be taken to improve slough habitat in the Delta include the following:

- Protect existing dead-end and open-ended sloughs from possible future degradation through cooperative agreements with land management agencies or conservation easements or purchase from willing sellers.
- Restore hydrologic conditions necessary for establishing Delta sloughs by constructing setback levees, removing dikes, constricting slough openings, and managing flows through Delta channels.
- Where consistent with flood control objectives, modify vegetation management practices along levees adjacent to sloughs to allow wetland vegetation to reestablish naturally.
- Identify and implement solutions to levee and channel island erosion that do not remove shallow-water habitat, increase water velocities, or remove overhanging vegetation.
- Reduce the adverse effects of boat wakes in sensitive habitat areas by excluding boats from certain areas at certain times and establishing maximum speed limits.
- Restore connectivity between high-quality habitats through cooperative agreements with land management agencies or through conservation easements or purchase from willing sellers.
- Where possible create new slough habitat where tidal saline and freshwater emergent wetlands are created in the Bay and Delta.

MSCS CONSERVATION MEASURE

The following conservation measure was included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- To the extent practicable, direct ERP salt marsh enhancement efforts toward existing degraded marshes that are of sufficient size and configuration to develop fourth order tidal channels (marshes would likely need to be at least 1,000 acres in size).

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◆ MIDCHANNEL ISLANDS AND SHOALS

INTRODUCTION

Midchannel islands and shoals provide unique remnant shallow-water habitats in many Delta channels. They typically support tule marsh, and to a lesser extent willow scrub, tidal mudflat habitats and associated wildlife and fish. Some midchannel islands have small, remaining riparian woodlands with oaks, cottonwoods, alders, and willows.

Midchannel islands and shoals have been shrinking or disappearing from progressive erosion of the remaining habitat. Loss of islands and shoals affects fish and wildlife habitats, and foodweb productivity. Major factors contributing to the loss of midchannel islands and shoals are gradual erosion from channels conveying water across the Delta to south Delta pumping plants, boat wakes, and dredging within the Delta or on adjacent waters.

> **MIDCHANNEL ISLANDS AND SHOALS** are defined in the MSCS as a component of both tidal perennial aquatic and tidal freshwater emergent habitats. Tidal perennial aquatic habitat is defined as deepwater aquatic (greater than 3 meters deep from mean low low tide), shallow aquatic (less than or equal to 3 meters deep from mean low low tide), and unvegetated intertidal zone of estuarine bays, river channels and slough. Tidal freshwater emergent habitat includes portions of the intertidal zones of the Delta that support emergent wetland plant species that are not tolerant of saline or brackish conditions (Multi-Species Conservation Strategy 2000).

RESOURCE DESCRIPTION

Midchannel islands and adjacent shoals provide shallow-water edge, riparian scrub, and emergent marsh habitats in selected Delta channels. The midchannel islands in some Delta locations retain many of these qualities because of their relative isolation. In other channels, high water velocities, heavy use for boating, and associated wave-induced erosion have degraded these islands. Many Delta channels and their midchannel islands and shoals are changing rapidly because of increased wakes from boats and changes in water velocities.

Midchannel islands vary in size, shape, and elevation, creating a diversity of habitat types and associated wildlife benefits. Protecting midchannel islands and shoals will help improve the overall quality and diversity of Bay-Delta aquatic habitats. Improving the productivity of the Bay-Delta aquatic habitat foodweb is needed to support the sustainable production and survival of fish.

The Delta formerly supported broad expanses of tule marshes, riparian forests, and shallow-water habitats. Today, intensive agricultural production on levee-bounded islands has replaced most of these habitats. Delta islands are separated by steep-banked waterways, which provide few shallow-water areas where natural vegetation can take root. Natural vegetation is generally limited to midchannel islands and a narrow band along levee edges. In many areas, even this remaining band of vegetation has been displaced by bank protection. Cumulative loss of natural vegetation has a detrimental impact on the Delta's fish and wildlife populations.

Midchannel islands and shoals in the Delta are the remnants of naturally occurring islands that existed prior to reclamation or are remnants of natural or old levees. The islands are the surviving examples of an expansive tule marsh with largely shallow and diffuse channels separating the stands. Early efforts to convert the Delta islands into agricultural lands included dredging near these islands for material to form levees. At first, dredging was simple because most of the excavated land was intertidal marsh. While converting the marsh to agriculture lands, naturally meandering channels were straightened, resulting in the creation of tule islands. In other areas, the distance between levees was wide and marsh was left between the levees. The sizes of these remainders varied considerably.

Midchannel islands and their adjacent shoals present a wide array of physiographic types and include a variety of habitats. Island habitats range from small tule islands that are essentially freshwater marshlands to large upland sites with riparian woodland, dredge spoils, brushland, ponds, and a variety of marsh types.

An important attribute of these islands is their isolation from mainland activities. Isolation turns these islands into wildlife refuges during spring and summer months when recreational use of the Delta is at its peak.

Midchannel islands and shoals provide valuable riverine-edge and shallow-water habitat within main channels. Actual descriptions of midchannel islands would have to be made on a site-by-site basis, since their physical features depend on parameters such as elevation, size, location, and amount of human disturbance. The island's isolation from human disturbance and the amount of disturbance to the terrestrial-aquatic interface determine the value of midchannel islands to wildlife, especially listed species.

Midchannel islands and shoals are important components of the landscape and contribute to the health of the Bay-Delta. Other important ecological functions influencing Bay-Delta health include natural sediment supply, aquatic habitat, nutrient input, and areas of primary and secondary production. Various life stages and species of fish require a variety of habitats and the ability to move between habitat patches. Habitat variations and access are important for the reproduction and survival of fish in flowing water ecosystems. Shallow water habitat in the Delta is predominantly found along levees, islands, and shoals. The terrestrial-aquatic interface provides habitat diversity, a large supply of organic matter, and shallow habitats with few aquatic predators. Most Delta-spawning fish spawn in shallow water.

Human activities on stream ecosystems typically concentrated at the terrestrial-aquatic interface. Shallow water land uses decrease the diversity and connectivity of physical habitats. The result of these alterations is a reduction in fish diversity, a shift in fish trophic structure, and an increase in temporal variability of fish abundance in water ecosystems.

The terrestrial-aquatic interface experiences extreme physical-chemical variability when hydraulic conditions fluctuate. Floodflows are confined by levees and bank protection structures. Fluvial energy increases flows that scour and cut into the midchannel islands and shoals.

The main concern regarding midchannel islands is the rate at which they are eroding. Midchannel islands are built up by sediment deposition and reduced by erosion. Reduction of flow or sediments reduces or halts the rate of midchannel island formation. Some waterways within the Delta lack sufficient sediment, while in other areas, erosion exceeds deposition. Lack of sediment supply to the Delta causes midchannel islands and shoals to erode, decreasing both the quality and quantity of island and shoal habitat. Dredging the shoals immediately adjacent to channel islands undermines the structural stability of the islands and subjects them to slumping and increased erosion. Boat wakes and boat-related recreational activities play a large role in the increased rate of erosion.

VISION

The vision for mid-channel islands and shoals is to increase and enhance the area and protect the quality of existing habitat for fish and wildlife dependent on the Bay-Delta.

Restoring midchannel islands is dependent on local hydrologic conditions (e.g., water depth, water velocity, and wave action). Depositing sediment necessary for establishing and maintaining shoals and terrestrial-aquatic interfaces will help rebuild the islands and reduce harmful erosion. Preserving midchannel island isolation will protect the islands and shoals from further damage and allow for natural habitat restoration.

Direct restoration of midchannel islands and shoals will be the primary approach to achieving this vision. The primary method of restoring midchannel islands would be to protect and improve existing channel islands. Restoration should include reconstructing the natural flows and velocities that provided consistent and predictable flows and sediments. Consequently, sediment supply must be restored to that which formed islands, shoals, and habitat for native fish and wildlife.

Reducing erosion rates and offsetting erosion losses would reduce the effects of major stressors on these islands. Reducing boat wakes and excessive channel velocities will allow deposits and wetlands to establish.

LINK TO MSCS EVALUATED SPECIES

The MSCS has identified the following species as potentially benefitting from restoration of tidal perennial aquatic habitat in the Bay-Delta system:

MSCS SPECIES INCLUDED IN THE ERP

- steelhead
- delta smelt
- winter-run chinook salmon
- Sacramento splittail
- fall-run chinook salmon
- spring-run chinook salmon
- Sacramento perch
- longfin smelt
- green sturgeon
- California freshwater shrimp.

OTHER SPECIES EVALUATED IN THE MSCS

- California least tern
- western snowy plover
- American peregrine falcon
- bald eagle
- Aleutian Canada goose
- California brown pelican
- tidewater goby
- California gull
- long-billed curlew
- osprey.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Midchannel islands as described here is very similar to the channel island designation in Madrone Associates (1980).

The U.S. Army Corps of Engineers and U.S. Fish and Wildlife Service Deep Water Ship Channel Monitoring Program provided information to successfully design and create wetland habitats in the Delta. The project deposited dredged spoils to create new shallow-water, wetland, and upland habitats within two flooded islands in the Sacramento-San Joaquin Delta. The Levee Subvention Program demonstration projects for erosion control and habitat establishment is another related effort.

The San Francisco Estuary Project's Delta In-Channel Island Work Group has reviewed and researched a number of candidate islands for restoration and investigated available biotechnical techniques for erosion control, land restoration, and revegetation. The Group is presently funded to conduct demonstration restoration projects on Little Tinsley and Webb Tract islands.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Midchannel islands and shoals are linked to other ecosystem elements including ecological processes, habitat, species, and stressors.

Ecological processes include contribution to the Bay-Delta aquatic foodweb and natural sediment supply which helps to maintain channel islands.

Midchannel islands and shoals provide riverine-edge habitat, shallow-water habitat, escape cover for young fish and wildlife, riparian and riverine aquatic habitat, and mudflats. Numerous aquatic and terrestrial fish, wildlife, and plant species rely on the complex array of habitats provided by this type of habitat.

Erosion seems to be the major stressor that is impairing the ecological health of this resource. This erosion is a result of wind-driven and boat wake wave erosion and high channel water velocities.

OBJECTIVES, TARGETS, ACTIONS, AND MEASURES

Midchannel islands and shoals are addressed by two Strategic Objectives. One objective addresses habitat and the other addresses the physical processes necessary to maintain channel islands.

> The Strategic Objective is to restore large expanses of all major habitat types, and sufficient connectivity among habitats, in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay to support recovery and restoration of native species and biotic communities and rehabilitation of ecological processes.

LONG-TERM OBJECTIVE: Restore midchannel islands and shoals in the Delta to a substantial fraction of their pre-settlement areas, or to a point where all at-risk species that depend on the habitats are no longer at risk.

SHORT-TERM OBJECTIVE: Develop and begin implementation of action plans for restoring large and significant examples of midchannel islands and shoals in the Delta.

RATIONALE: All major natural habitat types in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay have been reduced to a small fraction of the area they once occupied, resulting in a large number of at-risk plant and animal species and an increased susceptibility of the remaining areas to irreversible degradation (e.g., invasion by non-native species). The reduction trend is continuing and will have to be reversed if self-sustaining examples of these habitats, and the diverse organisms they support, are to persist into the future. This reversal will require a large number of diverse and localized actions, from levee setbacks to land acquisition to better management of existing sites. The major habitat types to be restored include tidal shallow water habitat, freshwater emergent wetland, channel islands and associated habitats, tidal sloughs, nontidal freshwater emergent wetlands, seasonal upland wetlands, vernal pools and surrounding uplands, riparian forests and associated upland areas, perennial grassland, and inland dune scrub. In order to make restoration actions systematic and cost-effective, specific objectives need to be established for each of the habitat types, as well as subsets of them that have distinctive biological characteristics, and then priorities set within each objective for protection and restoration activities.

STAGE 1 EXPECTATIONS: A classification system for Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay habitats that can be used as a basis for conservation actions will have been developed. Specific, numeric objectives should be formulated for each habitat type, with restoration objectives based on clearly stated conceptual models. Within and among habitat types, conservation and restoration activities should be prioritized. Work should begin on those projects given highest priority within a year of adoption of the strategic plan.

A second Strategic Objective is to rehabilitate natural processes to create and maintain complex channel morphology, in-channel islands, and shallow water habitat in the Delta and Suisun Marsh.

LONG-TERM OBJECTIVE: Have large expanses of shallow water habitat, both on the edges of channels and on small channel islands, maintained by natural processes.

SHORT-TERM OBJECTIVE: Set priorities for channels in terms their importance for shallow water habitat; develop and implement protection strategies for existing and restored shallow water habitat in those channels; investigate the value of shallow-water habitat in supporting and increasing abundances of desirable species.

RATIONALE: There is widespread agreement that more shallow water habitat needs to be created in the Delta and that existing shallow water habitat needs to be maintained. However, opinions differ on whether creating more habitat will actually increase abundance of desirable species. Ecosystem-based restoration is predicated on this assumption, but adaptive management demands that it be rigorously tested. Staged implementation will allow an increase in confidence in whether or not habitat restoration in the estuary will result in higher abundance of desirable species. Ultimately much of this shallow water habitat will be along Delta and Suisun Marsh channels (recreating some of the original channel-marsh system) or on small islands in the channels. The desirable physical and biotic characteristics of these habitats may be created artificially at first, but the expectation is that they will be maintained by natural processes (e.g., tidal flux, sediment inputs from upstream). This will require restrictions on human activities in these channels that have negative impacts on the habitats, such as boating at speeds that generate erosive wakes or channel dredging.

STAGE 1 EXPECTATIONS: Channels or channel reaches most suited for restoration and protection of shallow water habitats should be identified and given priorities for restoration activities. Detrimental human activities in these channels should be eliminated through a phased program associated with restoration activities. Major studies of the use of shallow water habitats by native and non-native species should be undertaken to test the assumption that shallow water habitat is indeed the key to restoring many of the native species.

RESTORATION ACTIONS

The general restoration target for midchannel islands and shoals is to restore and maintain 50-200 acres of high quality midchannel islands and shoals.

The following actions would help to protect and restore channel islands and shoals:

- Implement restoration projects currently proposed in the Delta by resource and cooperating agencies.
- Develop and implement an inventory and assessment of the existing midchannel Delta islands. Use this information to develop long-term actions to protect and enhance the islands.
- Install structures, such as floating booms, to weaken the force of waves to reduce midchannel erosion in sensitive areas.
- Reduce boat traffic near high quality midchannel islands.

Mid-channel islands are important habitat, but restoration cost will be a consideration in designing and implementing restoration actions. To most effectively link the restoration of mid-channel islands with adaptive management, a Delta-wide understanding of the value of natural flows, water velocities, and sediment transport processes need to be well understood. This can be facilitated by developing conceptual models based on our present understanding of the processes that create, maintain, or erode channel islands. Locating areas where sediment accretion is occurring naturally is vital to restoring channel islands. Projects in these areas may be cost-effective.

MSCS CONSERVATION MEASURES

The Multi-Species Conservation Strategy (2000) has developed draft recommendations identifying the types of potential conservation measures to protect mid-channel island and shoal dependent species.

- Restore and enhance delta smelt habitat to provide suitable water quality (i.e., low concentrations of pollutants) and substrates for egg attachment (submerged tree roots, branches, rock, and emergent vegetation) to important spawning areas.
- To the extent consistent with CALFED objectives, protect spawning areas by providing suitable water quality (i.e., low concentrations of pollutants) and substrates for egg attachment (submerged tree roots, branches, rock, and emergent vegetation).
- To the extent consistent with CALFED objectives, incorporate sufficient edge habitat to support Mason's lilaeopsis in levee setback and channel island habitat restoration designs.

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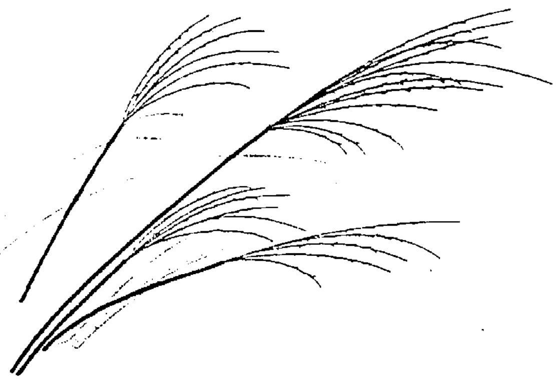
◆ Saline Emergent Wetland



INTRODUCTION

Saline emergent wetland habitats are located on the western edge of the Delta and in Suisun Marsh on the Bay. Saline emergent wetland habitats, including brackish and saline wetlands, are important habitats for fish and wildlife that are dependent on marshes and tidal shallows. This designation is similar to the Goals Project (1999) descriptions of tidal marsh which includes tidal salt marsh and tidal brackish marsh.

The loss or degradation of historic saline emergent wetlands has substantially reduced the habitat area available for associated or dependent fish and wildlife species. Several plant and animal species closely associated with tidal saline emergent wetlands have been listed as endangered under the State and federal Endangered Species Acts, primarily as a result of the extensive loss of this habitat type. Major factors that limit this resource's contributions to the health of the Delta are related to harmful effects of saline emergent wetlands conversion for agricultural, industrial, and urban uses.

SALINE EMERGENT WETLAND HABITAT is defined in the MSCS as saline emergent habitat. It includes portions of San Francisco, San Pablo, and Suisun bays and the Delta that support emergent wetland plant species that are tolerant of saline or brackish conditions within the intertidal zone or on lands that historically were subject to tidal exchange (i.e., diked wetlands) (Multi-Species Conservation Strategy 2000).

RESOURCE DESCRIPTION

Saline emergent wetlands were once continuous from San Francisco Bay into the western Delta. Saline emergent habitat also is found in low-elevation areas of the Central Valley where salts have accumulated and groundwater is near the surface. Most remnant tidal saline emergent wetlands are narrow bands along the margins of San Pablo Bay and Suisun Marsh and Bay. Extensive relict tidal marshes are associated with Cutoff Slough and eastern Hill Slough flank the Potrero Hills in the north-central Suisun Marsh and are especially unique in that there is a wetland continuum from tidal sloughs through low, middle, and high marsh zones and into adjacent uplands which are rich with associated vernal pools.

Land use changes over the past century have reduced the amount of saline emergent wetland habitat and fragmented what was once nearly contiguous habitat. In particular, diking of historic wetlands has substantially reduced the amount of tidally influenced saline emergent wetlands. Large areas of nontidal wetlands that were created largely by diking for reclamation are present in the Suisun Marsh and Bay areas.

Saltwater flowing into the Delta was reduced by water management in California's Central Valley. Before the development of California's reservoir system, saltwater intruded far into the upper Delta during summer months. This saltwater intrusion created a seasonally wide range of salinity over a large portion of the estuary. Reservoir operations and other water management practices have reduced saltwater intrusion into the Delta by retaining water during winter and releasing water during summer. Consequently, the area that can support brackish wetlands has been reduced, and the area that can support fresh emergent wetlands has increased. Complex water control systems are now required in Suisun Marsh to preserve the largest single area of saline emergent wetland habitat in California.

Saline emergent wetland area and quality have decreased because of historical conversion to other uses, and reduced land subject to tidal flooding. This habitat has a reduced potential to maintain populations of many native plant and wildlife species.

Many plant species that depend on saline emergent wetlands, including Ferris's milkvetch, soft bird's beak, palmate bird's beak, narrow-leaf gumplant, Suisun Marsh thistle, heartscale, San Joaquin spearscale, crownscale, brittlescale, Delta button celery, and hairy bird's beak, have been given special status because of their reduced populations.

More than 25 species of birds and mammals use saline emergent wetlands in the estuary. Populations of some wildlife species that are heavily dependent on saline emergent wetlands, such as the endangered clapper rail and salt marsh harvest mouse, have been substantially reduced in the Bay-Delta and designated as special-status species. A few wetland-associated species, such as waterfowl and egrets, have adapted to foraging on some types of croplands.

Saline emergent wetland also serves as an important transitional habitat between open water and uplands. Wildlife species that use tidally influenced areas, such as the salt marsh harvest mouse, have adapted to moving during high tides to seasonal wetlands and uplands above the saline emergent wetlands. Loss of adjacent seasonal wetlands and uplands has prevented species associated with these intertidal habitat areas from finding refuge in the higher tidal zone elevations.

Since the turn of the century, an estimated 70,000 acres of saline emergent wetland have been lost in the Suisun Marsh and Bay and the west Delta. The primary factor causing this loss has been wetland conversion to agricultural and other land uses.

Diking has isolated most of the remaining saline emergent wetlands from tidal flows. Loss of tidal flows into and out of the wetlands has substantially reduced the exchange of nutrients between these wetlands and tidal aquatic communities. Wetlands receiving tidal flows are highly productive, supporting large numbers of important foodweb microorganisms, and maintaining rearing areas for many fish species. Consequently, loss of tidal exchange has greatly reduced the contribution of saline emergent wetlands to the Bay-Delta aquatic ecosystem.

The loss of tidal exchange can also affect the biochemical balance in the soil-water interface. Excessive accumulation of salt in some soils has created conditions unsuitable for plant growth. Agricultural and other land uses have allowed undesirable non-native plant species to become established in remaining wetlands. Non-native plants compete with native plants and change the structure and diversity of the saline emergent plant community from historical conditions.

Tidal exchange is the primary process that supports healthy saline emergent wetlands in the Bay-Delta. Tides flush the wetland system, replacing nutrients and balancing salinity concentrations. Changes in the tidal flux and the accompanying daily and seasonal salinity changes are critical to habitat functioning. Saline emergent wetlands are recognized for their high productivity, which results from the complex interactions of dissolved nutrients with the saline or brackish water. The process of mixing estuarine freshwater with tide-driven saltwater is critical for the biochemical transformations (i.e., carbon and nitrogen cycles) which support the entire estuarine ecosystem.

Human-made stressors negatively affect the health of saline emergent wetlands. Controls placed on seasonal inflow of fresh water to the Delta effect the salinity gradient of the estuary. Land use practices, primarily those associated with agriculture, result in the establishment of weedy plants that displace native, saline-adapted plant species. An associated stressor is the loss of adjacent native upland habitats, which are used by some wildlife species as a temporary refuge when escaping high tides. Collectively, these stressors have substantially reduced the habitat quality of remaining saline emergent wetlands. The combined effect of these actions could eventually be the elimination of much of the remaining habitat.

VISION

The vision is to increase the area and protect the quality of existing saline emergent wetlands from degradation or loss to assist in the recovery of special-status plant, fish, and wildlife populations.

Restoration will provide high-quality habitat for other fish and wildlife dependent on the Bay-Delta. Restoration of saline emergent wetlands would focus on protecting and improving important existing wetlands and restoring wetlands in the Suisun Marsh/North San Francisco Bay Ecological Management Zone. Restoring saline emergent wetland is dependent on restoring tidal flows, establishing and maintaining healthy estuarine salinity gradients and reestablishing elevation gradients from open water to uplands.

Enhancing and increasing saline emergent wetland habitat would also help to increase water quality. Areas restored to tidal flow will contribute to the aquatic foodweb of the Bay-Delta and provide fish rearing habitats. Restoring saline emergent wetland would improve the ecological value of adjacent associated habitats, including tidal aquatic habitats, and will provide an important transitional zone between open water and uplands.

Other habitat restoration efforts will be directed toward reestablishing native plant species, controlling competitive weedy plants, increasing the quality of adjacent upland habitats to provide refuge for wildlife during high tides, and modifying land use practices that are incompatible with maintaining healthy wetlands. Restoring saline emergent wetlands would be coordinated with restoration of other habitats to increase overall habitat values. For example, saline emergent wetland greatly increases wildlife habitat quality of deep and shallow open-water areas and adjacent grasslands.

These protection and restoration needs could be met by establishing cooperative efforts between government and private agencies. This effort would coordinate implementation of existing restoration strategies and plans; develop and implement alternative land management practices on public lands to improve wetland habitat quality or promote habitat recovery; provide incentives to private landowners to implement desirable land use practices; establish additional incentive programs to encourage landowners to create and maintain saline emergent wetlands; and protect existing habitat areas from future degradation through acquisition of conservation easements or purchase from willing sellers.

LINK TO MSCS EVALUATED SPECIES

The MSCS has identified the following species as potentially benefitting from restoration of saline emergent wetland habitat in the Bay-Delta system:

MSCS SPECIES INCLUDED IN THE ERPP

- salt marsh harvest mouse
- California clapper rail
- steelhead
- delta smelt
- winter-run chinook salmon
- Mason's lilaeopsis
- Sacramento splittail
- fall-tun chinook salmon
- spring-run chinook salmon
- Suisun ornate shrew
- saltmarsh common yellowthroat
- San Pablo song sparrow
- Suisun song sparrow
- Sacramento perch
- San Pablo California vole
- longfin smelt
- delta tule pea
- soft bird's-beak
- Suisun thistle

OTHER SPECIES EVALUATED IN THE MSCS

- American peregrine falcon
- California black rail
- white-tailed kite
- Aleutian Canada goose
- tidewater goby
- black tern
- California seablite
- short-eared owl
- California gull
- long-billed curlew
- norther harrier
- Point Reyes bird's-beak
- Marin knotweed.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

The use of saline emergent wetland habitat here is similar to the Goals Project (1999) designation of tidal salt marsh and tidal brackish marsh, and Cowardin's (1979) emergent wetland classification.

Efforts to restore fresh emergent wetland habitat would involve cooperation with other wetland restoration and management programs. These include:

- Suisun Marsh Preservation Agreement,
- Natural Resources Conservation Service's Wetland Reserve Program,

- Wildlife Conservation Board's Inland Wetlands Conservation Program,
- restoration programs administered by Ducks Unlimited and the California Waterfowl Association,
- ongoing management of State and federal wildlife refuges and private duck clubs,
- and the San Francisco Bay Area Wetlands Ecosystem Goals Project.

Proposed ERPP targets are intended to be consistent with wetland habitat goals identified by the San Francisco Bay Area Wetlands Ecosystem Goals Project. Agencies or organizations with responsibility or authority for restoring wetland and aquatic habitats will be asked to cooperate. These include:

- U.S. Bureau of Reclamation,
- California Department of Water Resources,
- California Department of Fish and Game,
- U.S. Fish and Wildlife Service,
- California Coastal Conservancy,
- San Francisco Bay Area Conservancy Program,
- San Francisco Bay Conservation and Development Commission,
- San Francisco Bay Joint Venture,
- San Francisco Bay Regional Water Quality Control Board,
- and the Delta Protection Commission,

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Saline emergent wetlands are linked to other ecological elements in the Bay. Tidal exchange is an important ecological function that restores the proper salinity and nutrient balance and mixed fresh and estuarine waters.

Saline emergent wetlands are closely linked to open water areas and upland habitats. The value of each habitat is increase by the presence and quality of the adjacent types of habitats. A variety of aquatic and terrestrial fish, wildlife and plant communities depend on healthy saline emergent wetlands. These include numerous plant species and the salt marsh harvest mouse.

Saline emergent wetland are impaired by reduced seasonal inflow of fresh water, land use and loss of upland habitat, and introduction and proliferation of invasive salt marsh plant species.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

> The Strategic Objective is to restore large expanses of all major habitat types, and sufficient connectivity among habitats, in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay to support recovery and restoration of native species and biotic communities and rehabilitation of ecological processes.

LONG-TERM OBJECTIVE: Restore saline emergent wetlands in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay to a substantial fraction of their presettlement areas, or to a point where all at-risk species that depend on the habitats are no longer at risk.

SHORT-TERM OBJECTIVE: Inventory and prioritize for restoration diked former tidal marsh sites, develop techniques for restoration through implementation of pilot restoration projects, and begin implementation of large-scale manipulations of high priority areas, especially in the Suisun Marsh.

RATIONALE: Tidal wetlands are a diverse group of habitats included under Objective 1 and 2 in this series. However, they merit additional attention beyond those objectives because their restoration is urgently needed for the benefit of many species. They also represent, by acreage, some of the largest restoration projects that are likely to be attempted in the system. Restoration of tidal marshes in the Suisun Marsh and San Pablo Bay in particular will require innovation and a concerted and collaborative effort with existing landowners, because restoration of tidal action to one parcel may result in special levee rehabilitation needs on adjacent lands and because successful restoration of natural marsh building processes requires careful consideration of any potential site's elevation, topography, and geomorphology. Therefore, restoration will initially require pilot projects to ensure the success of larger scale tidal restoration projects.

STAGE 1 EXPECTATIONS: Ongoing efforts to restore large expanses of tidal marsh should continue and experimental pilot projects to restore tidal marshes to areas in the Suisun Marsh and San Pablo Bay should be undertaken.

RESTORATION ACTIONS

The general target for saline emergent wetland is to restore 7,000 to 11,000 acres in the Suisun Marsh/North San Francisco Bay Ecological Management Zone.

The following actions would help achieve–saline emergent wetlands restoration:

- restore tidal flows to diked wetlands by breaching dikes in suitable areas;
- establish desirable estuarine salinity gradients by managing water diversions and water releases from upstream reservoirs to control seasonal freshwater inflows to the Delta;
- balance seasonal flows from reservoirs for fisheries, water conveyance, flood control, and the needs of other habitats; and
- restore a more natural elevation gradient in wetlands to allow a greater diversity of native saline plant species, including special-status species, that are adapted to different elevations and provide a broader range of habitats for wildlife.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions to restore saline emergent wetlands that would help achieve species habitat or population targets.

- The geographic priorities for implementing actions to protect, enhance, and restore saline emergent wetlands and associated habitats for the Suisun ornate shrew should be: 1) western Suisun Marsh, 2) Napa Marshes and eastern Suisun Marsh, and 3) Sonoma Marshes and Highway 37 marshes west of Sonoma Creek.
- The geographic priorities for implementing actions to protect, enhance, and restore saline emergent wetlands and associated habitats for the San Pablo song sparrow should be: 1) Gallinas/Ignacio marshes and Napa marshes, 2) Sonoma Marshes, Petaluma Marshes, and Highway 37 marshes west of Sonoma Creek, 3) Point Pinole marshes, and 4) Highway 37 marshes east of Sonoma Creek.
- The geographic priorities for implementing actions to protect, enhance, and restore saline emergent wetlands and associated habitats for the Suisun song sparrow should be: 1) western Suisun Marsh, 2) eastern Suisun Marsh, and 3) Contra Costa County shoreline.
- The geographic priorities for implementing actions to protect, enhance, and restore saline emergent wetlands and associated habitats for the salt marsh harvest mouse should be: 1) western Suisun Marsh, 2) Gallinas/Ignacio Marshes, Napa Marshes and eastern Suisun Marsh, and 3) Sonoma Marshes, Petaluma Marshes and Highway 37 marshes west of Sonoma Creek, 40 Point Pinole Marshes, 5) Highway 37 marshes east of Sonoma Creek, and 6) the Contra Costa County shoreline.
- The geographic priorities for implementing actions to protect, enhance, and restore saline emergent wetlands and associated habitats for the California clapper rail should be: 1) Gallinas/Ignacio marshes and Napa Marshes, 2) Sonoma Marshes, Petaluma Marshes, and Highway 37 marshes west of Sonoma Creek, 3) Point Pinole Marshes, 4) Highway 37 marshes west of Sonoma Creek, and 5) the Contra Costa County shoreline.
- The geographic priorities for implementing actions to protect, enhance, and restore saline emergent wetlands and associated habitats for the California black rail should be: 1) western Suisun Marshes, 2) Gallinas/Ignacio marshes, Napa Marshes and eastern Suisun Marshes, 3) Sonoma Marshes, Petaluma Marshes, and Highway 37 marshes west of Sonoma Creek, 4) Point Pinole Marshes, 5) Highway 37 marshes west of Sonoma Creek, and 6) the Contra Costa County shoreline.

- The geographic priorities for implementing actions to protect, enhance, and restore saline emergent wetlands and associated habitats for the saltmarsh common yellowthroat should be: 1) Gallinas/Ignacio marshes and Napa Marshes, 2) Sonoma Marshes, Petaluma Marshes, and Highway 37 marshes west of Sonoma Creek, 3) Point Pinole Marshes, 4) Highway 37 marshes west of Sonoma Creek, and 5) the Contra Costa County shoreline.

- The geographic areas for implementing actions to protect, enhance, and restore saline emergent wetlands and associated habitats for Suisun song sparrow, San Pablo song sparrow, Suisun ornate shrew, San Pablo California vole, California clapper rail, California black rail, salt marsh harvest mouse, saltmarsh common yellowthroat include western Suisun Marshes, Gallinas/Ignacio marshes, Napa Marshes eastern Suisun Marshes, Sonoma Marshes, Petaluma Marshes, Highway 37 marshes west of Sonoma Creek, Point Pinole Marshes, Highway 37 marshes west of Sonoma Creek, and the Contra Costa County shoreline.

- Coordinate protection, enhancement, and restoration of saltmarsh and associated habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, and USFWS species recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.

- Initial Suisun ornate shrew recovery efforts should be directed to locations where there are immediate opportunities for protection, enhancement, and restoration of suitable habitat.

- To the extent practicable, direct ERP salt marsh enhancement efforts towards existing degraded marshes that are of sufficient size and configuration to develop fourth order tidal channels (marshes would likely need to be at least 1,000 acres in size).

- Restore wetland and perennial grassland habitats adjacent to emergent wetland habitats to create a buffer of natural habitat to protect populations of covered species form potential adverse affects that could be associated with future changes in land use on nearby lands and to provide habitat suitable for the natural expansion of populations.

- To the extent practicable, design dikes constructed in enhanced and restored saline emergent wetlands to provide optimal wetland to upland transitional habitat.

- Design salt marsh enhancements and restorations to provide low-angle upland slopes at the upper edge of marshes to provide for the establishment of suitable and sufficient wetland to upland transition habitat. To the extent feasible, transition habitat zones should be at least 0.25 miles in width.

- Identify and implement feasible methods for controlling invasive non-native marsh plants.

- Direct salt marsh habitat enhancements and restoration towards increasing habitat connectivity among existing and restored tidal marshes.

- To the extent practicable, direct ERP restorations to improve tidal circulation to diked wetlands that currently sustain partial tidal exchange.

- To the extent practicable, acquire, restore, and manage historic tidal salt marshes and surrounding land occupied by the San Pablo California vole along the west side of Point Pinole to tidal marsh with sufficient wetland to upland transition and adjacent upland habitat to improve habitat conditions for the San Pablo California vole.

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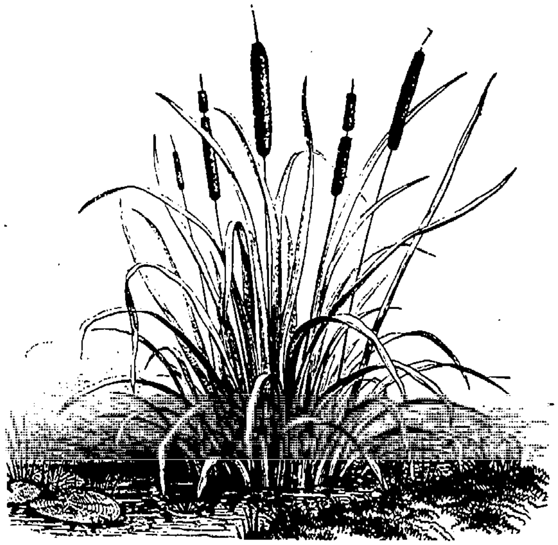
◆ Fresh Emergent Wetland



Introduction

Most fresh emergent wetlands in the Delta occur as narrow, fragmented bands. These fragmented wetlands appear along island levees, channel islands, shorelines and levee blowout ponds. Small areas of nontidal fresh emergent wetlands exist on Delta islands. These Delta island wetlands are primarily associated with agricultural infrastructure (e.g., drainage ditches), levee blowout ponds, and areas managed for wetlands (e.g., duck clubs). Fresh emergent wetlands also include natural non-tidal wetlands outside of the Delta and found throughout the ERP focus area.

Tidal and nontidal fresh emergent wetland habitats are important habitat areas for fish and wildlife dependent on marshes and tidal shallows and support several special-status plant species. The loss or degradation of historic fresh emergent wetlands has substantially reduced the habitat area available for associated fish and wildlife species. Major factors that limit this resource's contribution to the health of the Bay-Delta are related to adverse effects of wetlands conversion to agricultural, industrial, and urban uses.

Resource Description

Over the past 150 years, more than 300,000 acres of fresh emergent wetlands have been lost in the Sacramento-San Joaquin Delta Ecological Management Zone. Less than 15,000 acres remain.

Prior to the mid-1800s, extensive areas of fresh emergent habitat occurred throughout the Central Valley, particularly in the Delta. A complex network of rivers, sloughs, and channels connected low islands and basins that supported a diverse and dense variety of freshwater emergent vegetation. This freshwater emergent vegetation supported a diversity of fish and wildlife species and ecological functions.

> **Fresh Emergent Wetland Habitat** is included in the MSCS description of tidal freshwater emergent habitat and nontidal freshwater permanent emergent habitat. The MSCS tidal freshwater emergent habitat includes portions of the intertidal zones of the Delta that support emergent wetland plans species that are not tolerant of saline or brackish conditions. Tidal freshwater emergent habitat includes portions of the ERP delta slough, midchannel island, and fresh emergent wetland habitats. The MSCS nontidal freshwater permanent emergent habitat included permanent (natural and managed) wetlands, including meadows, dominated by wetland plant species that are not tolerant of saline or brackish conditions. Nontidal freshwater permanent emergent habitat included portions of the ERP fresh emergent wetland habitat. (Multi-Species Conservation Strategy 2000).

Vast areas of the Sacramento-San Joaquin Valley were commonly flooded in winter by a slow-moving blanket of silt-laden water. Flood control activities and land settlements in the late 1800s and early 1900s led to the development of leveed Delta islands. Levees and other land uses led to the loss of fresh emergent wetlands in the Delta. Loss of wetlands has substantially reduced habitat for wetland wildlife species in the Bay-Delta system. Fresh emergent wetland losses have also substantially reduced the area available for the biological conversion of nutrients in the Delta. The Delta contains insufficient wetland area to provide adequate levels of nutrient transformation, which results in lower quality water in San Francisco Bay.

Central Valley wetlands have experienced over a 95% reduction from historic extent. Though mostly managed wetlands remain, these areas are critical wintering grounds for migratory birds along the Pacific Flyway, even now supporting nearly 70% of the migratory ground for migratory birds along the Pacific Flyway. Wetlands in the central Valley are species rich and have probably supported the highest biomass of wildlife in California.

The loss of fresh emergent wetlands has substantially reduced the habitat of several plant and wildlife species. Some species being designated as California or federal special-status and threatened with local extermination. At least eight plant species, Suisun Marsh aster, California hibiscus, bristly sedge, Jepson's tule pea, Mason's lilaeopsis, marsh mudwort, Sanford's arrowplant, and marsh scullcap, are endemic to the Delta. Most of these plants are adapted to a complex tidal cycle and are typically found with more common vegetation such as tule, cattails, common reed, and a great diversity of other herbaceous plant species. Changes in habitat conditions have allowed the invasion of hundreds of non-native weedy plant species. Some of these species, such as water hyacinth, now clog waterways and irrigation ditches and reduce overall habitat quality for native plants and wildlife.

Over 50 species of birds, mammals, reptiles, and amphibians use fresh emergent wetlands in the Delta. Populations of some wildlife species that are closely dependent on fresh emergent wetlands, such as the California black rail, giant garter snake, and western pond turtle, have been substantially reduced in the Delta and designated as special-status species. A few wetland-associated species, such as waterfowl and egrets, have successfully adapted to foraging on some types of Delta croplands converted from historic wetland areas.

Isolating wetlands from tidal flows and removing Delta island fresh emergent wetlands changed the ecological processes that support wetlands. Removing the perennial water and vegetation from the organic soils of Delta islands resulted in soil oxidation and, subsequently, the subsidence of the interior islands. Loss of these tidal flow to islands has reduced habitat for native species of fish, plants, and wildlife; reduced water quality; and decreased the area available for floodwater dispersion and suspended silt deposition.

High water velocities in confined Delta channels continue to erode remaining fresh emergent wetland at a greater rate than habitat formation. Continued erosion reduces the amount of fresh emergent habitat changes the elevation of the land. Elevation affects the types of plant species that can grow depending on a species' ability to tolerate flooding. Flood protection and levee maintenance continue to impair wetland vegetation and prevent the natural reestablishment of fresh emergent wetlands in some locations.

Wind, boat-wake waves, and high water velocities in confined channels actively erode the soil needed to support remnant fresh emergent wetlands. Continued erosion of existing habitat, such as midchannel islands and levees and levee berms, is currently the primary cause of habitat loss in the Delta.

VISION

The vision is to increase the area and improve the quality of existing fresh emergent wetlands from degradation or loss and increase wetland habitat to assist in the recovery of special-status plant, fish, and wildlife populations, and provide high-quality habitat for other fish and wildlife dependent on the Bay-Delta.

Restoration of fresh emergent wetlands would focus on protecting and improving important existing wetlands, such as channel islands, and restoring wetlands in the Sacramento-San Joaquin Delta and Suisun Marsh/North San Francisco Bay Ecological Management Zones.

To prevent further loss of existing fresh emergent wetlands erosion rates must be reduced. Inchannel islands and levee berms are of particular concern. Erosion losses could be offset by allowing deposition and wetland establishment. Wetlands erosion could be reduced by reducing boat speeds where wetlands are subject to boat-wake-induced erosion (e.g., Snodgrass Slough). Constructing protective structures around eroding channel islands would weaken wave action (e.g., wave barriers and riprap groins) in a way that retains habitat value for fish and wildlife. Protecting inchannel islands from further erosion and connecting with larger islands would provide greater protection for this unique habitat.

Restoring fresh emergent wetland is dependent on local hydrological conditions (e.g., water depth, water velocity, and wave action); land elevation and slope; and the types and patterns of sediment deposition. The approach to restoring fresh emergent wetlands would include:

- reestablishing the hydraulic, hydrologic, and depositional processes that sustain fresh emergent wetlands and inchannel islands;
- restoring a full spectrum of wetland elevations to allow the establishment of a greater diversity of plant species, including special-status species adapted to different elevations within the tidal or water (nontidal sites) column;
- providing a broader range of habitats for wildlife; and
- including wetland habitats throughout the Central Valley in the ERP focus area.

Restoration of fresh emergent wetlands would be coordinated with restoration of other habitats to increase overall habitat values. Restoration would also include reestablishment of the full diversity of fresh emergent wetland plant associations to ensure that the habitat needs of special-status and other species that are dependent on specific vegetation associations are met.

Protecting and restoring fresh emergent wetlands could be accomplished by implementing elements of existing restoration plans such as Central Valley Habitat Joint Venture; expanding State and federal wildlife areas to create additional wetland complexes; improving management of existing and restoring additional fresh emergent wetlands on private lands; and reestablishing connectivity between the Delta and Delta islands, and between channels with their historic floodplains.

LINK TO MSCS EVALUATED SPECIES

The MSCS has identified the following species as potentially benefitting from restoration of fresh emergent wetland habitat in the Bay-Delta system:

MSCS SPECIES INCLUDED IN THE ERPP

- giant garter snake
- Central Valley steelhead
- delta smelt
- winter-run chinook salmon
- California black rail
- Mason's lilaeopsis
- Sacramento splittail
- Central Valley fall-run chinook salmon
- Central Valley spring-run chinook salmon
- Suisun ornate shrew
- Suisun song sparrow
- Sacramento perch
- longfin smelt
- green sturgeon
- delta mudwort
- delta tule pea
- rose-mallow, and
- Suisun marsh aster.

OTHER SPECIES EVALUATED IN THE MSCS

- American peregrine falcon
- Aleutian Canada goose
- Central Coast steelhead
- tidewater goby
- white-tailed kite
- short-eared owl
- California gull
- northern harrier
- white-faced ibis
- grasshopper sparrow
- long-billed curlew, and
- western burrowing owl.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Fresh emergent wetland habitat use here is similar to the Goals Project (1999) designation of managed marsh, Madrone Associates (1980) description of freshwater marshes, Moyle and Ellison's (1991) description of valley marsh, and Cowardin's (1979) designation of emergent wetland.

Efforts to restore fresh emergent wetland habitat would involve cooperating with other wetland restoration and management programs. These include:

- Agricultural Stabilization and Conservation Service's Wetland Reserve Program,
- Wildlife Conservation Board's Inland Wetlands Conservation Program,
- restoration programs administered by Ducks Unlimited and the California Waterfowl Association,

- and ongoing management of State and federal wildlife refuges and private duck clubs.

Restoration efforts would be conducted in cooperation with agencies or organizations with responsibility or authority for restoring wetland and aquatic habitats, including:

- California Department of Fish and Game,
- California Department of Water Resources,
- U.S. Fish and Wildlife Service,
- U.S. Army Corps of Engineers,
- and the Delta Protection Commission.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Fresh emergent wetlands are linked to other ecological elements in the ERPP study area. This type of habitat contributes to the aquatic foodweb by supporting nutrient transformation. Fresh emergent wetland also provides habitat for many wildlife and plant species. Some of these are designated California or federal special status species.

Stressors that have reduced the extent of fresh emergent wetlands include flood protection practices, levee construction, and the loss of tidal flow. Increased water velocities in Delta channels causes erosion of wetlands and changes the elevation of the land. Wind and boat wake erosion also contribute to the loss of soil needed to support fresh emergent wetlands in areas where midchannel islands and levee berms are present.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

The Strategic Objective is to restore large expanses of all major aquatic, wetland, and riparian habitats, and sufficient connectivity among habitats, in the Central Valley and its rivers to support recovery and restoration of native species and biotic communities and rehabilitation of ecological processes.

LONG-TERM OBJECTIVE: Restore fresh emergent wetlands in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay to a substantial fraction of their pre-settlement areas, or to a point where all at-risk species that depend on the habitats are no longer at risk.

SHORT-TERM OBJECTIVE: Inventory and prioritize for restoration diked former tidal marsh sites, develop techniques for restoration through implementation of pilot restoration projects, and begin implementation of large-scale manipulations of high-priority areas, especially on Delta islands.

RATIONALE: All major natural habitat types in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay have been reduced to a small fraction of the area they once occupied, resulting in a large number of at-risk plant and animal species and an increased susceptibility of the remaining areas to irreversible degradation (e.g., invasion by non-native species). The reduction trend is continuing and will have to be reversed if self-sustaining examples of these habitats, and the diverse organisms they support, are to persist into the future. This reversal will require a large number of diverse and localized actions, from levee setbacks to land acquisition to better management of existing sites. The major habitat types to be restored include tidal shallow water habitat, freshwater emergent wetland, channel islands and associated habitats, tidal sloughs, nontidal freshwater emergent wetlands, seasonal upland wetlands, vernal pools and surrounding uplands, riparian forests and associated upland areas, perennial grassland, and inland dune scrub. In order to make restoration actions systematic and cost-effective, specific objectives need to be established for each of the habitat types, as well as subsets of them that have distinctive biological characteristics, and then priorities set within each objective for protection and restoration activities.

STAGE 1 EXPECTATIONS: A classification system for Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay habitats that can be used as a basis for conservation actions will have been developed. Specific, numeric objectives should be formulated for each habitat type, with restoration objectives based on clearly stated conceptual models. Within and among habitat types, conservation and restoration activities should be prioritized. Work should begin on those projects given highest priority within a year of adoption of the strategic plan.

RESTORATION ACTIONS

The overall target for fresh emergent wetlands is to restore or recreate 30,000 to 45,000 acres in the Sacramento-San Joaquin Delta Ecological Management Zone.

Actions that would help restore fresh emergent wetlands include:

- Setbacks or breaches of island levees to allow water flows to reestablish wetlands with improved but limited ecological functions.
- Increase land elevations in the interior of Delta islands where subsidence has lowered land elevations below tidal emergent wetlands–
- Use substrate materials to create levee berms at elevations necessary for fresh emergent vegetation
- Modify, where consistent with flood control objectives, levee vegetation management practices to allow wetland vegetation to naturally reestablish.
- Reintroduce native wetland plants into suitable sites.

These protection and restoration strategies could be implemented by:

- establishing cooperative efforts between government and private agencies to coordinate the efficiency of implementing existing restoration strategies and plans;
- developing and implementing alternative land management practices on public lands to improve wetland habitat quality or promote habitat recovery, and provide incentives to private landowners to implement desirable land use practices;
- establishing additional incentive programs to encourage landowners to establish and maintain fresh emergent wetlands; and
- protecting existing habitat areas from potential future degradation through acquisition of conservation easements or purchase from willing sellers.

Restoration of stream meander belts and the process of overbank flooding along major tributaries to the Bay-Delta as proposed in the ERPP in other ecological management zones will also create the conditions necessary for the natural reestablishment of fresh emergent wetlands elsewhere in the Central Valley.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions to enhance or restore fresh emergent wetlands that would help achieve species habitat or population targets.

- To the extent consistent with CALFED objectives, direct ERP actions towards setting back levees in the south Delta to increase shallow water habitat.
- Restore and enhance delta smelt habitat to provide suitable water quality (i.e., low concentrations of pollutants) and substrates for egg attachment (submerged tree roots, branches, rock, and emergent vegetation) to spawning areas in the Delta: Barker, Lindsey, Cache, Prospect, Georgiana, Beaver, Hog, and Sycamore sloughs, and the Sacramento River in the Delta and tributaries of northern Suisun Bay.
- Coordinate protection, enhancement, and restoration of fresh emergent wetland habitats with other federal, state, and regional programs (e.g., USFWS recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- To the extent practicable, design restoration of tidal habitat to create unvegetated, exposed substrate habitat for Mason's lilaeopsis at tidal margins of tidal fresh emergent wetland and riparian habitats.
- Direct ERP salt and freshwater marsh enhancement efforts towards existing degraded marshes that are of sufficient size and configuration that are large enough to develop fourth order tidal channels (marshes would likely need to be at least 1,000 acres in size).

- To the extent practicable, design salt and freshwater marsh enhancements and restorations to provide low-angle upland slopes at the upper edge of marshes to provide for the establishment of suitable and sufficient wetland to upland transition habitat. To the extent feasible, transition habitat zones should be at least 0.25 mile in width.
- To the extent practicable, control non-native predator populations in occupied habitat areas and salt and freshwater marshes enhanced and restored under the ERP.
- Identify and implement feasible methods for controlling invasive non-native marsh plants.
- Monitor to determine use of restored salt and freshwater marsh habitats by California black rails and the rate at which restored habitats are colonized.
- A substantial portion of tidal wetlands to be restored under the ERP should be restored in the North Delta (the Yolo Basin and Bypass) to benefit giant garter snake.
- Identify and implement opportunities to restore suitable wetland habitat within ERP nontidal freshwater marsh restoration actions.
- Consistent with CALFED objectives, create unvegetated, exposed substrate at tidal margins of restored and created tidal fresh emergent wetland and riparian habitat to benefit delta mudwort.
- To the extent consistent with ERP objectives, design and manage wetland habitat restorations and enhancements to provide suitable nesting and foraging habitat conditions for dependent species.

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INTRODUCTION

Bay-Delta seasonal wetlands include vernal pools, wet meadows or pastures, lands that are seasonally flooded, federal refuges, privately owned waterfowl hunting clubs, and private environmental refuge lands, and seasonally flooded areas within a stream course or its floodplain. Historically, seasonal wetlands occurred throughout the Central Valley. Vernal pools and wet meadows are probably best described as specialized components of terrestrial habitats. The remaining seasonal wetland types are flooded for periods that are too long to support characteristic upland vegetation.

Seasonal wetlands and aquatic habitats are important habitat areas for many species of fish and wildlife. Loss or degradation of historic seasonal wetlands has substantially reduced the habitat area available for waterfowl, shorebirds, and other wildlife. The loss of seasonal aquatic floodplain habitat has substantially reduced refuge habitat for fish and spawning habitat for the Sacramento splittail. Loss of vernal pools seasonally flooded shallow areas, in particular, has directly resulted in the listing of several species as threatened or endangered under the federal Endangered Species Act.

Major factors that limit the contribution of this habitat type to the health of the Bay-Delta are related to adverse effects of land conversion, and substantial reductions in seasonal overbank flooding.

RESOURCE DESCRIPTION

Vernal pools and wet meadows are associated with soils (basalt flow, claypan, hardpan, volcanic ash-flow, volcanic mudflow, mesa, and plateau) that maintain standing water after winter and spring rains. In some areas of the Central Valley, high spring flows from the rivers and creeks saturate soils. Seasonal wetlands are created when puddles or small ponds form in depressions or standing water remains in low-lying grass fields after river flows recede. Although aquatic plants can establish in areas that are frequently flooded, upland plants cannot survive.

SEASONAL WETLANDS are included in two MSCS habitat descriptions: natural seasonal wetland and managed seasonal wetland. *Natural seasonal wetland habitat* includes vernal pools and other non-managed seasonal wetlands with natural hydrologic conditions that are dominated by herbaceous vegetation and annually pond surface water or maintain saturated soils at the ground surface for a portion of the year of sufficient duration to support facultative or obligate wetland plant species. Alkaline and saline seasonal wetlands that were not historically part of a tidal regime are included in natural seasonal wetlands. Natural seasonal wetland habitat includes portions of the ERP seasonal wetlands habitat. Managed seasonal wetland habitat includes wetlands dominated by native or non-native herbaceous plants, excluding croplands farmed for profit (e.g., corn and rice), that land managers flood and drain during specific periods to enhance habitat values for specific wildlife species. Ditches and drains associated with managed seasonal wetlands are included in this habitat type. Managed seasonal wetland habitat includes portions of the ERP seasonal wetlands habitat (Multi-Species Conservation Strategy 2000).

Wet meadows are grassy areas with saturated soils and standing water of varying depths that remain after winter and spring rains end. This habitat is conducive to the production of invertebrates. Invertebrates are the main food source of migrating waterfowl and other birds that periodically forage in these fields. Sandhill cranes forage and roost, and many ducks, geese, and shorebirds also commonly forage in wet meadows throughout the valley. During the dry seasons, many ground-nesting birds, such as pheasants and meadowlarks, nest in meadow grasses. Most wet meadow habitat remaining in the Central Valley, now composed almost entirely of non-native grasses, is used as pasture for livestock.

Vernal pools are often referred to as hog wallows or ponds. These pools are common in grasslands in northern Central Valley where the natural geomorphology remains relatively unchanged. Many State- and federally listed plants (including vernal pool plants), invertebrates, and wildlife, including the western spadefoot toad, California tiger salamander, and various fairy shrimp, are native to or associated with vernal pools. In addition, a variety of birds, including migrating waterfowl, shorebirds, and ground-nesting birds such as meadowlarks, commonly use seasonal wetlands habitat.

Seasonal wetlands play a vital role in the natural succession of plant communities. Seasonal wetlands that maintain surface water for long periods may support cattails, bulrushes, and sedges. Historically, these emergent plant species were probably prevalent along natural stream courses where long-standing water reduced the ability of upland species to establish. These types of wetlands provide the essential building blocks for the future establishment of riparian scrub and eventually riparian woodland. Beyond the normal river flows, wetlands probably formed where rains and high flows left areas too wet for terrestrial plants to establish. These wetland areas provided high-quality habitat for waterfowl, other migratory birds, shorebirds, red-legged frogs, giant garter snakes, tricolored blackbirds, and many other wildlife species.

The continued existence of these seasonal wetland types is closely linked to overall ecosystem integrity and health. Although many species that use seasonal wetlands are migratory (e.g., waterfowl and sandhill cranes), many others have evolved (e.g., spadefoot toad, fairy shrimp, and many specialized plants) and adapted to seasonal wetlands.

The extent and quality of seasonal wetlands has declined because of cumulative effects of many factors, including:

- modification of natural geomorphology such as ground leveling for agriculture and development,
- adverse effects of overgrazing,
- contamination from herbicides,
- establishment of non-native species that have an adverse effect on native wetland plants and wildlife,
- flood control and water supply infrastructure that reduces overbank flooding and floodplain size, and
- reduction of the natural underground water table that supported wetlands.

Existing wetland regulations have been in effect for several years in an attempt to prevent the further loss of wetlands. The protected status of wetlands has resulted in an extensive permitting process for construction in wetland areas. Mitigation measures have been developed to offset loss of existing wetlands as a result of construction activities. These efforts have slowed the rate of wetland loss in many areas. Large-scale efforts in areas such as the Suisun Marsh, Grasslands Resource Conservation District, Yolo Bypass, and Butte Sink have been successful in maintaining and restoring seasonal wetlands.

VISION

The vision is to increase the area and improve the quality of seasonal wetlands by restoring ecosystem processes that sustain them and reduce the effect of stressors that can degrade the quality of seasonal wetlands in order to assist in the recovery of special-status plant and animal populations and provide high-quality habitat for waterfowl, water birds, and other wildlife dependent on the Bay-Delta.

Restoration of seasonal wetlands will focus on protecting and improving important existing wetlands, reestablishing vernal pools within and adjacent to existing ecological reserves, and restoring seasonal wetlands in the Sacramento-San Joaquin Delta and Suisun Marsh/North San Francisco Bay Ecological Management Zones. Seasonal wetland restoration will be coordinated with restoration of other habitats, including shallow-water and riparian woodland and scrub. Restoration would include reestablishment of the full diversity of seasonal wetland plant associations to ensure that the habitat needs of special-status and other species that are dependent on specific vegetation associations are met.

Link to MSCS Evaluated Species

The MSCS has identified the following species as potentially benefitting from restoration of seasonal wetland habitats in the Bay-Delta system.

MSCS Species Included in the ERPP

- giant garter snake
- California red-legged frog
- California tiger salamander
- greater sandhill crane
- Swainson's hawk
- western spadefoot
- western pond turtle
- Delta green ground beetle
- mad-dog skullcap
- alkali milk-vetch
- recurved larkspur
- Boggs Lake hedge-hyssop
- Contra Costa goldfields
- Legenere
- Colusa grass, and
- Crampton's tuctoria.

Other Species Evaluated in the MSCS

- American peregrine falcon
- white-tailed kite
- tricolored blackbird
- short-eared owl
- California gull
- long-billed curlew
- norther harrier
- Conservancy fairy shrimp
- longhorn fairy shrimp
- Mid-valley fairy shrimp
- vernal pool fairy shrimp
- vernal pool tadpole shrimp
- grasshopper sparrow, and
- western burrowing owl.

Integration with Other Restoration Programs

Efforts to restore seasonal wetlands would involve cooperation with other restoration programs, including:

- Upper Sacramento River Fisheries and Riparian Habitat Council,
- Suisun Marsh Protection Plan,
- California Department of Fish and Game wildlife areas,
- U.S. Fish and Wildlife Service refuges,
- Jepson Prairie Preserve,
- Ducks Unlimited Valley Care Program,
- California Waterfowl Association,
- Cache Creek Corridor Restoration Plan,
- The Nature Conservancy,
- Putah Creek South Fork Preserve,
- Woodbridge Ecological Reserve,
- Yolo County Habitat Conservation Plan, and
- Central Valley Habitat Joint Venture.

Linkage with Other Ecosystem Elements

The description of seasonal wetland here is similar to the Goals Project (1999) description of grassland/vernal pool complex, Moyle and Ellison's (1991) floodplain pool and vernal pool classifications, Madrone Associates (1980) description of vernal pools, and Cowardin's (1979) classifications for seasonally flooded and intermittently flooded wetlands.

Seasonal wetlands are linked to other ecosystem elements in the ERP Study Area. Seasonal wetlands include wet meadows or seasonally flooded pastures, vernal pools, and federal, State, and privately owned refuges and hunting clubs. This habitat supports many species and communities of wildlife and plants.

The health and extent of seasonal wetlands is adversely influenced by land use, herbicide application, proliferation of non-native plant species, flood control practices, and lowering of ground water tables.

Objectives, Targets Actions, and Measures

One Strategic Objective for seasonal wetlands is to restore large expanses of all major aquatic, wetland, and riparian habitats, and sufficient connectivity among habitats, in the Central Valley and its rivers to support recovery and restoration of native species and biotic communities and rehabilitation of ecological processes.

Another Strategic Objective for seasonal wetlands is to restore large expanses of all major habitat types, and sufficient connectivity among habitats, in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay to support recovery and restoration of native species and biotic communities and rehabilitation of ecological processes.

LONG-TERM OBJECTIVE: Restore, protect and manage, throughout the watershed, multiple large areas of seasonal wetlands in association with other aquatic, wetlands, and riparian habitat types in the Central Valley and its rivers to a point where the wintering needs of waterfowl and shorebirds are met and all at-risk species that depend on the habitat are no longer at risk.

SHORT-TERM OBJECTIVE: Conserve the best examples of seasonal wetlands, particularly in the Bay-Delta, begin implementation of action plans for restoring significant, large areas of seasonal wetland.

RATIONALE: Restoring seasonal wetlands in combination with other wetland habitat types will help restore and maintain the ecological health of aquatic and terrestrial resources in the Delta and other areas of the Central Valley. Foodweb processes will be supported and the effects of contaminants reduced. Seasonal wetlands will provide high quality foraging and resting habitat for wintering waterfowl, greater sandhill cranes, and migratory and wintering shorebirds. Restoration of seasonal wetlands will occur as a by product of restoring floodplain processes in a manner that improves spawning habitat for fish species such as splittail while avoiding concurrent increases in non-native predatory fish. Furthermore, restoring other wetland habitats in the Delta, such as tidal emergent wetland and tidal perennial aquatic habitat, can reduce habitat values for species such as waterfowl and the State listed greater sandhill crane. Increasing seasonal wetlands in the Delta will ensure that any adverse impacts associated with those habitat losses will be fully mitigated.

Each habitat, including seasonal wetlands, supports a different assemblage of organisms and quite likely many of the invertebrates and plants are still unrecognized as endemic forms. Thus systematic protection of examples of the entire array of habitats in the region provides some assurance that rare and unusual aquatic organisms will also be protected, preventing contentious endangered species listings.

STAGE 1 EXPECTATIONS: Several large seasonal wetland projects will be initiated in the Delta. At least two of the projects will be associated with floodplain process restoration projects. At least two projects will be associated with restoring seasonal wetlands in heavily subsided areas where land elevations are too low to support actions to restore aquatic habitat.

RESTORATION ACTIONS

The general target for seasonal wetland habitat is to restore 30,000 acres in the Sacramento-San Joaquin Delta Ecological Management Zone and 1,000-1,500 acres in the Suisun Marsh/North San Francisco Bay Ecological Management Zone.

The following actions would help protect and restore seasonal wetlands:

- implement existing restoration plans;
- expand State and federal wildlife areas to create additional wetland complexes;
- improve management of existing wetlands and restore seasonal wetlands on private lands; and
- reconnect channelized streams and rivers with their historic floodplains.

The following actions would help implement protection and restoration strategies:

- establish cooperative efforts between government and private agencies to coordinate the efficiency of implementing existing restoration strategies and plans;
- develop and implement alternative land use practices that will protect grasslands containing vernal pools and wet meadows and allow existing, compatible land uses, such as grazing, to continue;
- develop and implement alternative land management practices on public lands to improve seasonal wetland habitat quality or promote habitat recovery, and provide incentives to private landowners to implement desirable land use practices;

- establish additional incentive programs to encourage landowners to establish and maintain seasonal wetlands;
- protect existing habitat areas from potential future degradation through acquisition of conservation easements or purchase from willing sellers; and
- set back or breach levees and dikes to create the hydrologic conditions necessary for establishing seasonal wetland vegetation.

Restoration of stream meander belts and the process of overbank flooding along major Bay-Delta tributaries proposed in the ERP in other ecological management zones will also create the conditions necessary for the natural reestablishment of seasonal wetlands elsewhere in the Central Valley.

MSCS Conservation Measures

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions to enhance or restore seasonal wetland habitat that would help achieve species habitat or population targets.

- To the extent practicable, design restored seasonal wetlands in habitat areas occupied by Swainson's hawk to provide overwinter refuge for rodents to provide source prey populations during spring and summer.
- Incorporate restoration of permanent or seasonal flooded (April-October) suitable habitat areas for giant garter snake as part of a mosaic of the seasonal wetland and agricultural land enhancements to be implemented under the ERP.

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◆ RIPARIAN AND RIVERINE AQUATIC HABITATS

INTRODUCTION

Habitats associated with shorelines of rivers and the Delta include riparian and shaded riverine aquatic habitat. Riparian vegetation includes scrub, woodland, and forest habitats that support a great diversity of wildlife species. Riverine aquatic habitat shaded by riparian vegetation, is important habitat for many species of fish, waterfowl, and wildlife.

Major factors that limit these habitats' contribution to the health of the Bay-Delta include historic riparian vegetation loss or degradation and near-shore aquatic habitat alteration from channelization, stabilization of channel banks with riprap, construction of levees, and control of flows.

Restoring riparian and riverine aquatic habitats will involve reactivating or improving natural physical processes. Natural streamflows, stream meanders, and sediment transport create and sustain these habitats and increase the complexity and structural diversity of the habitat. Natural streamflow patterns help sculpt healthy riparian and riverine aquatic habitats. High winter and spring flows trigger seed dispersal and germination, move sediment, stimulate stream meander, and flood and scour riparian and riverine habitat.

Natural stream channel meanders (often termed "meander belts") provide healthy, high-quality riparian and riverine aquatic habitats. Channelizing rivers (e.g., constructing levees), protecting banks (e.g., adding riprap), and channel dredging hinder natural stream meander and natural river channel morphology.

Natural sources of gravel and other sediments along rivers and floodplains provide materials needed to create and sustain healthy riparian and riverine aquatic habitats. Where improvement to physical processes do not adequately restore riparian and riverine habitats, direct modification may be necessary to restore habitats to their target acreage and quality.

> **Riparian and Riverine Aquatic Habitats** are included in the MSCS description of *valley/foothill riparian habitat.* Valley/foothill riparian habitat includes all successional stages of woody vegetation generally dominated by willow, Fremont cottonwood, valley oak, or sycamore within the active and historical floodplains of low-gradient reaches of streams and rivers generally below an elevation of 300 feet. Valley/foothill riparian habitat includes portions of the ERP riparian and riverine aquatic habitat (Multi-Species Conservation Strategy 2000).

A major increase in floodplain riparian habitat will contribute sediment and nutrient to the rivers and estuaries. It will also improve the foodweb, and provide critical habitat for threatened and endangered terrestrial wildlife species, such as the yellow-billed cuckoo and Swainson's hawk. More extensive and continuous riparian forest canopy on the banks of estuaries and rivers will stabilize channels; help to shape submerged aquatic habitat structure; benefit the aquatic environment by contributing shade, overhead canopy, and instream cover for fish; and reduce river water temperature. More extensive and continuous shoreline vegetation associated with woody debris (branches and root wads) and leaf and insect drop in shallow aquatic habitats will increase the survival and health of juvenile salmonids, resident Delta native fishes, and introduced resident fishes. Achieving this objective will also greatly enhance the scenic quality and recreational experience of our Delta and riverine waterways.

Resource Description

Riparian habitats include the trees, shrubs, vines, herbaceous undergrowth, and organic material and snags along estuaries. These habitat elements combine to create the complex variety of species mixes, age classes, and distribution patterns common to shoreline vegetation. The landforms and changing fluvial streamflow patterns processes that create and interact with riparian vegetation are also an important but often overlooked part of the habitat.

Historically, the Central Valley floor had approximately 922,000 acres of riparian vegetation (Katibah 1984) supported by a watershed of more than 40,000 square miles. Today, approximately 100,000 acres of riparian forest remain. About half of this riparian habitat is in a highly degraded condition, representing a decline of 90% (Katibah 1984). The Sacramento River once supported 500,000 acres of riparian forest; it now supports 10,000-15,000 acres, or just 2-3% of historic levels (McGill 1979, 1987). From about 1850 to the turn of the century, most of the forest was destroyed for fuel as a result of the Gold Rush and river navigation, and by large-scale agricultural clearing.

Additional clearing in early and mid 1900s coincided with the aftermath of flood control reservoir and levee projects. These projects allowed ongoing clearing of floodplain riparian stands for orchards, crops, flood bypasses, levee construction, and urban areas. Similar patterns occurred along the San Joaquin River, which was also greatly affected when major portions of the river were dried up following construction of Friant Dam and other large reservoirs in the San Joaquin Basin. Resulting major changes in river flow conditions and sediment deposits triggered channel instability, and downcutting of rivers and streams that caused additional riparian and riverine habitat loss and fragmentation.

Riverine aquatic habitats comprise the relatively shallow submerged and seasonally flooded areas in estuary and river channel beds. Channel beds contain gravel beds, bars, and riffles; transient sandy shoals; waterlogged woody debris piles; and the shaded riverine aquatic habitat zone. The shaded riverine aquatic habitat is located where the river meets the riparian canopy. Riverine aquatic zones provide spawning substrate, rearing and escape cover, feeding sites, and refuge from turbulent stormflows for fish and other aquatic organisms.

The condition of riverine aquatic and nearshore habitats is not well documented for most of Central Valley and Delta estuaries, rivers, and streams. The condition of these habitats has been degraded by channel straightening; channel incising; channel dredging and clearing; instream gravel mining; riparian zone grazing; flow modifications; removal and fragmentation of shoreline riparian vegetation; and the loss of sediment, bedload, and woody debris from watershed sources upstream of dams.

Riparian and riverine aquatic habitats are created and sustained by natural fluvial processes associated with rivers. Fluvial dynamics are affected by the presence and pattern of riparian vegetation. Vegetation patterns define and contribute to riparian and riverine aquatic ecosystem structure and functions.

In general, riparian and riverine aquatic habitats are healthiest where ecosystem processes are in the most unaffected natural state. These sites are also the most resilient to human and natural disturbance. Ecosystem processes that are integral components of riparian and riverine aquatic habitats are described in greater detail in the ecosystem restoration visions for stream meander corridors, floodplains, natural geomorphology and sediment supply.

Sediment transport, deposition, and scour support, succession, and regeneration of riparian vegetation. These secondary processes require frequent high flow events in winter and spring. These frequent high flows redistribute sediment and bedload. After new vegetation is established on sediment bars and freshly deposited floodplains, the primary physical factors that sustain riparian vegetation are adequate streamflow, winter inundation of the floodplain, and shallow groundwater during the dry season.

Sediment transport and deposition, are also the processes that create and replenish riverine aquatic habitats. A high-quality aquatic habitat requires a continuous supply of sediment. Riverflows must periodically be high enough and of sufficient duration to move streambed materials.

Sediment deposits are shaped, in part, by riparian vegetation. Riparian vegetation resists flow and causes fine sediment to aggrade within the dense stems. Riparian vegetation also redirects flows and causes the channel water to scour the bed. Scouring action forms pools, riffles, and bar patterns. Away from high-energy estuary channels, tidal mudflats form in broad, low-velocity areas when shoals of organic-rich fines are deposited.

Riparian vegetation serves many important ecological functions. Riparian vegetation absorbs nutrients and produces primary and secondary biomass at very high rates. This biomass feeds numerous fish and wildlife species. Birds and small mammals nest and take cover in the protective canopy foliage of trees. Trees also shade and cool floodplains and channels. Channel velocities are slowed by riparian foliage, allowing sediment to settle and create new landforms. Riparian foliage also stabilizes channels and banks, thereby rendering the characteristic geomorphology of estuaries, rivers, and streams.

Primary stressors affecting riparian habitats include:

- channel straightening and clearing;
- levee construction and bank hardening to protect bridge abutments and diversion structures (e.g., with riprap);
- instream gravel mining and riparian zone grazing;
- flow modifications affecting sediment transport and spring germination;
- removal, burning, and fragmentation of mature riparian vegetation; and
- loss of sediment and bedload from watershed sources upstream of dams.

Other stressors increasing in importance and magnitude include:

- displacement by invasive non-native trees and shrubs (e.g., tamarisk and giant reed),
- new expansion of orchards and vineyards into the riparian floodplain,
- human-set fires along river parkways,
- unusually high summer stage in rivers that supply increasing demand for downstream water diversions,
- groundwater lowered below the root zone, and
- expanded clearing of channel vegetation in response to recent flood events that called into question the capacity of levee-confined rivers and streams.

Most stressors have an indirect but lasting effect on the physical structure and post-disturbance recovery of streambed habitat. Collectively, these stressors have substantially reduced the quality and resilience of riverine aquatic habitats, thereby diminishing their effectiveness in providing for the life cycle requirements of fishes of the Delta and Sacramento and San Joaquin rivers and their tributaries.

VISION

The vision for riparian and riverine aquatic habitats is to increase their area and protect and improve their quality to assist in the recovery of special-status fish and wildlife populations and provide high-quality habitat for other fish and wildlife dependent on the Bay-Delta.

The vision includes restoring native riparian communities ranging from valley oak woodland associated with higher, less frequently inundated floodplain elevations to willow scrub associated with low, frequently inundated floodplain elevation sites such as streambanks, point bars, and inchannel bars.

The simple preservation of remaining natural riparian areas and riverine aquatic zones will not ensure the diversity, and resilience of these habitats. Preservation alone is not adequate because of the scarcity, degradation, and fragmentation of existing river and estuary systems. Most riparian restoration projects in the Central Valley have been implemented on a relatively small scale, primarily as mitigation for project impacts or infill of existing protected preserves. The National Research Council (1992) has recommended a national strategy for restoring rivers and aquatic ecosystems through integrated restoration of large landscape units.

If the floodplain, meander width, sediment supply, and natural spring flows are in place, the river will respond by creating natural landforms. These landforms will support self-sustaining vegetation communities and streambed habitats. Even partial restoration or simulation of natural physical processes and floodplains will amplify ecosystem characteristics and resultant habitat quality. Rivers and Delta estuaries where natural fluvial processes and landforms are relatively intact need to be identified and highlighted as potential reserves of riparian and riverine habitat. Complete restoration on many segments may be limited by unalterable levee confinement and bridge crossings.

Restoring riparian and riverine aquatic habitat depends on recovery or simulation of natural fluvial processes and landforms. Revegetating and artificially altering stream channels will be considered only where overwhelming limitations prevent natural recovery of these physical processes and ecosystem functions.

LINK TO MSCS EVALUATED SPECIES

The MSCS has identified the following species as potentially benefitting from the restoration of riparian and riverine aquatic habitat in the Bay-Delta system:

MSCS SPECIES INCLUDED IN THE ERP

- Least Bell's vireo
- giant garter snake
- California red-legged frog
- valley elderberry longhorn beetle
- riparian brush rabbit
- little willow flycatcher
- western yellow-billed cuckoo
- Swainson's hawk
- San Joaquin Valley woodrat
- California yellow warbler
- western pond turtle, and
- foothill yellow-legged frog.

OTHER SPECIES EVALUATED IN THE MSCS

- bald eagle
- Alameda whipsnake
- ringtail
- white-tailed kite
- golden eagle
- greater western mastiff-bat
- yellow-breasted chat
- long-eared owl
- short-eared owl
- Cooper's hawk
- osprey
- double-crested cormorant
- marsh checkerbloom, and
- Delta coyote-thistle.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to achieve the vision for riparian and riverine aquatic habitats may involve coordination with other programs. These include:

- U.S. Army Corps of Engineers' proposed reevaluation of the Sacramento River flood control project and ongoing bank protection project, including more comprehensive floodplain management and river ecosystem restoration opportunities;
- SB1086 Advisory Council efforts and river corridor management plan for the Sacramento River;
- the San Joaquin River Parkway and Management plans;
- proposed riparian habitat restoration and floodplain management and riparian restoration studies for the San Joaquin River, including potential new flood bypass systems and expanded river floodplains on lands recently acquired by State and federal agencies and land trusts;
- ongoing Sacramento Valley conservation planning by The Nature Conservancy and other private nonprofit conservation organizations;
- expansion plans and conservation easements underway for the Sacramento River National Wildlife Refuge and California Department of Fish and Game's Sacramento River Wildlife Management Area;
- ongoing coordination efforts and programs of the Wildlife Conservation Board, including the Riparian Habitat Joint Venture;
- all county-sponsored instream mining and reclamation ordinances and river and stream management plans;
- and the California Department of Conservation reclamation planning assistance programs under the Surface Mining and Reclamation Act.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Riparian and riverine aquatic habitat used here is similar to the Goals Project (1999) description of riparian forest, willow grove, oak woodland, and mixed evergreen forest, Madrone Associates (1980) designations of riparian habitats including riparian woodland, riparian shrub-brush, brushy riprap, and herbaceous banks, and Cowardin's (1979) classifications of scrub/shrub wetland and forested wetland.

Riparian and riverine aquatic habitats are closely linked to the ecological health of many Ecological Management Zones and Units. This type of habitat is important to many fish, wildlife, and plants species and communities. It is adversely affected by many stressors that include levee construction, gravel mining, flow patterns, fragmentation of existing stands of riparian vegetation, competition and displacement by non-native plant species, land use and conversions, fires, lowered groundwater levels, and removal to increase flood control channel capacity.

OBJECTIVES, TARGETS ACTIONS, AND MEASURES

One Strategic Objective is to restore large expanses of all major aquatic, wetland, and riparian habitats, and sufficient connectivity among habitats, in the Central Valley and its rivers to support recovery and restoration of native species and biotic communities and rehabilitation of ecological processes.

Another Strategic Objective for riparian and riverine aquatic habitat is to restore large expanses of all major habitat types, and sufficient connectivity among habitats, in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay to support recovery and restoration of native species and biotic communities and rehabilitation of ecological processes.

LONG-TERM OBJECTIVE: Restore, protect and manage, on a self-sustaining basis throughout the watershed, multiple large areas containing all aquatic, wetland, and riparian habitat types in the Central Valley and its rivers to a substantial fraction of their pre-settlement areas or to a point where all at-risk species that depend on the habitats are no longer at risk.

SHORT-TERM OBJECTIVES: Systematically identify and locate the best remaining areas containing the aquatic, wetland, and riparian habitat types, and prioritize them for conservation. Develop and begin implementation of action plans for restoring significant examples of each habitat type.

RATIONALE: Moyle and Ellison (1991) and Moyle (1996) developed a scheme for classifying the aquatic habitats of California for the purposes of conservation. Other classification schemes of aquatic habitats also exist, as do schemes for classifying riparian and wetland habitats. Whatever the system, it is obvious that the diversity of aquatic habitats is declining in Central Valley watersheds, especially in lowland areas. Each habitat supports a different assemblage of organisms, and quite likely many of the invertebrates and plants are still unrecognized as endemic forms. Thus, systematic protection of examples of the entire array of habitats in the region provides some assurances that rare and unusual aquatic organisms will also be protected, preventing contentious endangered species listings.

STAGE 1 EXPECTATIONS: A classification system for riverine and riparian habitats that can be used as a basis for conservation actions will have been developed. Inventory of habitat types should be completed and areas prioritized for conservation actions. Restoration actions should be evaluated and initiated where feasible.

RESTORATION ACTIONS

General restoration targets for riparian and riverine aquatic habitat include acquisition of easements or in-fee title to 16,000 to 24,000 acres of riparian lands in the stream meander zone along the Sacramento River between Red Bluff and Colusa and the acquisition or protection of riparian corridors along most of the streams and rivers throughout the ERP Study Area.

Recovery and simulation of natural fluvial processes and landforms will be accomplished using the following integrated steps:

- locating setback levees to expand potential riparian floodplain;
- expanding the storage, detention, and bypass capacity of the Sacramento and San Joaquin River flood control project to allow natural expansion of riparian vegetation within levees and the Sutter and Yolo bypasses; and
- designating, acquiring title or easements for, and deliberately managing river corridor meander zones on appropriate rivers and stream throughout the Central Valley.

The following actions would restore or enhance sediment supply to rivers and streams:

- reduce bank hardening by creating meander zones and widening floodplains;
- analyze alternative approaches for water diversions and associated intake and screening facilities on the mainstem river to avoid hardening the bank in some sections of the river;
- remove small, nonessential dams on gravel-rich streams;
- eliminate mining in streams and on low floodplains near channels; and
- widen bridges to broaden out-of-bank flow and eliminate the need to riprap vulnerable bridge abutments.
- breach or remove nonessential levees restricting former tidelands that would capture sediment needed to create tidal mudflats and estuary landforms.

These measures will significantly increase the extent and distribution of shallow-water and nearshore habitats. These habitats are productive generators of the Delta foodweb and provide essential new rearing habitat for juvenile Delta and anadromous fish. Where Delta land elevations are suitable, levee systems can be set back or altered to allow out-of-bank shallow flooding during high flood stage. Floodplain inundation will also provide additional flood storage and moderation of peak flows to decrease the risk of flooding elsewhere in the Delta. Foodweb support, spawning and rearing habitat for native fish (e.g., splittail), would be further enhanced by altering levees.

Opportunities for reducing riparian habitat stressors include:

- phasing out instream gravel mining;
- designating and acquiring "stream erosion zones" to reduce the use of bank riprap and allow greater natural recolonization;
- designing biotechnical slope protection measures that allow riparian vegetation to be established within levees;
- phasing out or reducing livestock grazing in riparian zones;
- establishing conservation easements for purchase of land or using other incentives to reduce or eliminate cropland conversion of riparian forest;
- eliminating or modifying programs which remove large woody debris from stream channels and rivers;
- identifying levee-confined channels and banks where routine vegetation removal by local reclamation districts can be safely discontinued; and
- establishing weed control programs to suppress the expansion of tamarisk, giant reed, locust, and other invasive non-native plants degrading habitat quality and native flora.

Opportunities for reducing stressors affecting riverine aquatic habitat include:

- phasing out instream gravel mining, especially downstream of dams and on streams that support salmon and steelhead spawning;
- designating and acquiring "stream erosion zones" to reduce the use of bank riprap and allow natural meander patterns;
- designing slope protection measures that allow shoreline riparian vegetation to be established within levees;
- phasing out or reducing livestock grazing in riparian and aquatic zones, especially on tributary streams that support salmon and steelhead spawning; and
- identifying levee-confined channels and banks where routine channel clearing and grading can be safely discontinued.

Reservoir operations will be evaluated to determine whether winter and spring releases can be augmented with flood simulation spikes every 1-10 years.

Simulated flood spikes would mobilize bed and bank deposits to redistribute, sort, and clean spawning gravels and scour deep pools between riffles.

Restoring riparian and riverine aquatic habitat should be accomplished by eliminating the stressors and recovering or simulating the physical processes and fluvial landforms described above. Habitat restored in this way will be more resilient to future disturbances; require little or no long-term maintenance; be self-sustaining; and be more compatible with flood control requirements.

However, habitat fragmentation and severe limitations of the physical environment will not allow ecosystem processes and functions to fully recover on many segments of valley streams and Delta estuaries. In these situations, some large-scale stream channel sculpting, gravel additions, and riparian replanting may be necessary. For example, the lower Sacramento River has abandoned river floodplains and sediment is in short supply. Naturally reactivating these habitats would be nearly impossible. Restoring these habitats would require human intervention. Revegetation projects should be contemplated only where native trees and grasses may no longer germinate naturally but have a high probability of unaided survival and vigorous growth following 1-5 years of artificial irrigation.

MSCS Conservation Measures

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions to enhance and restore riparian and riverine aquatic habitats that would help achieve species habitat or population targets.

- Provide suitable water quality (i.e., low concentration of pollutants) and substrates for delta smelt, longfin smelt, and splittail egg attachment (submerged tree roots, branches, rock, and emergent vegetation) to important spawning areas.
- Implement management measures identified in the proposed recovery plan for the Sacramento River winter-run chinook salmon.
- Coordinate protection and restoration of riparian habitats with other federal and state programs (e.g., U.S. Fish and Wildlife Service recovery plans, the SB 1086 program, and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of occupied and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Coordinate protection and restoration of riparian brush rabbit populations and its habitat with other federal and state programs (e.g., U.S. Fish and Wildlife Service recovery plans) that could affect management of occupied and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Coordinate protection and restoration of San Joaquin Valley woodrat populations and its habitats with other federal and state programs (e.g., U.S. Fish and Wildlife Service recovery plans and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of occupied and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Coordinate protection and restoration of riparian habitat areas with other federal and state programs (e.g., the Riparian Habitat Joint Venture, the SB 1086 program, and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of occupied and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Coordinate protection and restoration of riparian habitats for the least Bell's vireo with other federal, state, and non-profit programs (e.g., the least Bell's vireo recovery plan team, Riparian Habitat Joint Venture, and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of occupied and historic habitat use areas to avoid potential conflicts among management objectives and identify

opportunities for achieving multiple management objectives.

- Within the current range of valley elderberry longhorn beetle, design ERP riparian habitat enhancements and restorations to include suitable riparian edge habitat, including elderberry savanna.
- Initially direct ERP riparian habitat actions towards enhancement and restoration of habitat areas located near habitat occupied by valley elderberry longhorn beetle to encourage the natural expansion of the species range.
- Direct ERP actions proposed for the Stanislaus River towards protecting, enhancing, and restoring suitable riparian and associated flood refuge habitats for riparian brush rabbit and San Joaquin Valley woodrat in and adjacent to occupied habitat at Caswell Memorial State Park.
- Direct ERP actions proposed for the Stanislaus River towards protecting and enhancing existing occupied habitat areas; restoring suitable habitat adjacent to occupied habitat areas; and restoring suitable riparian habitat to create habitat corridors linking isolated populations of San Joaquin Valley woodrat.
- Consistent with Program objectives, protect existing suitable riparian habitat corridors from potential future changes in land use or other activities that could result in the loss or degradation of bank swallow habitat.
- A portion of restored riparian habitat area should be designed to include riparian scrub communities.
- Restore riparian habitats in patch sizes sufficient to discourage nest parasitism by brown-headed cowbirds.
- Proposed ERP actions to restore valley/foothill riparian habitat should initially be implemented in the Delta for Swainson's hawk.
- Initially restore suitable valley/foothill riparian forest and woodland under the ERP along at least 10 contiguous miles of channels in the Delta to create a riparian forest corridor at least 200 meters in width for western yellow-billed cuckoo.
- Restore large contiguous blocks of suitable valley/foothill riparian forest and woodland at least 200 meters in width and 500 acres in size along reaches of the Sacramento River adjacent to habitat occupied by the yellow-billed cuckoo (Red Bluff to Colusa).

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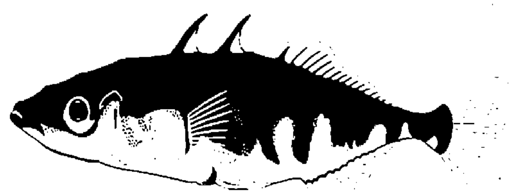

INTRODUCTION

Freshwater fish habitats and native fishes are closely linked in the Central Valley as the health of native fish populations is largely dependent on the health of their habitats. The Sacramento-San Joaquin drainage system's large size, diversity of aquatic habitats, and isolation from other systems have provided a basis for freshwater fish speciation (Moyle 1976). Seventeen fish species evolved and live in the system. In addition, the diversity of habitats present in the Central Valley support a variety of native resident fish species, native anadromous species, native marine species, and an ever increasing number of introduced species.

The diversity of habitats include clear headwater streams that support rainbow trout, small warm tributaries and larger streams that flow through open foothill oak woodlands and support California roach, streams with average summer flows of 300 cfs or more and support squawfish, suckers, and hardheads, sluggish river channels, oxbow and floodplain lakes, and sloughs that support or supported Sacramento perch, hitch, and tule perch (Moyle 1976).

The designation of these habitats is important to allow the systematic protection of biological diversity within distinct geographic regions. The application of such a conservation-oriented classification system is of particular importance in the Central Valley where a rapidly growing human population and large tracts of irrigated agriculture compete with aquatic organisms for water (Moyle and Ellison 1991).

RESOURCE DESCRIPTION

Freshwater fish habitats complement the other habitats described in this volume. In general, the proposed freshwater fish habitat designations are based on a hierarchical classification system (Moyle and Ellison 1991) developed to provide a structure for conservation efforts and is based on fish distribution and endemism.

This classification system has additional utility as it assumes that observations of fishes are representative of less well-known aquatic organisms such as insects and amphibians.

Major habitat classifications for the Central Valley include standing waters, flowing waters, and artificial habitats.

> **Essential Fish Habitat** is consistent with the MSCS designations of valley riverine and montane riverine aquatic habitats. Valley riverine aquatic habitat included the water column of flowing streams and rivers in low-gradient channel reaches below an elevation of approximately 300 feet that are not tidally influenced, including associated shaded riverine aquatic, pool, riffle, run, and unvegetated channel substrate (including seasonally exposed channel beds) habitat features, and sloughs, backwaters, overflow channels, and flood bypasses hydrologically connected to stream and river channels. Montane riverine aquatic has the same description as valley riverine aquatic except is includes the areas above 300 feet elevation.

STANDING WATERS

This classification included ephemeral waters such as floodplain and vernal pools, and permanent waters such as lakes, sloughs, oxbow lakes, and backwaters. Floodplain pools are shallow pools and ponds resulting from receding floodwaters of the Sacramento and San Joaquin rivers and their major tributaries. These waters often support fish and other aquatic organisms early in the season but can become detrimental as they gradually become too warm to support fish and typically evaporate by late summer.

Vernal pools in the Central Valley are northern claypan pools. They are shallow, temporary pools formed in depressions that hold winter and spring rainfall. These pools support a rich variety of invertebrates and flowering plants. The larger pools may support tiger salamander and spadefoot larvae.

Permanent waters supporting fish are found throughout the Central Valley. These areas resulted from the meandering of the Sacramento and San Joaquin rivers which created oxbow lakes, backwater areas, and sloughs.

FLOWING WATERS

Flowing water fish habitats include the following classifications: resident trout streams, salmon-steelhead streams, and low elevation streams.

Resident trout streams include resident rainbow trout streams and rainbow trout/cyprinid streams. Resident rainbow trout streams are low order, cold, high gradient streams dominated by rainbow trout and riffle sculpins. Rainbow trout/cyprinid streams are small streams of moderate gradient supporting rainbow trout and one or more species of native minnows such as California roach or Sacramento sucker.

Salmon-steelhead streams include spring chinook streams and steelhead streams. Spring chinook streams are third to fifth order streams at elevations of 500-1500 m with deep canyons containing deep, cold pools that can sustain spring-run chinook salmon through the summer. Steelhead streams are second to fourth order streams used by steelhead for spawning and are dominated by juvenile steelhead.

Low elevation streams include valley floor rivers, fall chinook spawning stream, hardhead/squawfish streams, hitch streams, and California roach streams. Valley floor rivers include the main channels of the Sacramento and San Joaquin rivers, and the lower reaches of their tributary streams. Much of the flow is sluggish in summer and considerable cover is provided by woody debris and shaded riverine aquatic habitat. These low elevation streams flood seasonally and support a wide variety of fishes. Fall chinook salmon spawning streams are low elevation, low gradient tributaries to major rivers that dry up in summer but are used for spawning by both anadromous and resident fish species. Hardhead/squawfish stream are low- to mid-elevation streams characterized by deep, bedrock pools, clear water, and cool temperatures. The typical assemblage of fish include hardhead, Sacramento squawfish, and Sacramento sucker. Hitch streams are warm, low-elevation streams with low to moderate current and long reaches with sandy bottoms. Typical fish assemblages include hitch and

Freshwater Fish Habitats

Standing Waters

- ephemeral waters
  - floodplain pools
  - vernal pools
- permanent waters
  - lakes
  - sloughs
  - oxbow lakes
  - backwaters

Flowing Waters

- resident trout streams
  - resident rainbow trout streams
  - rainbow trout/cyprinid streams
- salmon-steelhead streams
  - spring chinook streams
  - steelhead streams
- low elevation streams
  - valley floor rivers
  - fall chinook spawning streams
  - hardhead/squawfish streams
  - hitch streams
  - California roach streams

Artificial Habitats

- ephemeral waters
  - rice paddies
  - wildlife refuges
  - drainage and evaporation ponds
  - seasonally irrigated lands
- permanent waters
  - cold water ponds
  - warm water ponds
  - ornamental ponds
  - cold water reservoirs
  - cool water stratified reservoirs
  - warm water reservoirs
  - run-of-river reservoirs
  - forebays
  - flooded pit lakes
- flowing waters
  - aqueducts
  - drainage ditches
  - irrigation ditches
  - flood control bypasses

Sacramento blackfish, although Sacramento squawfish and Sacramento sucker and other species may be present. California roach streams are small, clear, mid-elevation second, third, or fourth order streams that typically contain deep pools in canyons and are often intermittent in flow by late summer. The dominant species is California roach but juveniles of Sacramento squawfish and Sacramento sucker may be present.

ARTIFICIAL HABITATS

Artificial habitats include ephemeral water, permanent waters and flowing waters. Given the high development within the Central Valley and the development of water resources, it is not surprising that artificial habitats provide a significant amount of habitat.

Ephemeral water include rice paddies, wildlife refuges, drainage and evaporation ponds, and seasonally irrigated lands. Permanent waters include cold water ponds, warm water ponds, ornamental ponds, cold water reservoirs, cool water stratified reservoirs, warm water reservoirs, run-of-river reservoirs, forebays, and flooded pit lakes such as gravel and rock quarries. Flowing waters include aqueducts, drainage ditches, irrigations ditches, and flood control canals and bypasses such as the Yolo Bypass.

VISION

The vision for freshwater fish habitats is to protect existing habitat from degradation or loss, to restore degraded habitats, and restore areas to a more natural state to assist in the recovery of special-status plant, fish, and wildlife populations.

LINK TO MSCS EVALUATED SPECIES

The MSCS has identified the following species as potentially benefitting from the restoration freshwater fish habitat in the Bay-Delta system:

MSCS SPECIES INCLUDED IN THE ERP

- California red-legged frog
- Central Valley steelhead
- winter-run chinook salmon
- bank swallow
- Sacramento splittail
- Central Valley fall-run chinook salmon
- Central Valley spring-run chinook salmon
- western pond turtle
- foothill yellow-legged frog
- western pond turtle
- hardhead
- Sacramento perch
- green sturgeon, and
- eel-grass pondweed.

OTHER SPECIES EVALUATED IN THE MSCS

- bald eagle
- Central Coast steelhead
- rough sculpin
- black tern, and
- osprey.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore freshwater fish habitat would involve cooperation with other restoration and management programs. These include:

- Central Valley Project Improvement Act including the Anadromous Fish Restoration Program,
- Department of Water Resources programs to provide water supplies (State Water Project), flood protection facilities, water quality monitoring, and multipurpose management of California water resources,
- U.S. Army Corps of Engineers flood control operations of reservoirs and management of flood control facilities (e.g., levees, overflow channels and bypass weirs),
- U.S. Bureau of Reclamation operation of the federal Central Valley Project to provide for multiple beneficial uses of water including fish and wildlife protection and habitat restoration,
- U.S. Fish and Wildlife Service and National Marine Fisheries Service programs to recommend flows and other measures needed for mitigating impacts from federal projects and protecting endangered species,
- Other independent water projects in the Central Valley to provide for multiple beneficial uses of

water including fish and wildlife protection and habitat restoration (e.g., Yuba County Water Agency, East Bay Municipal Utilities District, Pacific Gas and Electric Company),

- California Department of Fish and Game responsibility to study and recommend streamflows and temperature requirement for fish protection and propagation is streams,
- FERC regulations of minimum flow below hydropower projects, and
- State Water Resources Control Board administration of water rights for diversion and storage including decisions regarding instream flows for fish, water quality, and public trust resource protection.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Freshwater fish habitats are linked to other ecological elements in the Bay-Delta watershed. These important habitats are linked to our visions for:

- Central Valley streamflows,
- Central Valley stream temperatures,
- natural sediment supply,
- stream meander,
- natural floodplain and flood processes,
- Delta sloughs,
- riparian and riverine aquatic habitat,
- water diversions,
- dams, reservoirs, weirs, and other structures,
- levees, bridges, and bank protection,
- dredging and sediment disposal,
- gravel mining,
- invasive species,
- predation and competition, and
- fish and wildlife harvest.

OBJECTIVE, TARGETS ACTIONS, AND MEASURES

The Strategic Objective is to restore large expanses of all major aquatic, wetland, and riparian habitats, and sufficient connectivity among habitats, in the Central Valley and its rivers to support recovery and restoration of native species and biotic communities and rehabilitation of ecological processes.

LONG-TERM OBJECTIVE: Restore, protect and manage, on a self-sustaining basis throughout the watershed, multiple large areas containing all aquatic, wetland, and riparian habitat types in the Central Valley and its rivers to a substantial fraction of their pre-settlement areas or to a point where all at-risk species that depend on the habitats are no longer at risk.

SHORT-TERM OBJECTIVES: Systematically identify and locate the best remaining areas containing the aquatic, wetland, and riparian habitat types, and prioritize them for conservation. Develop and begin implementation of action plans for restoring significant examples of each habitat type.

RATIONALE: Moyle and Ellison (1991) and Moyle (1996) developed a scheme for classifying the aquatic habitats of California for the purposes of conservation. Other classification schemes of aquatic habitats also exist, as do schemes for classifying riparian and wetland habitats. Whatever the system, it is obvious that the diversity of aquatic habitats is declining in Central Valley watersheds, especially in lowland areas. Each habitat supports a different assemblage of organisms, and quite likely many of the invertebrates and plants are still unrecognized as endemic forms. Thus, systematic protection of examples of the entire array of habitats in the region provides some assurances that rare and unusual aquatic organisms will also be protected, preventing contentious endangered species listings.

STAGE 1 EXPECTATIONS: A classification system for riverine and riparian habitats that can be used as a basis for conservation actions will have been developed. Inventory of habitat types should be completed and areas prioritized for conservation actions. Restoration actions should be evaluated and initiated where feasible.

RESTORATION ACTIONS

The general targets for freshwater fish habitat are:

- protect and rehabilitate floodplain pools, sloughs, backwaters and oxbow lakes,
- improve the quality and extent of flowing water habitats,
- establish and protect a variety of functional habitats for biodiversity, scientific research (e.g., for resident trout streams, salmon-steelhead streams, etc),
- improve the quality of artificial habitats in the Central Valley to better support native fish species.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions to enhance or restore freshwater fish habitats that would help achieve species habitat or population targets.

- Implement management measures identified in the proposed recovery plan for the Sacramento River winter-run chinook salmon.
- Coordinate protection and restoration of freshwater fish habitats with other federal and state programs (e.g., U.S. Fish and Wildlife Service recovery plans, the SB 1086 program, and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of occupied and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Implement applicable management measures identified in the restoration plan for the Anadromous Fish Restoration Program and the recovery plan for the native fishes of the Sacramento/San Joaquin Delta.
- To the extent consistent with CALFED objectives, manage operations of the Red Bluff diversion dam to improve fish passage, reduce the level of predation of juvenile fish, and increase fish survival.
- To the extent consistent with CALFED objectives, manage export flows from the San Joaquin River to improve conditions for upstream migration of adult fish (i.e., attraction flows).
- To the extent consistent with CALFED objectives, operate physical barriers in the Delta in a manner to assist in achieving recovery goals for listed fish species.

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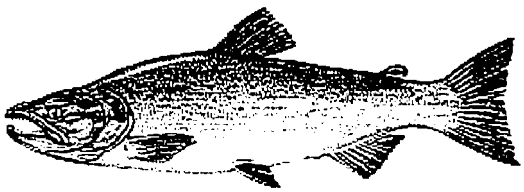

INTRODUCTION

Essential Fish Habitat (EFH) is the aquatic habitat necessary to allow for salmon production needed to support a long-term sustainable salmon fishery and salmon contributions to a healthy ecosystem. The salmon fishery EFH includes all those streams, lakes, ponds, wetlands, and other water bodies currently or historically accessible to salmon. In the estuarine and marine areas, salmon EFH extends from the nearshore and tidal submerged environments to 60 km offshore. Salmon EFH excludes areas upstream of longstanding naturally impassible barriers (i.e., natural waterfalls in existence for several hundred years) (National Marine Fisheries Service 1998a).

The designation of these habitats is important to allow the systematic protection of biological diversity within distinct geographic regions. The application of such a conservation-oriented classification system is of particular importance in the Central Valley where a rapidly growing human population and large tracts of irrigated agriculture compete with aquatic organisms for water (Moyle and Ellison 1991).

RESOURCE DESCRIPTION

Public Law 104-267, the Sustainable Fisheries Act of 1996, amended the Magnuson-Stevens Fishery Conservation and Management Act to establish new requirements for "Essential Fish Habitat" description in federal Fishery Management Plans (FMPs) and to require federal agencies to consult with the National Marine Fisheries Service on activities that may adversely affect EFH. The amended act requires the National Marine Fisheries Service to assist the Pacific Fisheries Management Council in the description and identification of EFH for each managed fishery and to provide the Pacific Fishery Management Council with proposed recommendations for EFH (National Marine Fisheries Service 1998a).

ESSENTIAL HABITATS FEATURES

Habitat and biological associations examined in the development of proposed EFH included:

- Eggs and spawning requirements
- Larvae and alevins requirements
- Juveniles in freshwater
- Juveniles in estuarine waters
- Juveniles in marine waters, and
- Adults requirements.

The National Marine Fisheries Service will assume a holistic approach toward implementation of EFH, and prefers not to subdivide by life stage or habitat type. The intent is to provide habitat conditions that support all life-cycle stages of chinook salmon: an approach fundamentally consistent with the ERP's emphasis on ecosystem management.

In summary, EFH is an integration of two major subdivisions: freshwater essential habitat and marine essential habitat.

Important features of essential habitat for spawning, rearing and migration include adequate: (1) substrate composition; (2) freshwater water quality (e.g., dissolved oxygen, nutrients, temperature); (3) freshwater water quantity, depth and velocity; (4) channel gradient and stability; (5) food; (6) freshwater cover and habitat complexity (e.g., large woody debris, pools, channel complexity, aquatic vegetation); (7) space, (8) access and passage; (9) floodplain and habitat connectivity; (10) adequate marine water quality; (11) adequate marine water temperature; (12) adequate marine prey species and forage base; and (13) adequate depth, cover, marine vegetation, and algae in estuarine and near-shore habitats.

VISION

The vision for essential fish habitats is to maintain and improve the quality of existing habitats and to restore former habitats in order to support self-sustaining populations of chinook salmon.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore freshwater fish habitat would involve cooperation with other restoration and management programs. These include:

- Central Valley Project Improvement Act including the Anadromous Fish Restoration Program,
- Department of Water Resources programs to provide water supplies (State Water Project), flood protection facilities, water quality monitoring, and multipurpose management of California water resources,
- U.S. Army Corps of Engineers flood control operations of reservoirs and management of flood control facilities (e.g., levees, overflow channels and bypass weirs),
- U.S. Bureau of Reclamation operation of the federal Central Valley Project to provide for multiple beneficial uses of water including fish and wildlife protection and habitat restoration,
- U.S. Fish and Wildlife Service and National Marine Fisheries Service programs to recommend flows and other measures needed for mitigating impacts from federal projects and protecting endangered species,
- Other independent water projects in the Central Valley to provide for multiple beneficial uses of water including fish and wildlife protection and habitat restoration (e.g., Yuba County Water Agency, East Bay Municipal Utilities District, Pacific Gas and Electric Company),
- California Department of Fish and Game responsibility to study and recommend streamflows and temperature requirement for fish protection and propagation is streams,
- FERC regulations of minimum flow below hydropower projects, and
- State Water Resources Control Board administration of water rights for diversion and storage including decisions regarding instream flows for fish, water quality, and public trust resource protection.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Essential Fish Habitats are linked to other ecological elements in the Bay-Delta watershed. These important habitats are linked to our visions for:

- Central Valley streamflows,
- Central Valley stream temperatures,
- natural sediment supply,
- stream meander,
- natural floodplain and flood processes,
- Delta sloughs,
- riparian and riverine aquatic habitat,
- water diversions,
- dams, reservoirs, weirs, and other structures,
- levees, bridges, and bank protection,
- dredging and sediment disposal,
- gravel mining, and
- invasive species.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

> The Strategic Objective is to restore large expanses of all major aquatic, wetland, and riparian habitats, and sufficient connectivity among habitats, in the Central Valley and its rivers to support recovery and restoration of native species and biotic communities and rehabilitation of ecological processes.

LONG-TERM OBJECTIVE: Protect and manage, on a self-sustaining basis throughout the watershed, multiple large areas containing all aquatic, wetland, and riparian habitat types in the Central Valley and its rivers (including the Delta and Suisun and San Francisco Bays) to a point where all at-risk species that depend on the habitats are no longer at risk.

SHORT-TERM OBJECTIVE: Systematically identify and locate the best examples of essential fish habitats and prioritize them for conservation. Develop and begin implementation of action plans for restoring significant examples of each habitat type.

RATIONALE: Declines in the abundance of chinook salmon have been well-documented throughout the southern portion of their range. Concern over coast wide declines from southeastern Alaska to the Pacific Northwest was a major factor leading to the signing of the Pacific Salmon Treaty between the United States and Canada in 1985. Naturally spawning chinook salmon populations have been extirpated from large portions of their historic range in a number of watersheds in California and all Evolutionarily Significant Units have been proposed for listing by the National Marine Fisheries Service (1998b).

Habitat degradation is the major cause for extinction of populations and many extinctions are related to dam construction and operation. Urbanization, agricultural land use, water diversion, and logging are also factors contributing to habitat degradation and the decline of chinook salmon (Nehlsen 1991). The development of large-scale hatchery programs have, to some degree, mitigated the decline in abundance of chinook in some areas. However, the genetic and ecological interactions of hatchery and wild fish have also been identified as risk factors for wild populations, and high harvest rated directed at hatchery fish may cause over-exploitation of co-mingled wild stocks (Reisenbichler 1997).

STAGE 1 EXPECTATIONS: Inventory of habitat types should be completed and areas prioritized for conservation actions. Restoration actions should be evaluated and initiated where feasible.

RESTORATION ACTIONS

The general targets for essential fish habitat are:

- protect and rehabilitate habitat required for chinook salmon spawning and egg development,
- improve the quality and extent of flowing water habitats,
- protect and improve habitats required for short-term and long-term juvenile freshwater rearing,
- improve the quality of habitats in the Central Valley to better support adult migration and holding.

MSCS CONSERVATION MEASURES

The following conservation measures wee included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions to enhance and restore essential fish habitat that would help achieve species habitat or population targets.

- Coordinate protection, enhancement, and restoration of occupied and historic winter-run chinook habitat with other federal, state, and regional programs, (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, the Anadromous Fish Restoration Program, the SB 1086 program, and the Corps' Sacramento and San Joaquin River Basins Comprehensive Study) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Implement management measures identified in the proposed recovery plan for the Sacramento River winter-run chinook salmon.
- To the extent consistent with CALFED objectives, manage operations at the Red Bluff diversion dam to improve fish passage, reduce the level of predation on juvenile fish and increase fish survival.
- Implement applicable management measures identified in the restoration plan for the Anadromous Fish Restoration Program and the recovery plan for the native fishes of the Sacramento/San Joaquin Delta.
- To the extent consistent with program objectives, minimize flow fluctuations to reduce or avoid stranding of juvenile fish.

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◆ Inland Dune Scrub Habitat

Introduction

Inland dune scrub is associated with inland sand dunes and is limited in the ERPP focus area to the vicinity of the Antioch Dunes National Wildlife Refuge. This habitat area supports two plant and one butterfly species listed as endangered under the federal Endangered Species Act. Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of sand mining, dune conversion to other land uses, dune stabilization, and land use practices that maintain the dominance of non-native plants.

Resource Description

Historic dunes within the Sacramento-San Joaquin Delta Ecological Management Zone may have covered 15,560 acres, based on soil surveys, including 8,510 acres of Delhi series, 5,810 acres of Piper series in Contra Costa County, and 1,300 acres of Tinnin series in Sacramento County. The Delhi series was a large area of dunes in the Antioch-Oakley area, of which the Antioch Dunes National Wildlife Refuge is a tiny remnant. The Piper series were small areas of remnant dunes within the organic soils of the Delta marshes, remnants of larger areas of dunes that existed prior to the rise in sea level at the end of the last ice age. The Tinnin series were small isolated dunes on the eastern edge of the Delta.

Remaining habitat areas are being protected. Recent land-use changes help this habitat support several special-status plant and wildlife species. Most protected inland dune scrub is located within the Antioch Dunes National Wildlife Refuge and Brannan Island State Park. Most of the inland dune scrub habitat outside these two areas are protected to various degrees.

> **Inland Dune Scrub Habitat** is defined in the MSCS as habitat comprised of vegetated stabilized sand dunes associated with river and estuarine systems. Inland dune scrub includes all of the ERP inland dune scrub habitat (Multi-Species Conservation Strategy 2000).

Two special-status plant species, the Antioch Dunes evening primrose and the Antioch Dunes wallflower, are found with inland dune scrub. The Lange's metalmark, a butterfly listed as endangered under the federal Endangered Species Act (ESA), is known only from the Antioch Dunes, where it feeds on naked buckwheat. The low nutrient conditions of the soils and natural instability of dune sands limit the amount of vegetation that establishes on the inland dunes. The dunes represent a localized habitat that does not support other types of upland vegetation.

As in other dune ecosystems, such as coastal dunes and desert sand dunes, wind is the major process that shapes dunes and dune structures. The presence of the wind-modified, river-deposited sands, in combination with the Delta wind patterns, maintain a natural disturbance threshold that favors the establishment of the plant species that are characteristic of dunes and prevents the establishment of species less tolerant of these conditions.

Direct and indirect disturbances are reducing the extent and health of inland dune scrub habitat and its associated plants and animals. Sand mining directly removes habitat. Urban development has moved onto historical dune habitat and changed wind-flow patterns. Excessive foot traffic, off road vehicle traffic, and grazing disturb dune surfaces, which makes dunes more susceptible to erosion. Application of herbicides, pesticides, and fertilizers change ecological processes that may encourage or support non-native species. Structures or activities that reduce or accelerate winds, wind-disturbances, or barriers to wind-driven sand movement, disrupt the processes that sustain dunes. Wind patterns blow river-deposited sand into shifting dunes. Shifting sand offers little stability for establishing plant root systems. Plant species characteristic of dunes survive within a disturbance threshold. Direct disturbances inhibit the ability of dune-associated plants to establish and result in loss of plant vigor or mortality. Sand movement barriers create conditions unfavorable for establishing native dune vegetation. These types of disturbances create site conditions conducive to establishing invasive weedy plants. Non-native weeds compete with native dune plants and reduce overall habitat quality. Continued disturbance of potentially restorable adjacent habitat could interfere with protecting and restoring additional areas of high-quality habitat by affecting dune structure and destroying buckwheat, Antioch evening primrose, and Antioch Dunes wallflower plants.

VISION

The vision for inland dune scrub habitat is to protect and enhance existing areas and restore former habitat areas. Achieving this vision will to provide high-quality habitat for associated special-status plant and animal populations.

Restoration of inland dune scrub would focus on protecting and improving important existing habitat areas. Historic inland dunes adjacent to existing ecological reserves in the Sacramento-San Joaquin Delta Ecological Management Zone would be reestablished. Protecting and restoring inland dune scrub habitat would begin by identifying areas that are not currently managed for their resource values. Appropriate methods to protect and restore identified areas would be developed. Protected habitat areas would be evaluated to determine effective restoration management practices to increase habitat value. The results of these evaluations would determine how habitat would be protected and restored.

LINK TO MSCS EVALUATED SPECIES

The MSCS had identified the following species as potentially benefitting from the enhancement of inland dune scrub habitat in the Bay-Delta system.

MSCS SPECIES INCLUDED IN THE ERP

- Lange's metalmark
- Antioch Dunes evening primrose, and
- Contra Costa wallflower.

OTHER SPECIES EVALUATED IN THE MSCS

- San Joaquin whipsnake.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore inland dune habitats will involve cooperation with programs managed by the Antioch Dunes National Wildlife Refuge. Cooperation from agencies with responsibility or authority for restoring inland dune habitat will be solicited. These include:

- California Department of Fish and Game,
- U.S. Fish and Wildlife Service,
- U.S. Army Corps of Engineers,
- and the Delta Protection Commission,

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Inland dune scrub habitat is limited to the area near the Antioch Dunes Ecological Reserve, Brannan Island State Park and a few other localities. This type of habitat is important for two plant and one butterfly species listed as endangered under the federal Endangered Species Act.

It is adversely affected by human caused actions that contribute to erosion and spread of non-native species. One important linkage in maintaining this habitat is maintenance of river flows which deposit sediments including sand which feed the dune formation process.

OBJECTIVE, TARGETS ACTIONS, AND MEASURES

The Strategic Objective is to restore large expanses of all major habitat types, and sufficient connectivity among habitats, in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay to support recovery and restoration of native species and biotic communities and rehabilitation of ecological processes.

LONG-TERM OBJECTIVE: Restore inland dune scrub habitat in the Delta to a substantial fraction of its presettlement areas, or to a point where all at-risk species that depend on the habitat are no longer at risk.

SHORT-TERM OBJECTIVE: Develop and begin implementation of action plans for significant examples of inland dune scrub habitat in the Delta.

RATIONALE: All major natural habitat types in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay have been reduced to a small fraction of the area they once occupied, resulting in a large number of at-risk plant and animal species and an increased susceptibility of the remaining areas to irreversible degradation (e.g., invasion by non-native species). The reduction trend is continuing and will have to be reversed if self-sustaining examples of these habitats, and the diverse organisms they support, are to persist into the future. This reversal will require a large number of diverse and localized actions, from levee setbacks to land acquisition to better management of existing sites. The major habitat types to be restored include tidal shallow water habitat, freshwater emergent wetland, channel islands and associated habitats, tidal sloughs, nontidal freshwater emergent wetlands, seasonal upland wetlands, vernal pools and surrounding uplands, riparian forests and associated upland areas, perennial grassland, and inland dune scrub. In order to make restoration actions systematic and cost-effective, specific objectives need to be established for each of the habitat types, as well as subsets of them that have distinctive biological characteristics, and then priorities set within each objective for protection and restoration activities.

RESTORATION ACTIONS

General restoration targets for inland dune scrub habitat are directed at protecting and restoring 50 to 100 acres of low- to moderate-quality Antioch inland dune scrub habitat within or adjacent to existing ecological preserves in the Central and West Delta Ecological Management Unit.

Managing protected areas could include reducing disturbance of dunes and dune vegetation. This could be accomplished by reducing vehicle and pedestrian access to dune areas. Protective structures, such as small boardwalks could be built. These actions would reduce habitat disturbance while maintaining recreational access. The following actions would help restore inland dunes:

- remove barriers to wind-driven sand-dune movement to increase the area that would be available for natural expansion of the sand-dune base;
- import sands from areas being developed or clean sand dredged from Bay-Delta channels to increase restoration potential and dune area;
- control non-native weeds to recreate conditions suitable to reestablishing native dune plants; and
- reduce the use of herbicides, pesticides, and fertilizers that adversely effect native dune vegetation and animals.

Dune habitat protection and restoration strategies could be implemented through cooperative efforts with existing ecological reserves. Restoration efforts should focus on implementing existing protection and restoration programs, establishing cooperative agreements with land management agencies, and establishing conservation easements or purchasing land from willing sellers.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions to enhance and restore inland dune scrub habitat that would help achieve species habitat or population targets.

- Coordinate protection and restoration of inland dune scrub habitats with other programs (e.g., U.S. Fish and Wildlife Service recovery plans and management of the Antioch Dunes Preserve) that could affect management of occupied and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Conduct surveys to locate potential habitat restoration sites on Tinnin soils and identify opportunities for and implement permanent protection, restoration, and management of these

habitat areas to enhance habitat conditions for the Lange's metalmark.

REFERENCES

Multi-Species Conservation Strategy. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000

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INTRODUCTION

Perennial grasslands provide important breeding and foraging habitat areas for many wildlife species and support several special-status plant species. Perennial grassland was historically common throughout the Central Valley. Most perennial grassland has been lost or converted into annual grassland. Major factors that limit this resource's contribution to the health of the Bay-Delta are related to the adverse effects of grasslands conversion for agricultural, urban, and industrial uses, and continuing land use practices that maintain non-native annual grasses dominance in historic perennial grassland habitat.

RESOURCE DESCRIPTION

Perennial grassland provides habitat for many plant and wildlife populations and are important for maintenance of vernal pools and their associated plant and animal species.

In addition to supporting vernal pools, perennial grasslands provide valuable habitat for many wildlife species. Common grassland species include deer, San Joaquin kit fox, ground squirrels, kangaroo rats, and blunt-nosed leopard lizards, and nesting waterfowl. Where grassland still occurs, it also provides an extremely valuable transition zone and support area for adjacent habitats.

Perennial grasslands and associated vernal pools historically were present at drier, higher elevations in the Delta. Grasslands developed adjacent to wetland and riparian habitats that occupied wetter, lower elevation. Much of the perennial grasslands have been converted for other uses. Most remaining grasslands are now dominated by non-native annual grasses. Annual grasses out competed and replaced perennial bunch grasses over most of the Central Valley.

Perennial grasslands are described in the MSCS as grasslands. MSCS grassland is defined to include upland vegetation communities dominated by introduced and native annual and perennial grasses and forbs, including non-irrigated and irrigated pasturelands. Grassland habitat includes all of the ERP perennial grassland habitat and much more extensive annual grassland vegetation that is not addressed in the ERP (Multi-Species Conservation Strategy 2000).

Extent and health of perennial grasslands in the Bay-Delta estuary are declining. Large areas of historic perennial grassland has been converted for agriculture, urban, and industrial uses. Remaining grasslands have been invaded by non-native annul grass. Many of the annual grass species out-compete native grasses. Fire-resistant, non-native species have been given an additional competitive edge from current fire suppression techniques. For example, native bunch grasses are fire resistant and adapted to relatively frequent fires because their perennating buds are near the ground and protected by the rest of the plant. Present fire suppression activities may favor non-native annuals which, because of infrequent catastrophic fires, destroy the bunch grasses when very hot fires burn the thatch which has built up over time. Fires promote plant succession and have aided in the intrusion of non-native fire-tolerant plants; and continuation of land use practices that maintain the dominance of non-native annual grasses.

VISION

The vision is to protect and improve existing perennial grasslands and increase perennial grassland area to provide high-quality habitat for special-status plant and wildlife populations and other wildlife dependent on the Bay-Delta.

This vision is a component of restoring wetland and riparian habitats.

Restoration of perennial grassland would focus on reestablishing historic grasslands and protecting and improving important existing grassland areas in the Sacramento-San Joaquin Delta, Suisun Marsh/North San Francisco Bay, and Yolo Basin Ecological Management Zones. Grasslands would be restored as a component of wetland and riparian habitat restoration. Combining these restoration efforts increases overall habitat value for species that require multiple habitats. The proximity of habitats to each other (e.g., grasslands adjacent to wetlands provides nesting habitat for several species of ducks and refuge habitat for small mammals during flooding) and provides a protecting buffer from potential adverse effects of adjacent land uses.

Reducing land use changes and the introduction of non-native species will decrease the major stressors affecting perennial grasslands and vernal pools. The promotion of fire as a natural method for succession would aid in managing fire-sensitive non-native plants. Alternatives to the use of herbicides and other contaminants to control vegetation should be encouraged to promote more natural revegetation.

Increasing the quantity and quality of grassland habitat conditions would help increase special-status plant and wildlife populations. Habitat improvements would also maintain or increase populations of other species that are dependent on grasslands in the estuary.

Link to MSCS Evaluated Species

The MSCS has identified the following species as potentially benefitting from the restoration of perennial grassland habitat in the Bay-Delta system.

MSCS Species Included in the ERP

- California red-legged frog
- greater sandhill crane
- Swainson's hawk
- California tiger salamander
- recurved larkspur, and
- heartscale.

Other Species Evaluated in the MSCS

- San Joaquin kit fox
- giant kangaroo rat
- Merced kangaroo rat
- California condor
- Alameda whipsnake
- blunt-nosed leopard lizard
- white-tailed kite
- golden eagle
- mountain plover
- greater western mastiff-bat
- tricolored blackbird
- short-eared owl
- long-billed curlew
- northern harrier. and
- San Joaquin whipsnake.

Integration with Other Restoration Programs

Perennial grasslands as used here is similar to the upland designation in Madrone Associates (1980) and the Goals Project (1999) description of grasslands.

Protecting and restoring perennial grasslands are objectives of agencies and organizations that operate many protected habitat areas. These include:

- Cosumnes River Preserve,
- Grizzly Slough Wildlife Area,
- Jepson Prairie Preserve,
- Putah Creek South Fork Preserve,
- Stone Lakes National Wildlife Refuge,
- and Woodbridge Ecological Reserve.

Restoring perennial grassland is also an objective of the Cache Creek Corridor Restoration Plan and Yolo County Habitat Conservation Plan.

Linkage with Other Ecosystem Elements

Perennial grasslands are an important component of the Bay-Delta ecosystem and provide habitat for many plant and wildlife populations. Common species dependent on perennial grasslands include deer, San Joaquin kit fox, blunt-nosed leopard lizards, kangaroo rats and nesting waterfowl. Grassland also provide an important transition habitat between adjacent habitat areas. In addition, health grasslands provide contributions to flood control function by slowing and extending storm events and by reducing erosion.

This type of habitat is adversely affected by land use, land conversion, and proliferation of non-native plant and grass species. Control of exotic plant species is a significant stressor and control programs need to be developed for protecting and restoring perennial grasslands.

OBJECTIVE, TARGETS ACTIONS, AND MEASURES

> The Strategic Objective is to restore large expanses of all major habitat types, and sufficient connectivity among habitats, in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay to support recovery and restoration of native species and biotic communities and rehabilitation of ecological processes.

LONG-TERM OBJECTIVE: Restore perennial grasslands in the Delta, Suisun Bay, Suisun Marsh, San Francisco Bay, and other areas of the Central Valley to a substantial fraction of their pre-settlement areas, or to a point where all at-risk species that depend on the habitats are no longer at risk.

SHORT-TERM OBJECTIVE: Develop and begin implementation of action plans for restoring large and significant examples of perennial grasslands in the Delta, Suisun Bay, Suisun Marsh, San Francisco Bay, and other areas of the Central Valley.

RATIONALE: All major natural habitat types in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay have been reduced to a small fraction of the area they once occupied, resulting in a large number of at-risk plant and animal species and an increased susceptibility of the remaining areas to irreversible degradation (e.g., invasion by non-native species). The reduction trend is continuing and will have to be reversed if self-sustaining examples of these habitats, and the diverse organisms they support, are to persist into the future. This reversal will require a large number of diverse and localized actions, from levee setbacks to land acquisition to better management of existing sites. The major habitat types to be restored include tidal shallow water habitat, freshwater emergent wetland, channel islands and associated habitats, tidal sloughs, nontidal freshwater emergent wetlands, seasonal upland wetlands, vernal pools and surrounding uplands, riparian forests and associated upland areas, perennial grassland, and inland dune scrub. In order to make restoration actions systematic and cost-effective, specific objectives need to be established for each of the habitat types, as well as subsets of them that have distinctive biological characteristics, and then priorities set within each objective for protection and restoration activities.

STAGE 1 EXPECTATIONS: A classification system for Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay habitats that can be used as a basis for conservation actions will have been developed. Specific, numeric objectives should be formulated for each habitat type, with restoration objectives based on clearly stated conceptual models. Within and among habitat types, conservation and restoration activities should be prioritized. Work should begin on those projects given highest priority within a year of adoption of the strategic plan.

RESTORATION ACTIONS

The general target for perennial grassland is to protect and restore 4,000-6,000 acres in the Sacramento-San Joaquin Delta Ecological Management Zone and 1,000 acres in the Suisun Marsh/North San Francisco Bay Ecological Management Zone.

Restoring, protecting, and improving grasslands could be achieved through:

- purchasing land or conservation easements or from willing landowners to protect important existing habitat areas from potential future degradation,
- establishing incentive programs to encourage landowners to establish and maintain perennial grasslands,
- implementing an intensive management program to control non-native vegetation and enhance native grasses and other plant species, and
- developing and implementing alternatives to land management practices on public lands that continue to degrade habitat quality or inhibit habitat recovery.

Restoring other ecological processes and habitats proposed by the Ecosystem Restoration Program Plan (ERPP) would also create opportunities for the managed reestablishment of grasslands elsewhere in the Central Valley.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions to enhance or restore perennial grassland habitats that would help achieve species habitat or population targets.

- Restore wetland and perennial grassland habitats adjacent to habitats occupied by Suisun ornate shrew to create a buffer of natural habitat to protect populations from potential adverse affects that could be associated with future changes in land use on nearby lands and to provide habitat suitable for the natural expansion of populations.
- Restore wetland and perennial grassland habitats adjacent to nesting habitats occupied by Suisun song sparrow to create a buffer of natural habitat to protect nesting pairs from potential adverse affects that could be associated with future changes in land use on nearby lands and to provide habitat suitable for the natural expansion of populations.
- Restore wetland and perennial grassland habitats adjacent to habitats occupied by salt marsh harvest mouse to create a buffer of natural habitat to protect populations from potential adverse affects that could be associated with future changes in land use on nearby lands and to provide habitat suitable for the natural expansion of populations.
- Restore wetland and perennial grassland habitats adjacent to habitats occupied by San Pablo California vole to create a buffer of natural habitat to protect populations from potential adverse affects that could be associated with future changes in land use on nearby lands and to provide habitat suitable for the natural expansion of populations.
- Restore wetland and perennial grassland habitats adjacent to habitats occupied by saltmarsh common yellowthroat to create a buffer of natural habitat to protect populations from potential adverse affects that could be associated with future changes in land use on nearby lands and to provide habitat suitable for the natural expansion of populations.

REFERENCES

Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Estuary Baylands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco and San Francisco Bay Regional Water Quality Control Board, Oakland, California.

Madrone Associates. 1980. Delta wildlife habitat protection and restoration plan. Prepared for the California Department of Fish and Game and the U.S. Fish and Wildlife Service.

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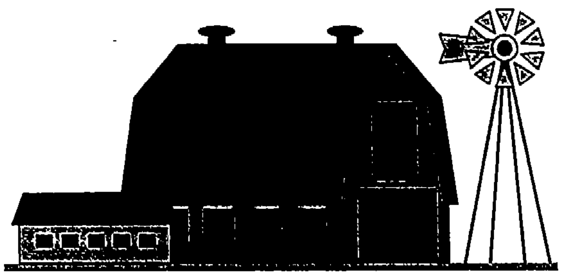


INTRODUCTION

Following extensive native habitats loss in the Central Valley to agricultural and urban lands, some wildlife species have adapted to the artificial wetland and upland environments created by some agricultural practices. Once adapted, species became dependent on these agricultural areas to sustain their populations.

A major factor that limits this resource's contribution to the health of the Bay-Delta is related to adverse effects of some agricultural practices. Clean farming practices reduce the availability and quantity of forage and fence-line vegetation. Converting production from crops that provide relatively high-values for wildlife to relatively low-value crop types, displaces or insufficiently supports species that have adapted to the habitat. Converting agricultural lands for urban or industrial uses, also reduces or eliminates available habitat.

RESOURCE DESCRIPTION

Agricultural lands are located throughout the Central Valley. These lands comprise many different types of agricultural land uses ranging from non-irrigated grazing land to drip-irrigated vineyard. The type of crops grown on any particular parcel are usually dictated by soil type, topography, and availability of water. Intensively managed agricultural lands or croplands are located on flat or slightly rolling terrain. Flat cropland is usually the product of extensive surveying and laser land-leveling activities. Flat croplands provide more efficient use of water, less soil erosion, and higher crop yields. A variety of fragmented habitats that support various resident and migratory wildlife species are closely associated with these agricultural lands and includes naturally occurring wetland types (creeks, vernal pools, and gullies).

Agricultural lands being managed for certain crops and following certain agricultural practices create wetland-like benefits for certain wildlife. These lands can provide significant habitat for some wildlife species. Crop type and cultivation practices determine the quality of habitats. For example, rice lands support millions of wintering waterfowl using the Central Valley. Lands where wheat and corn have been harvested, particularly if they have been shallowly flooded after harvest, also support large populations of wintering waterfowl and the State-listed greater sandhill crane.

Agricultural Lands are included in two MSCS habitat categories: upland cropland and seasonally flood agricultural lands. *Upland cropland* habitat includes agricultural lands farmed for grain and for field, truck, and other crops that are not seasonally flooded. *Seasonally flooded agricultural land* habitat included agricultural lands farmed for grain and rice and for field, truck, and other crops that require seasonal flooding for durations of at least 1 week as a management practice (e.g., pest control and irrigation) or are purposefully flooded seasonally to enhance habitat values for specific wildlife species (e.g., ducks for duck clubs). Upland cropland and seasonally flooded agricultural land are included in the ERP as agricultural lands (Multi-Species Conservation Strategy 2000).

Major stressors that determine the wildlife values provided by agricultural lands include activities such as water quantity and quality management, crop type conversion from relatively high-wildlife-value crops to relatively low-wildlife-value crops (e.g., conversion from pastureland rowcrops to vineyards), the use of "clean farming techniques," deep postharvest discing, practices that reduce crop and grain residue within the field, cropland management with varied pesticide application, and the timing of these activities. Implementing appropriate land use management techniques accompanied by reimbursement programs to the agricultural stakeholder can reduce the adverse impacts of stressors on diverse agricultural habitat.

VISION

The vision for agricultural lands is to improve associated wildlife habitat values to support special-status wildlife populations and other wildlife dependent on the Bay-Delta.

Protecting and enhancing agricultural lands for wildlife would focus on encouraging production of crop types that provide high wildlife habitat value, agricultural land and water management practices that increase wildlife habitat value, and discouraging development of ecologically important agricultural lands for urban or industrial uses in the Sacramento-San Joaquin Delta and Suisun Marsh/North San Francisco Bay Ecological Management Zones.

Protecting and enhancing agricultural lands for wildlife would focus on encouraging production of crop types that provide high wildlife habitat value, agricultural land and water management practices that increase wildlife habitat value, and discouraging development of ecologically important agricultural lands for urban or industrial uses in the Sacramento-San Joaquin Delta and Suisun Marsh/North San Francisco Bay Ecological Management Zones.

Vegetation management of agricultural lands could provide wildlife habitat at many locations, including rice checks, irrigation ditches, lowlands, ponds, fallow lands, fence rows, and other areas unsuitable for agricultural land use. Agricultural crop types that present excellent opportunities for enhancement include rice, alfalfa and pasture, corn and grain, and certain rowcrops. Enhancing agricultural lands adjacent to existing wildlife habitat areas, such as refuges, would be particularly beneficial. The value of enhanced land could be increased if nearby nonfarmed or fallow lands were managed to provide other habitats required by wildlife that use agricultural lands.

In some situations, altering common management practices can greatly increase wildlife habitat value with little or no change in crop production.

LINK TO MSCS EVALUATED SPECIES

The MSCS has identified the following species as potentially benefitting from the implementation of wildlife friendly agricultural practices in the Bay-Delta system.

MSCS SPECIES INCLUDED IN THE ERP

- greater sandhill crane
- giant garter snake, and
- Swainson's hawk.

OTHER SPECIES EVALUATED IN THE MSCS

- San Joaquin kit fox
- Aleutian Canada goose
- white-tailed kite
- mountain plover
- tricolored blackbird
- California gull
- long-billed curlew
- northern harrier
- white-faced ibis
- bald eagle
- short-eared owl.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Numerous agricultural habitat improvement projects involving a number of project proponents are proposed and in various stages of development throughout the ecological management zones. Some of the more notable projects are:

- Stones Lakes National Wildlife Refuge, Cosumnes River Preserve, and
- Yolo Bypass Wildlife Management Area.

There are also many voluntary landowner incentive programs that involve various agricultural habitat improvements in the ecological management zones. These include:

- Wetland Reserve Program,
- Agricultural Conservation Program,
- Water Bank Program,
- Partners for Wildlife,
- California Waterfowl Habitat Program,

- Inland Wetland Conservation Program,
- Conservation Reserve Program,
- Agricultural-Wildlife Incentive Program (CVPIA), and
- Permanent Wetland Easement Program.

Governmental and private agencies and agricultural stakeholders involved in current agricultural land enhancement and management include:

- California Department of Fish and Game,
- Delta Protection Commission
- California Department of Water Resources,
- California Department of Transportation,
- U.S. Fish and Wildlife Service,
- U.S. Bureau of Land Management,
- U.S. Bureau of Reclamation,
- U.S. Natural Resources Conservation Service,
- Ducks Unlimited
- Valley Care (Ducks Unlimited),
- Central Valley Habitat Joint Venture,
- The Nature Conservancy,
- resource conservation districts,
- farm bureaus,
- county agricultural commissions,
- and various county land planning agencies.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Agricultural lands are an important habitat for many migratory wildlife species, particularly for wintering waterfowl and the State-listed greater sandhill crane.

Wildlife values of agricultural lands are adversely affected by water quantity and quality, type of agricultural crop produced, farming techniques, and application of pesticides.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to minimize the conversion of agricultural land to urban and suburban uses and maintain open space buffers in areas adjacent to existing and future restored aquatic, riparian, and wetland habitats, and manage agricultural lands in ways that are favorable to birds and other wildlife.

LONG-TERM OBJECTIVE: Prevent agricultural land near or adjacent to restored habitats from being converted to urban and suburban uses likely to have a negative effect on natural areas, while encouraging agricultural practices that favor birds and other wildlife and that minimize run-off of contaminants into nearby waterways.

SHORT-TERM OBJECTIVES: Identify agricultural lands in the region that are likely to have strong interactions with nearby wetlands, riparian areas, or aquatic habitats or that are important as habitat for waterfowl and other birds. Acquire conservation easements on high priority lands and provide incentives to farmers to use farming methods and crops that are favorable to wildlife.

RATIONALE: The Bay-Delta watershed is one of the most productive agricultural areas in the world, so agricultural lands and practices will always have a big influence on natural habitats in the area. The agricultural land is important as winter feeding grounds for sandhill cranes, various species of geese, and many ducks. It is also frequently important for foraging raptors, such as Swainson's hawk, and other birds. These benefits are lost if the land becomes urbanized and intense land use disturbs or alters adjacent wetlands or aquatic systems. The negative aspects of modern agriculture from an ecological perspective include its heavy use of pesticides, its efficiency of crop harvest (leaving little for wildlife), its capacity to change land use quickly (e.g., from row crops to vineyards) and its ability to use every scrap of available land. Thus, ideally, there should be a buffer zone of agricultural land that is farmed in environmentally friendly ways between the natural habitats and more industrial agriculture lands or urban areas.

Managing significant areas of agricultural lands in the Delta in a wildlife friendly manner will help offset some of the effects of other restoration actions which will convert other agricultural lands in the Delta to tidal wetlands thus reducing their value to species such as the greater sandhill crane or the Swainson's hawk.

STAGE 1 EXPECTATIONS: High priority agricultural lands should be identified and the process begun to acquire easements from willing sellers; incentive programs should be developed and implemented to encourage the planting of crops favored by wildlife and to farm in ways that minimize environmental damage to adjacent areas.

RESTORATION ACTIONS

The general target for agricultural land is to cooperatively manage 40,000-75,000 acres for agriculture and wildlife in the Sacramento-San Joaquin Delta Ecological Management Zone.

Actions that would help increase wildlife quality include:

- deferring fall tillage until later in the year can increase the quantity of forage on cornfields for waterfowl and greater sandhill cranes,
- shallow flooding of seasonal croplands in fall/winter can greatly increase the availability of forage for wintering waterfowl
- retaining a percentage of the unharvested crop in the agricultural field would enhance the value of flooding.

Incidental benefits to agricultural stakeholders from improving conditions for wildlife would be:

- groundwater recharge to aquifers used for summer irrigation,
- leaching salts from soils,
- biological decomposition of crop residue,
- reduction in soil erosion, and
- create an opportunity for cash income from hunting and increase esthetic values, both of which may increase property values.

Protecting and enhancing agricultural lands would be achieved through participation and cooperation with agricultural stakeholders, including farmers, ranchers, and other landowners and lessees. Mechanisms to protect and enhance agricultural lands include various multi year agreements, conservation easements, and purchases through specific payment programs between resource agencies and willing participants.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions to enhance the ecological value of agricultural land help achieve species habitat or population targets.

- Implementation of proposed ERP actions to enhance agricultural habitats should give priority to improving the abundance and availability of upland forage (e.g., corn and winter wheat) in the greater sandhill crane core use area centered around Bract Tract.
- To the extent consistent with CALFED objectives, at least 10% of agricultural lands to be enhanced under the ERP in the Delta and Butte Sink should be to increase forage abundance and availability for greater sandhill cranes. Priority should be given to implementing these habitat improvements within 10 miles of core habitat area centered around Bract Tract.
- Include improvement to and maintenance of suitable agricultural infrastructure habitat (i.e., ditches, drains, canals, and levees) as part of ERP actions to improve wildlife habitat values associated with agricultural lands.
- To the extent consistent with ERP objectives, direct proposed actions for improving agricultural habitats for wildlife to protecting and improving traditional wintering habitat use areas for Aleutian Canada goose.

REFERENCES

Multi-Species Conservation Strategy. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

◆ Species and Species Group Visions

Introduction

This section presents visions for species and species group ecosystem elements. Species and species groups included occur in or are dependent on the Bay-Delta. Many of these species are listed or candidate species for listing as threatened or endangered under the California Endangered Species Act (CESA), listed or proposed for listing under the federal Endangered Species Act (ESA), or designated as a species of special concern by the California Department of Fish and Game (DFG), or the U.S. Fish and Wildlife Service (USFWS). Visions were also created for important recreational or commercial species. Table 16 identifies important fish and wildlife species and species groups and associated strategic objectives. Table 17 presents the basis for selecting each species or species group as an ecosystem element. Species are grouped by the following Strategic Plan Goals:

GOAL 1: Achieve recovery of at-risk native species dependent on the Delta and Suisun Bay as a first step toward establishing large, self-sustaining populations of these species; support similar recovery of at-risk native species in San Francisco Bay and the watershed above the estuary; and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed.

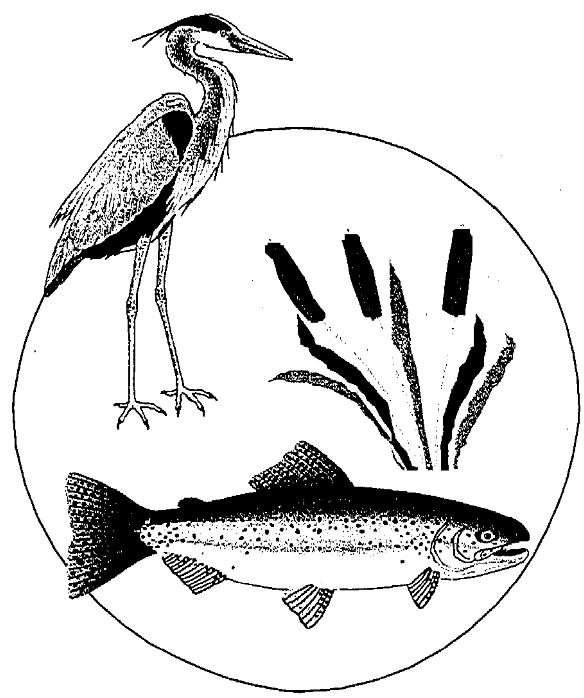
GOAL 3: Maintain and/or enhance populations of selected species for sustainable commercial and recreational harvest, consistent with the other ERP strategic goals.

Visions describe what the Ecosystem Restoration Program hopes to achieve for each species and species group, how the vision is to be achieved through restoring ecological processes and habitats and reducing the effects of stressors. Proposed population targets and programmatic actions to help achieve targets are also included in visions. "Ecosystem Restoration Program Plan, Volume II: Ecological Management Zone Visions" contains more specific objectives, targets, and programmatic actions for each species by specific geographic zone. Table 18 identifies which ecological management zone(s) in which the species are treated in more detail.

Species Designations

The Multi-Species Conservation Strategy (MSCS) addresses all federally and State listed, proposed, and candidate species that may be affected by the CALFED Program; other species identified by CALFED that may be affected by the Program and for which adequate information is available also are addressed in the MSCS. The term "evaluated species" is used to refer to all of the species addressed by the Conservation Strategy. Please refer to the MSCS appendix (Multi-Species Conservation Strategy 2000) for more information and for a complete list of evaluated species.

Recovery "R": For species designated "R," CALFED has established a goal to recover the species within the CALFED ERP Ecological Management Zones. A goal of "recovery" was assigned to those species whose recovery is dependent on restoration of the Delta and Suisun Bay/Marsh ecosystems and for which CALFED could reasonably be expected to undertake all or most of the actions necessary to



recover the species. Recovery is achieved when the decline of a species is arrested or reversed, threats to the species are neutralized, and thus, the species' long-term survival in nature is assured.

Recovery is equivalent, at a minimum, to the requirements for delisting a species under FESA and CESA. Certain species, such as anadromous fish, have threats outside the geographic scope or purview of the CALFED Program (i.e., ocean harvest regulated by the Magnuson-Stevens Act). Therefore, in some instances CALFED may not be able to complete all actions potentially necessary to recover the species; however; however, CALFED will implement all necessary recovery actions within the ERP Ecological Management Zones. For other species, CALFED aims to achieve more than would be required for delisting (e.g., restoration of a species and/or its habitat to a level beyond delisting requirements). The effort required to achieve the goal of "recovery" may be highly variable between species. In sum, to achieve a goal of "recovery" implies that CALFED is expected to undertake all actions within the ERP Ecological Management Zones and Program scope necessary to recover the species.

CONTRIBUTE TO RECOVERY ("r"): For species designated "r," CALFED will make specific contributions toward the recovery of the species. The goal "contribute to recovery" was assigned to species for which CALFED Program actions affect only a limited portion of the species range and/or CALFED Program actions have limited effects on the species.

To achieve the goal of contributing to a species' recovery, CALFED is expected to undertake some of the actions under its control and within its scope that are necessary to recovery the species. When a species has a recovery plan, CALFED may implement some of the measures identified in the plan, that are within the CALFED Problem Area, and some measures that are outside the Problem Area. For species without a recovery plan, CALFED would need to implement specific measures that would benefit the species.

MAINTAIN ("M"): For species designated "m," the CALFED Program will undertake actions to maintain the species. This category is less rigorous than "contribute to recovery." For this category, CALFED will avoid, minimize, and compensate for any adverse effects to the species commensurate with the level of effect on the species. Actions may not actually contribute to the recovery of the species; however, at a minimum, they will be expected to not contribute to the need to list an unlisted species or degrade the status of an already listed species. CALFED will also, to the extent practicable, improve habitat conditions for these species.

ENHANCE AND/OR CONSERVE"E": For those biotic assemblages and communities (aquatic, terrestrial, and plant) designated "E", the CALFED Program will undertake actions to maintain and enhance their diversity, distribution and abundance in the Bay-Delta estuary and watershed as appropriate to reverse their declines or to keep abundances and distributions at their present levels.

MAINTAIN AND/OR ENHANCE HARVESTED SPECIES ("H"): For those species designated "H" the CALFED Program will undertake actions to maintain the species at levels which support viable harvest rates. The goal "maintain harvested species" was assigned to species which are harvested for recreational or commercial purposes. A key to maintaining harvestable surplus levels is recognizing the need to recover, contribute to recovery, or maintain species evaluated in the MSCS. Thus, species interactions such as competition and predation and habitat needs for space and flow need to be balanced in favor of species designated for recovery, contribute to recovery and maintain. Those three designations apply only to native species and assemblages while the "maintain harvested species" designation includes some native species and non-native species. Thus, actions implemented to maintain harvested species would be expected, *at a minimum*, to not contribute to the need to list an unlisted species, degrade the status of an already listed species, or impair in any way efforts to recover, contribute to recovery, or maintain native species.

Some species, such as chinook salmon and steelhead trout, are covered by more than one strategic objective. For example, both chinook and steelhead are at-risk species and harvested species and thus covered by the objective to achieve, first, recovery and then large self-sustaining population, and by the objective to enhance fisheries for chinook, steelhead, white sturgeon, Pacific herring, and native cyprinid fishes.

Table 16. Species Designations, Species and Species Groups, Strategic Plan Goals, and Objectives.

SPECIES DESIGNATION:

RECOVERY ("R"): For those species designated "R", the CALFED Program has established a goal to recovery the species within the CALFED ERP Ecological Management Zones.

Strategic Plan Objective: Achieve, first, recovery and then large self-sustaining populations of the following at-risk native species dependent on the Delta, Suisun Bay, and Suisun Bay:

Delta Smelt	Suisun Marsh Aster
Longfin Smelt	Suisun Thistle
Green Sturgeon	Soft Bird's-Beak
Splittail	Antioch Dunes Evening-Primrose
Sacramento Winter-Run Chinook Salmon ESU	Contra Costa Wallflower
Sacramento Spring-Run Chinook Salmon ESU	Lange's Metalmark Butterfly
Fall-run Chinook Salmon ESU including Late-Fall-Run Chinook Salmon	Valley Elderberry Longhorn Beetle
Central Valley Steelhead Trout ESU	Suisun Ornate Shrew
Mason's Lilaeopsis	Suisun Song Sparrow
	San Pablo Song Sparrow

SPECIES DESIGNATION:

CONTRIBUTE TO RECOVERY ("r"): For those species designated "r", the CALFED Program will make specific contributions toward the recovery the species.

Strategic Plan Objective: Contribute to the recovery of the following at-risk native species in the Bay-Delta estuary and its watershed:

California Clapper Rail	Western Yellow-Billed Cuckoo
California Black Rail	Least Bell's Vireo
Swainson's Hawk	Saltmarsh Common Yellowthroat
Salt Marsh Harvest Mouse	Bank Swallow
San Pablo California Vole	Delta Green Ground Beetle
Riparian Brush Rabbit	Bristly Sedge
San Joaquin Valley Woodrat	Delta Tule Pea
Sacramento Perch	Delta Mudwort
Giant Garter Snake	Crampton's Tuctoria
Greater Sandhill Crane	Alkali Milkvetch
California Yellow Warbler	Point Reyes Bird's-Beak
Little Willow Flycatcher	Delta Coyote-Thistle

SPECIES DESIGNATION:

MAINTAIN ("m"): For those species designated "m," the CALFED Program will undertake actions to maintain the species (this category is less rigorous than "contribute to recovery).

Strategic Plan Objective: Maintain the abundance and distribution of the following species:

Western Least Bittern	Recurved larkspur
California Tiger Salamander	Mad-Dog Skullcap
Western Spadefoot Toad	Rose-mallow
California Red-Legged Frog	Eel-Grass Pondweed
Native Anuran Amphibians	Colusa grass
Western Pond Turtle	Boggs Lake Hedge-Hyssop
California Freshwater Shrimp	Contra Costa Goldfields
Hardhead	Legenere
	Heartscale

Table 16. Species Designation Species and Species Groups, Strategic Plan Goals, and Objectives (continued).

SPECIES DESIGNATION:

ENHANCE AND/OR CONSERVE ("E"): For those species designated "E," the CALFED Program will undertake actions to enhance and/or maintain the diversity, distribution, and abundance of non-listed native species in the estuary and watershed.

Strategic Plan Objective: Enhance and/or conserve native biotic communities in the Bay-Delta estuary and its watershed including the abundance and distribution of the following biotic assemblages and communities:

Native Resident Fish Species Bay-Delta Foodweb Organisms Shorebird Guild Wading Bird Guild Migratory Waterfowl Neotropical Migratory Birds Lamprey Family	Vernal Pool Communities Aquatic Habitat Plant Community Group Tidal Brackish and Freshwater Marsh Habitat Plant Community Group Seasonal Wetland Habitat Plant Community Group Inland Dune Habitat Plant Community Group Tidal Riparian Habitat Plant Community Group

SPECIES DESIGNATION:

MAINTAIN AND/OR ENHANCE HARVESTED SPECIES ("H"): For those species designated "H," the CALFED Program will undertake actions to maintain the species at levels that support viable harvest rates.

Strategic Plan Goal: Maintain and/or enhance populations of selected species for sustainable commercial and recreational harvest, consistent with the other ERP strategic goals.

Species	Strategic Objective
Striped Bass American Shad Signal Crayfish Grass Shrimp Non-native Warmwater Gamefish	Maintain, to the extent consistent with ERP goals, fisheries for striped bass, American shad, signal crayfish, grass shrimp, and nonnative warmwater gamefishes.
Chinook Salmon (all runs) Steelhead Trout White Sturgeon Pacific Herring Native Cyprinid Fishes	Enhance fisheries for salmonids, white sturgeon, Pacific herring, and native cyprinid fishes.
Waterfowl Upland Game	Enhance, to the extent consistent with ERP goals, populations of waterfowl and upland game for harvest by hunting and for non-consumptive recreation.
Artificial Fish Propagation	Ensure that chinook salmon, steelhead, and trout hatchery and planting programs do not have detrimental effects on wild populations of these species and ERP actions.

Table 17. Basis for Selection of Species and Species Group Ecosystem Elements.

Species and Species Groups	Basis for Selection as an Ecosystem Element
Delta Smelt	The delta smelt is a native estuarine resident fish that has been listed as threatened under the California and federal Endangered Species Acts. It is a species evaluated in the MSCS.
Longfin Smelt	The longfin smelt is a native estuarine resident species and is designated as a species of special concern by DFG and a species of concern by USFWS. It is a species evaluated in the MSCS.
Green Sturgeon	The green sturgeon is designated as a species of special concern by DFG and a species of concern by USFWS. It is a species evaluated in the MSCS.
Splittail	The splittail is a native resident fish that is listed under the federal Endangered Species Act and a candidate for listing under the California Endangered Species Act. The splittail also supports a small winter sport fishery in the lower Sacramento River. It is a species evaluated in the MSCS.
Sacramento Winter-run Chinook Salmon ESU	The chinook salmon is an important native anadromous sport and commercial fish with important ecological value. The winter-run race is listed as endangered under the California and federal Endangered Species Acts. It is a species evaluated in the MSCS.
Sacramento Spring-run Chinook Salmon ESU	The chinook salmon is an important native anadromous sport and commercial fish with important ecological value. The spring-run race on the Sacramento River is listed as a threatened species under CESA and ESA. It is a species evaluated in the MSCS.
Fall-run Chinook Salmon ESU	The chinook salmon is an important native anadromous sport and commercial fish with important ecological value. The fall-run race is the largest population of chinook salmon on the Sacramento River. It is a candidate species under the ESA. It is a species evaluated in the MSCS.
Sacramento Late-fall-run Chinook Salmon	The chinook salmon is an important native anadromous sport and commercial fish with important ecological value. The late-fall-run race on the Sacramento River is a candidate species under the ESA. It is a species evaluated in the MSCS.
Central Valley Steelhead Trout ESU	The steelhead is an important native anadromous sport fish of high recreational and ecological value. The Central Valley Steelhead Evolutionarily Significant Unit is listed as threatened under the ESA. It is a species evaluated in the MSCS.
Mason's Lilaeopsis	The Mason's lilaeopsis is a State protected plant and is on the CNPS 1B list. It is a species evaluated in the MSCS.
Suisun Marsh Aster	The Suisun marsh aster is on the CNPS 1B list. It is a species evaluated in the MSCS.
Suisun Thistle	The Suisun thistle is a federally listed endangered species and is on the CNPS 1B list. It is a species evaluated in the MSCS.
Soft Bird's-Beak	The soft bird's-beak is federally listed endangered species and is on the CNPS 1B list. It is a species evaluated in the MSCS.
Antioch Dunes Evening-Primrose	The Antioch dunes evening-primrose is a state and federally listed endangered species and is on the CNPS 1B list. It is a species evaluated in the MSCS.
Contra Costa Wallflower	The Contra Costa wallflower is a state and federally listed endangered species and is on the CNPS 1B list. It is a species evaluated in the MSCS.
Lange's Metalmark Butterfly	The Lange's metalmark is listed as endangered under the federal ESA. It is a species evaluated in the MSCS.

Table 17. Basis for Selection of Species and Species Group Ecosystem Elements (continued).

Species and Species Groups	Basis for Selection as an Ecosystem Element
Valley Elderberry Longhorn Beetle	The valley elderberry longhorn beetle listed as threatened under the federal ESA. It is a species evaluated in the MSCS.
Suisun Ornate Shrew	The Suisun ornate shrew is a species of special concern. It is a species evaluated in the MSCS.
Suisun Song Sparrow	The Suisun song sparrow is a species of special concern. It is a species evaluated in the MSCS.
San Pablo Song Sparrow	The San Pablo song sparrow is a species of special concern. It is a species evaluated in the MSCS.
California Clapper Rail	The California clapper rail is listed as endangered under the California and federal ESAs. It is a species evaluated in the MSCS.
California Black Rail	The California black rail is listed as threatened under the California ESA. It is a species evaluated in the MSCS.
Swainson's Hawk	The Swainson's hawk is listed as threatened under the California ESA. It is a species evaluated in the MSCS.
Salt Marsh Harvest Mouse	The salt marsh harvest mouse is listed as endangered under the California and federal ESAs. It is a species evaluated in the MSCS.
San Pablo California Vole	The San Pablo California vole is a California species of concern. It is a species evaluated in the MSCS.
Sacramento Perch	The Sacramento perch is a California species of special concern. It is a species evaluated in the MSCS.
Riparian Brush Rabbit	The riparian brush rabbit is listed as endangered under the CESA and ESA. It is a species evaluated in the MSCS.
San Joaquin Valley Woodrat	The San Joaquin Valley woodrat is listed as endangered under the ESA and is a California species of special concern. It is a species evaluated in the MSCS.
Greater Sandhill Crane	The greater sandhill crane is listed as a threatened species under CESA. It is a species evaluated in the MSCS.
California Yellow Warbler	The California yellow warbler is a California species of special concern. It is a species evaluated in the MSCS.
Least Bell's Vireo	Least Bell's vireo is listed as endangered under ESA and CESA. It is a species evaluated in the MSCS.
Western Yellow-billed Cuckoo	The western yellow-billed cuckoo is listed as endangered under the CESA. It is a species evaluated in the MSCS.
Bank Swallow	The bank swallow is listed as threatened under the CESA. It is a species evaluated in the MSCS.
Little Willow Flycatcher	The little willow flycatcher is listed as an endangered species under CESA. It is a species evaluated in the MSCS.
Giant Garter Snake	The giant garter snake is listed as threatened under the California and federal ESAs. It is a species evaluated in the MSCS.

Table 17. Basis for Selection of Species and Species Group Ecosystem Elements (continued).

Species and Species Groups	Basis for Selection as an Ecosystem Element
Delta Green Ground Beetle	The delta green ground beetle is listed as endangered under the federal ESA. It is a species evaluated in the MSCS.
Saltmarsh Common Yellowthroat	The saltmarsh common yellowthroat is a State species of special concern. It is a species evaluated in the MSCS.
Bristly Sedge	The bristly sedge is on the CNPS 1B list. It is a species evaluated in the MSCS.
Point Reyes Bird's-Beak	The Point Reyes bird's-beak is on the CNPS 1B list. It is a species evaluated in the MSCS.
Crampton's Tuctoria	Crampton's tuctoria is a state and federally listed endangered species and is on the CNPS 1B list. It is a species evaluated in the MSCS.
Delta Tule Pea	The delta tule pea is on the CNPS 1B list. It is a species evaluated in the MSCS.
Delta Mudwort	The delta mudwort is on the CNPS 2 list. It is a species evaluated in the MSCS.
Alkali Milk-Vetch	The alkali milk-vetch is on the CNPS 1B list. It is a species evaluated in the MSCS.
Delta Coyote-Thistle	The Delta coyote-thistle is a State listed endangered species and is on the CNPS 1B list. It is a species evaluated in the MSCS.
Mad-dog Skullcap	Mad-dog skullcap is on the CNPS 2 list. It is a species evaluated in the MSCS.
Rose-Mallow	Rose-mallow is on the CNPS 2 list. It is species a evaluated in the MSCS.
Eel-Grass Pondweed	The eel-grass pondweed is on the CNPS 2 list. It is a species evaluated in the MSCS.
Colusa Grass	Colusa grass is listed as a state and federal threatened species and is on the CNPS list 1B. It is a species evaluated in the MSCS.
Boggs Lake Hedge-Hyssop	The Boggs Lake hedge-hyssop is a State listed endangered species and is on the CNPS 1B list. It is a species evaluated in the MSCS.
Contra Costa Goldfields	The Contra Costa goldfields is a federally listed endangered species and is on the CNPS 1B list. It is a species evaluated in the MSCS.
Greene's Legenere	Legenere is on the CNPS 1B list. It is a species evaluated in the MSCS.
Recurved Larkspur	The recurved larkspur is on the CNPS 1B list. It is a species evaluated in the MSCS.
Heartscale	Heartscale is on the CNPS 1B list. It is a species evaluated in the MSCS.
California Freshwater Shrimp	The California freshwater shrimp is listed as an endangered species under ESA. It is a species evaluated in the MSCS.
Hardhead	The hardhead is a California species of special concern. It is a species evaluated in the MSCS.
Western Least Bittern	The western least bittern is a California species of special concern. It is a species evaluated in the MSCS.
California Red-legged Frog	The California red-legged frog is listed as a threatened species under the federal ESA. It is a species evaluated in the MSCS.

Table 17. Basis for Selection of Species and Species Group Ecosystem Elements (continued).

Species and Species Groups	Basis for Selection as an Ecosystem Element
California Tiger Salamander	The California tiger salamander is an amphibians designated as species of special concern. It is a species evaluated in the MSCS.
Western Pond Turtle	The western pond turtle is designated as a species of special concern and a species of concern by DFG and USFWS, respectively. It is a species evaluated in the MSCS.
Western Spadefoot Toad	The western spadefoot toad is an amphibian designated as species of special concern It is a species evaluated in the MSCS.
Lamprey Family	Anadromous lamprey is an important native anadromous fish of high ecological value. The status, abundance, and distribution of anadromous lamprey is unknown.
Native Resident Fishes	Native resident fish species of the Delta are important ecologically and serve as surrogate indicators of ecosystem health. Some native species are important elements of the foodweb; others are important predators. Native resident fish have been in decline as a percentage of total fish species abundance in tributaries of the Bay-Delta/Central Valley watershed.
Native Anuran Amphibians	Native anuran amphibians are ecologically important and serve as surrogate indicators of ecological health.
Migratory Waterfowl	Many species of waterfowl migrate through, winter, or breed in the Bay-Delta. Waterfowl are significant components of the ecosystem, are of high interest to recreational hunters and bird watchers, and contribute to California's economy through the sale of hunting and related equipment.
Shorebird and Wading Bird Guild	Many species of shorebirds and wading birds migrate through, winter, or breed in the Bay-Delta. These species are significant components of the ecosystem, are of high interest to recreational bird watchers, and contribute to California's economy through sales of equipment and other bird-watching-related expenditures.
Neotropical Migratory Birds	Many species of neotropical migratory birds migrate through or breed in the Bay-Delta. These species are significant components of the ecosystem, are of high interest to recreational bird watchers, and contribute to California's economy through sales of equipment and other bird-watching-related expenditures.
Bay-Delta Foodweb Organisms	Foodweb organisms are essential for the survival and productivity of fish, shorebirds, and other higher order animal populations in the Bay-Estuary.
Plant Community Groups	Plant community groups include aquatic habitat plant communities (pondweeds with floating and submerged leaves), tidal brackish and freshwater marsh plant communities (pickleweed series, saltgrass series, bulrush series, cattail series, and common reed series), seasonal wetland plant communities (northern claypan vernal pool communities, northern hardpan vernal pool communities, inland dune plant communities (Antioch Dunes plant community), and tidal riparian habitat plant communities (black willow series, narrowleaf willow series, white alder series, buttonbush series, Mexican elderberry series, and valley oak series).
White Sturgeon	The white sturgeon is an important native anadromous sport fish with high recreational and ecological value.
Striped Bass	The striped bass is an important non-native anadromous sport fish with high recreational value. It also plays an important role as a top predator in the aquatic system.
American Shad	The American shad is an important non-native anadromous sport fish with high recreational value.

Table 17. Basis for Selection of Species and Species Group Ecosystem Elements (continued).

Species and Species Groups	Basis for Selection as an Ecosystem Element
Non-native Warmwater Gamefish	Non-native warmwater gamefishes provide abundant opportunities for recreational angling.
Pacific Herring	Pacific herring support the most valuable commercial fishery in San Francisco Bay.
Grass Shrimp	Grass shrimp support bait fisheries in the Bay.
Signal Crayfish	The signal crayfish is an introduced species that supports a small commercial fishery, as well as a sport fishery, in the Delta.
Upland Game	Upland game species are of high interest to recreational hunters in the Bay-Delta and contribute to California's economy through the sale of hunting-related equipment and expenditures.

Table 18. Ecological Management Zones in Which Programmatic Actions Are Proposed That Will Assist in the Recovery of Species and Species Groups.

[Note: Refer to Volume II: Ecological Management Zone Visions for information regarding specific targets and actions.]

Species and Species Group Visions	Ecological Management Zone[1]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Species with the Designation "Recover"														
Delta Smelt	●	●												
Longfin Smelt	●	●										●		
Green Sturgeon	●	●	●	—				●						
Sacramento Splittail	●	●	●					●	●		●	●		
Winter-run Chinook Salmon	●	●	●	●	●		●	●	●	●	●	●	●	
Spring-run Chinook Salmon	●	●	●								●	●	●	
Fall-run Chinook Salmon (including late-fall-run)	●	●	●	●	●		●	●	●	●	●	●	●	
Steelhead Trout	●	●	●	●	●		●	●	●	●	●	●	●	
Mason's Lilaeopsis	●	●							●	●	●			●
Suisun Marsh Aster	●	●												
Suisun Thistle		●												
Soft Bird's-Beak		●								●				
Antioch Dunes Evening-Primrose and Contra Costa Wallflower		●								●				
Lange's Metalmark Butterfly	●	●												
Valley Elderberry Longhorn Beetle	●	●	●	●	●									
Suisun Ornate Shrew		●												
Suisun Song Sparrow		●												

Table 18. Ecological Management Zones in which programmatic actions are proposed that will assist in the recovery of species and species groups (continued).

Species and Species Group Visions	Ecological Management Zone[1]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
San Pablo Song Sparrow		●												
Species with the Designation "Contribute to Recovery"														
California Clapper Rail		●												
California Black Rail	●	●		—										
Swainson's Hawk	●	●							●	●	●	●	●	
Salt Marsh Harvest Mouse		●												
San Pablo California Vole		●												
Sacramento Perch	●	●	●	●							●	●	●	●
Riparian Brush Rabbit	●												●	
San Joaquin Valley Woodrat	●												●	
Greater Sandhill Crane	●													
California Yellow Warbler	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Least Bell's Vireo	●	●	●	●								●		
Western Yellow-Billed Cuckoo	●		●									●	●	
Bank Swallow				●										
Little Willow Flycatcher				●					●		●	●	●	
Giant Garter Snake	●	●				●	●		●		●	●	●	
Delta Green Ground Beetle	●	●												

Table 18. Ecological Management Zones in which programmatic actions are proposed that will assist in the recovery of species and species groups (continued).

Species and Species Group Visions	Ecological Management Zone[1]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Saltmarsh Common Yellowthroat		●												
Bristly Sedge		●												
Point Reyes Bird's-Beak		●												
Crampton's Tuctoria	●									●				
Delta Mudwort		●								●	●			
Delta Tule Pea	●	●												
Alkali Milk-Vetch		●	●			●				●	●	●	●	●
Delta Coyote-Thistle											●	●	●	●
Species with the Designation "Maintain"														
Mad-dog Skullcap											●			
Rose-Mallow			●			●	●	●	●	●	●	●		●
Eel-grass Pondweed	●					●		●	●	●	●		●	
Colusa Grass		●	●			●				●	●	●	●	●
Boggs Lake Hedge Hyssop		●	●	●	●	●	●	●	●	●	●			
Green's Legenere			●	●						●				
Contra Costa Goldfields		●								●				
Recurved Larkspur and Heartscale	●	●				●	●	●		●		●	●	●
California Freshwater Shrimp		●												
Hardhead	●		●	●	●	●	●	●	●	●	●	●	●	●
Western Least Bittern	●	●	●	●								●		

Table 18. Ecological Management Zones in which programmatic actions are proposed that will assist in the recovery of species and species groups (continued).

Species and Species Group Visions	Ecological Management Zone[1]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
California Red-Legged Frog	●	●				●	●		●		●	●	●	●
Western Pond Turtle	●	●				●	●		●		●	●	●	
California Tiger Salamander	●													
Western Spadefoot	●													
Species with the Designation "Enhance and/or Conserve Biotic Communities"														
Lamprey	●	●	●	●	●		●	●	●	●	●	●	●	
Native Resident Fish Species	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Native Anuran Amphibians	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Waterfowl	●	●	●	●	●	●	●	●	●		●	●	●	●
Shorebird and Wading Bird Guild	●	●											●	
Neotropical Migratory Bird Guild	●	●	●	●						●	●	●	●	●
Bay-Delta Foodweb Organisms	●	●												
Plant Communities														
Species with the Designation "Maintain and/or Enhance Harvested Species"														
White Sturgeon	●	●	●					●				●		
Striped Bass	●	●	●					●	●			●		
American Shad	●	●	●					●	●			●		
Non-native Warmwater Gamefish	●	●	●							●	●	●	●	●

Table 18. Ecological Management Zones in which programmatic actions are proposed that will assist in the recovery of species and species groups (continued).

Species and Species Group Visions	Ecological Management Zone[1]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pacific Herring		●												
Grass Shrimp		●												
Signal Crayfish	●		●											
Upland Game	●		●	●						●	●	●	●	●

[1]
1 = Sacramento-San Joaquin Delta
2 = Suisun Marsh/North San Francisco Bay
3 = Sacramento River
4 = North Sacramento Valley
5 = Cottonwood Creek
6 = Colusa Basin
7 = Butte Basin
8 = Feather River/Sutter Basin
9 = American River Basin
10 = Yolo Basin
11 = Eastside Delta Tributaries
12 = San Joaquin River
13 = East San Joaquin Basin
14 = West San Joaquin Basin

◆ Species Designated for Recovery

Introduction

The Strategic Plan for Ecosystem Restoration presents 6 goals to guide the implementation of restoration actions during the 20-30 year program.

The first Strategic Goal focuses on at-risk species which includes all species designated for recovery by the MSCS and the ERP.

> *STRATEGIC GOAL 1: Achieve, first, recovery and then large self-sustaining populations of at-risk native species dependent on the Delta and Suisun Bay; support similar recovery of at-risk native species in San Francisco Bay and the watershed above the estuary; and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed.*

Recovery Designation

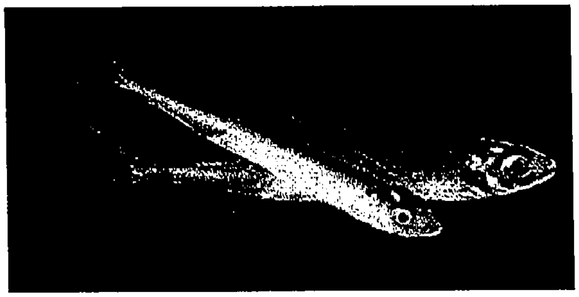
Recovery "R": For species designated "R," CALFED has established a goal to recover the species within the CALFED ERP Ecological Management Zones. A goal of "recovery" was assigned to those species whose recovery is dependent on restoration of the Delta and Suisun Bay/Marsh ecosystems and for which CALFED could reasonably be expected to undertake all or most of the actions necessary to recover the species. Recovery is achieved when the decline of a species is arrested or reversed, threats to the species are neutralized, and thus, the species' long-term survival in nature is assured.

Recovery is equivalent, at a minimum, to the requirements for delisting a species under FESA and CESA. Certain species, such as anadromous fish, have threats outside the geographic scope or purview of the CALFED Program (i.e., ocean harvest regulated by the Magnuson-Stevens Act). Therefore, in some instances CALFED may not be able to complete all actions potentially necessary to recover the species; however; however, CALFED will implement all necessary recovery actions within the ERP Ecological Management Zones. For other species, CALFED aims to achieve more than would be required for delisting (e.g., restoration of a species and/or its habitat to a level beyond delisting requirements). The effort required to achieve the goal of "recovery" may be highly variable between species. In sum, to achieve a goal of "recovery" implies that CALFED is expected to undertake all actions within the ERP Ecological Management Zones and Program scope necessary to recover the species.

The "recover" species addressed in this section include:

- Delta smelt
- Longfin smelt
- Green sturgeon
- Splittail
- Sacramento winter-run chinook salmon
- Central Valley spring-run chinook salmon
- Late-fall-run chinook salmon
- Fall-run chinook salmon
- Central Valley steelhead
- Mason's lilaeopsis
- Suisun Marsh aster
- Suisun thistle
- Soft bird's-beak
- Antioch Dunes evening-primrose
- Contra Costa wallflower
- Lange's metalmark butterfly
- Valley elderberry longhorn beetle
- Suisun ornate shrew
- Suisun song sparrow, and
- San Pablo song sparrow.

> Note: the use of Species Targets in this section is synonymous with the Species Goal Prescriptions provided in the Multi-species Conservation Strategy.



INTRODUCTION

The delta smelt is a native estuarine resident fish. Delta smelt are found mainly in the waters of the Sacramento-San Joaquin Delta and in Suisun and San Pablo bays. They are found only in the Sacramento-San Joaquin Estuary. Delta smelt are most abundant in Montezuma Slough, Suisun Bay, and the western Delta, but beginning in December and continuing through perhaps June 30, migrate upstream and are more abundant in the Delta. They have been found as for upstream as the mouth of the American River on the Sacramento River at Mossdale on the San Joaquin River. Human-caused adverse habitat modifications reduced delta smelt populations resulting in its listing as threatened under State and federal Endangered Species Acts

Major factors that limit this species' contribution to the health of the Delta are adverse effects of low Delta outflow, poor foodweb productivity, reduced low-salinity habitat, losses to water diversions, poor spawning habitat, and potentially higher concentrations of toxins.

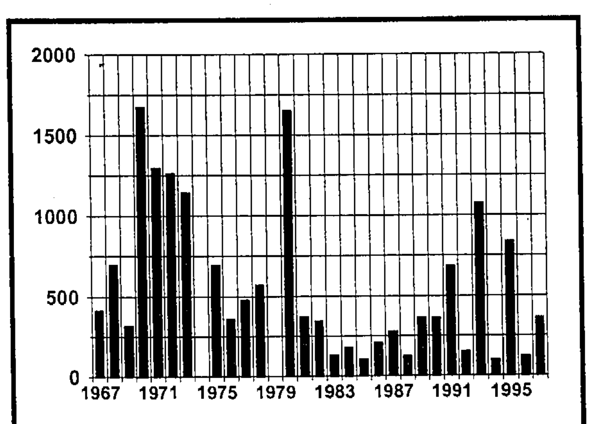
RESOURCE DESCRIPTION

Delta smelt are native to the Sacramento-San Joaquin Delta estuary and represent an important component of the historic native fish fauna and Bay-Delta foodweb (i.e., as a prey species for species such as chinook salmon). Delta smelt's 1-year life span and relatively low reproductive rate make its population abundance sensitive to short-term habitat changes. As a consequence, the population abundance of delta smelt is characterized by sharp declines followed by dramatic recovery. Low abundance through the drought years (1987-1992) indicated need for actions to restore the delta smelt population. Delta smelt are considered environmentally sensitive because the have a one year life cycle, unusually low fecundity, a limited diet, and reside primarily within the interface between salt and freshwater.

During late-winter to early-summer, delta smelt migrate to freshwater to spawn. Females only produce between 1,000 and 2,600 eggs which sink to the bottom and attach to the substrate. Spawning habitat includes shallow freshwater sloughs and edge waters with firm substrate, submerged vegetation, and woody debris. Rearing habitat includes shallow freshwater and low salinity (less than 6-8 ppt salinity) habitats that provides a protective, food-rich environment. Such habitats include shallow bays, tidal sloughs, shoals, shorelines, and marsh channels.

Land reclamations in the Bay-Delta have diminished the quality and quantity of shallow-water, marsh-slough habitat. Remaining shallow-water, low-salinity habitat is further reduced in dry-water years because of extensive water diversions from the Delta.

Population abundance during 1993 and 1995 (relative to abundance during the 1987-1992 drought) suggests that recovery potential may be high. Sharp population declines during drought conditions (as in 1994), however, illustrate the potential threat of poor conditions to the species' survival under existing habitat and stressor conditions. A preliminary low abundance index in 1996, a wet year, is further cause for concern. The fall



Abundance Data for Delta Smelt from DFG September through December Fall Mid Water Trawl Survey.

mid water trawl (FMWT) is best measure of delta smelt abundance (Sweetnam and Stevens 1993) as it measures the abundance of pre-spawning adults. It includes cumulative data for 35 sampling stations.

Delta smelt tolerate a wide range of salinity but are most abundant in the Bay-Delta estuary, where salinity is around 2 parts per thousand (ppt). Spawning occurs in freshwater in the upstream areas of the Delta. Construction of levees in the 1800s created narrow channels and eliminated vast areas of marshes and interconnecting sloughs. Marshes and adjoining sloughs are very productive and support an abundance of zooplankton, on which delta smelt feed, and are important as spawning and rearing habitat for the species.

Reduced freshwater outflow during the late winter and spring of dry years allows saltwater to move farther upstream in the estuary than during wet years. This reduces the amount of low-salinity habitat for delta smelt. The increased upstream saltwater movement changes the location of habitat that meets the salinity needs of the delta smelt, similar to effects on other Delta fish species such as striped bass, longfin smelt, and Sacramento splittail. Habitat location is shifted upstream from the relatively shallow, productive bays, marshes, and sloughs of Suisun Bay and into the narrow, deeper, and less-productive channels of the Delta.

The upstream shift also increases exposure to Delta water diversions. Water is drawn from the Delta by hundreds of small agricultural diversions, Central Valley Project (CVP) and State Water Project (SWP) South Delta export pumps, and Pacific Gas & Electric (PG&E) power generation facilities. During most years, large numbers of delta smelt are lost to Delta diversions.

Food availability, toxic substances, competition and predation (particularly from non-native species), and loss of genetic integrity through hybridization with the introduced Japanese pond smelt (wagasaki) also are other factors believed to influence smelt abundance.

Overall, the threats to the population, in decreasing order of importance, are:

- reduction in outflow from the Estuary,
- entrainment to water diversions,
- extremely high outflow,
- changes in food organisms,
- toxic substances,
- disease, competition, and predation, and
- loss of genetic integrity by hybridization with introduced wagasaki.

VISION

The vision for delta smelt is to recover this State- and federally listed threatened species in order to contribute to the overall species richness and diversity of the Bay-Delta and to improve water management for beneficial uses of the Bay-Delta system.

Achieving this vision will reduce the conflict between protection for this species and other beneficial water uses in the Bay-Delta. Increases in the population and distribution of delta smelt can be realized through habitat restoration accompanied by reductions in stressors.

Delta smelt would benefit from the many expected improvements in ecosystem processes and habitats, and reductions in stressors. These improvements will result from the wide variety of actions proposed for the Delta and Suisun Bay. Improvements in streamflow (Delta inflow and outflow) would better attract adults to spawning habitat, ensure transport or movement of larvae and early juveniles to productive rearing habitat, and maintain productivity and suitability of spawning and rearing habitat, including production of food. Additional freshwater flow could be provided by reservoir releases during spring to maintain salinity requirements of delta smelt in areas that provide high quality nursery habitat, such as Suisun Bay and Marsh.

Delta smelt would benefit from spawning and rearing habitat restoration. Habitat restoration may be achieved by adding and modifying physical habitat and creating additional freshwater flow during critical periods. More habitat can be created by breaching levees to inundate lands once part of the Bay and Delta, setting levees back to increase shallow-water habitat along existing channels, protecting existing shallow-water habitat from erosion, and filling relatively deep water areas with sediments to create shallow-water habitat.

Reducing stressors is a major component of delta smelt restoration. Reducing delta smelt losses to diversions is of primary concern.

RECOVERY GOALS

The basic strategy for the recovery of delta smelt is to manage the estuary is such a way that it is a better habitat for native fish in general and delta smelt in particular (U.S. Fish and Wildlife Service 1996). Improved habitat will allow delta smelt to be widely distributed throughout the Delta and Suisun Bay. Recovery of delta smelt will occur in two phases, restoration and delisting. Restoration is defined as a return of the population to pre-decline levels, but delisting is not recommended until the population has been tested by extreme outflows. Delta smelt will be considered restored when its population dynamics and distribution pattern within the estuary are similar to those that existed in the 1967-1981 period.

If abundance and distributional criteria are met for a five-year period, the species will be considered restored. Delta smelt will meet the remaining recovery criteria and be considered for delisting when abundance and distribution criteria are met for a five-year period that includes two successive extreme outflow years, with one year dry or critical.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore delta smelt involve cooperation and support of other established programs that are protecting and improving conditions for delta smelt and other species in the Bay and Delta.

- The Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes (U.S. Fish and Wildlife Service 1996) would be considered in developing actions.
- The Central Valley Project Improvement Act will implement actions that will benefit delta smelt, including changing the timing of diversions, restoring habitat, and dedicating flow during critical periods (U.S. Fish and Wildlife Service 1997).
- Federal ESA requirements (biological opinions and habitat conservation plans) will ensure maintenance of existing habitat conditions and implementation of recovery actions.
- The State Water Resources Control Board will implement the Water Quality Control Plan for the San Francisco/Sacramento-San Joaquin Delta estuary, which includes provisions to limit entrainment in diversions and protect habitat conditions for delta smelt, chinook salmon, striped bass, and other species.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Successful restoration of delta smelt will be closely tied with improving late winter and spring Delta outflow, increasing shallow water and wetland-slough habitat, improving the productivity of the aquatic foodweb, reducing the effects of Delta water diversions, and reducing the level of contaminants in Bay-Delta waters. Restoration actions are similar to those prescribed for other native resident and anadromous fish including longfin smelt and striped bass.

Maintenance of rearing habitat is extremely important for the recovery of delta smelt and other native Delta species. Successful restoration of delta smelt will also be closely tied with improving Delta outflow that maintains the X2 location in Suisun Bay for rearing delta smelt and prevent adverse influence of the CVP/SWP export facilities in the southern Delta.

OBJECTIVE, TARGETS ACTIONS, AND MEASURES

> The Strategic Objective is achieve, first, recovery and then large self-sustaining populations of at-risk species dependent on the Delta, Suisun Bay, and Suisun Marsh.

SPECIES TARGET: The fall mid-water trawl survey in September and October must capture delta smelt in all zones in 2 out of 5 consecutive years and in at least 2 zones in 3 out of the 5 consecutive years, and in at least 1 zone in all 5 years; and the 5 consecutive years must include 2 sequential extreme outflow years (i.e., at least one critical or dry year followed by a critical, dry, or wet year) and the fall mid-water trawl catch for September and October must exceed 239 for 2 out of 5 years and not fall below 84 for more than 2 consecutive years.

LONG-TERM OBJECTIVE: To restore delta smelt abundance to levels that existed in the 1960s and 1970s, as measured over a period of at least 10 years.

SHORT-TERM OBJECTIVE: Achieve the recovery goals for delta smelt identified in the Delta Native Fishes Recovery Plan.

RATIONALE: The annual life cycle of delta smelt contributes to wide interannual variation in abundance, necessitating multiple sample years to discern a trend in abundance. Delta smelt were extremely abundant in the system when the "standard" trawling program in the Delta began in the 1960s. This period is used as a standard simply because that is when the data available for comparative purposes begin. Conditions in the estuary were clearly favorable for the species in that period. Achieving the long-term objective may be impeded by the presence of several introduced species, notably the clam, *Potamocorbula amurensis*, inland silversides, and wakasagi. If future investigations determine that substantial reductions in Delta smelt are attributable to the introduced species already established, the long-term population abundance objective may need to be lowered.

STAGE 1 EXPECTATIONS: In 7-10 years, the delta smelt population indices should be within the same range as during 1990-1998. The basic factors limiting delta smelt distribution and abundance should be determined (e.g., reduced food supply, interactions with non-native species, negative effects of diversions) and, where feasible, overcome through habitat and ecosystem process restoration.

RESTORATION ACTIONS

The targets for delta smelt include exceeding a fall midwater trawl catch index of 240 in dry water-year types and a wider distribution of delta smelt in the trawl survey.

The following general restoration actions would contribute to improving the delta smelt population:

- Improve Delta outflow during the late winter and spring to improve foodweb productivity and to disperse larvae and juveniles to downstream rearing habitat in Suisun Bay.
- Maintain Delta outflow once larvae and juveniles have reached downstream rearing habitat to keep them beyond the "zone of influence" of the CVP/SWP and agricultural diversions.
- Increase the residence time of X2 at key locations in Suisun Bay (e.g., Roe Island, Chipps Island, and Collinsville).
- Reduce adverse effects of CVP and SWP diversions during the period when larvae, juveniles, or adult life stages appear in the Delta.
- Increase the amount of shallow-water habitat in areas critical to spawning and rearing.
- Construct and improve fish facilities for Delta diversions, including agricultural diversions and CVP and SWP diversions, and improve handling and salvage practices at diversions.
- Develop and implement a program to reduce the adverse effects of introduced aquatic species and the potential for future introductions.
- Implement restoration actions identified in the Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes Recovery Plan.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (1999) to provide additional detail to ERP actions that would help achieve species habitat or population targets for delta smelt.

- Coordinate protection, enhancement, and restoration of occupied delta smelt habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, the Anadromous Fish Restoration Program, and the U.S. Fish and Wildlife Service recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.

- To the extent consistent with CALFED objectives, direct ERP actions towards setting back levees in the south Delta to increase shallow water habitat.
- Restore and enhance delta smelt habitat to provide suitable water quality (i.e., low concentrations of pollutants) and substrates for egg attachment (submerged tree roots, branches, rock, and emergent vegetation) to important spawning areas.
- Expand the Interagency Ecological Program (IEP) monitoring efforts in the south Delta for delta smelt.
- To the extent consistent with CALFED objectives, initiate implementation of the U.S. Fish and Wildlife Service's "Rainbow Report" or similar documentation to provide increased water quality in the south Delta and eliminate or reduce the need for installation of barriers.
- Monitor to determine if artificial substrates are used by delta smelt for spawning.
- Protect critical rearing habitat from high salinity (>2 ppt) and high concentrations of pollutants from the beginning of February to the end of August.
- Allow delta smelt unrestricted access to suitable spawning habitat and protect these areas from physical disturbance (e.g., heavy equipment operation) and flow disruption in the period from December to July by maintaining adequate flow and suitable water quality to attract migrating adults in the Sacramento and San Joaquin River channels and their tributaries, including Cache and Montezuma Sloughs and their tributaries.
- All in-channel modification projects implemented under CALFED should use best management practices to minimize mobilization of sediments that might contain toxins, localize sediment movement, and reduce turbidity.

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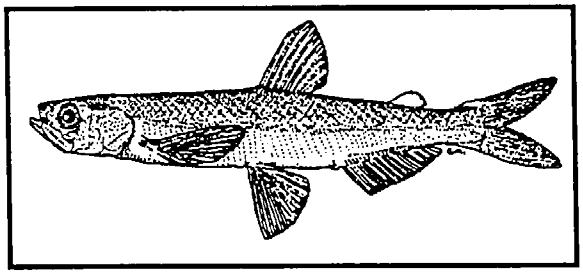
◆ LONGFIN SMELT



INTRODUCTION

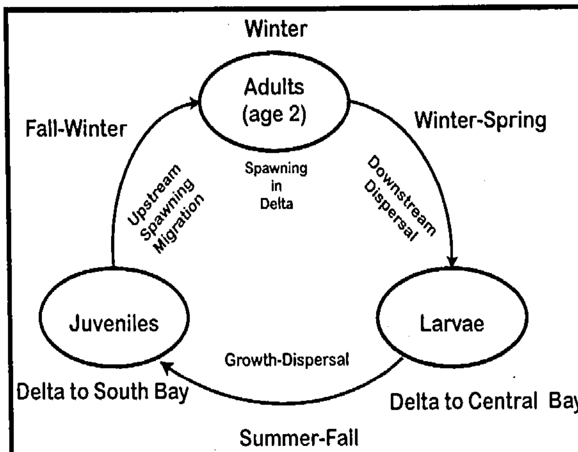
Longfin smelt are small native fish that live in the brackish waters of San Francisco Bay and the Delta. They can be found in water ranging from sea water to completely fresh water (Moyle 1976). They are an important element of the Bay-Delta foodweb as prey for chinook salmon, striped bass, and other predatory fish species. Because their abundance dropped sharply during dry periods over the past several decades, they are designated by the California Department of Fish and Game (DFG) and U.S. Fish and Wildlife Service (USFWS) as a species of special concern. Longfin smelt abundance was especially low during the 1987-1992 drought and showed signs of recovery only in 1995.

Major factors that limit this species' contribution to the health of the Delta are related to the adverse effects of low Delta outflow and include associated poor foodweb productivity, greater effects of water diversions, poorer larval transport and habitat conditions (i.e., poor dispersal is related to poor survival), and potentially higher concentrations of toxins that may limit its survival and production during droughts.

RESOURCE DESCRIPTION

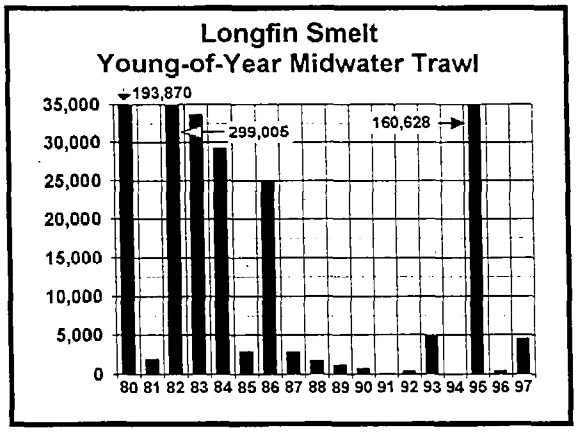
The largest, southernmost populations of longfin smelt in California inhabits San Francisco Bay and the Delta. Elsewhere in California, the longfin smelt is known from the Eel River, Humboldt Bay, and the Klamath River estuary, but none have been collected at these locations since the early 1990s. Longfin smelt migrate upstream into the Delta to spawn. Longfin smelt are well-adapted to the Bay-Delta estuary and are also found in other west-coast estuaries from northern California to southern Alaska.

In the Bay-Delta estuary, longfin smelt is anadromous. Adults, fish approaching their second year of age, migrate in winter from saltwater portions of the Bay and open coast to spawn in freshwater portions of the upper Bay and Delta. Spawning occurs in habitats with hard-bottom or plant substrates such as tidal wetlands and channels. Most spawning takes place from late December through April. High winter and early spring flows transport and disperse buoyant, newly hatched larvae downstream into Suisun and San Pablo bays, where the plankton food supply is characteristically abundant and necessary for high survival of longfin smelt larvae and juveniles. Flows of the magnitude to accomplish this increase the area and shifts the location of intermediate salinity (1.1 - 18.5 ppt) habitat downstream reducing competition and predation from marine and freshwater fishes.



Longfin Smelt Life Cycle. California Department of Fish and Game, 1992.

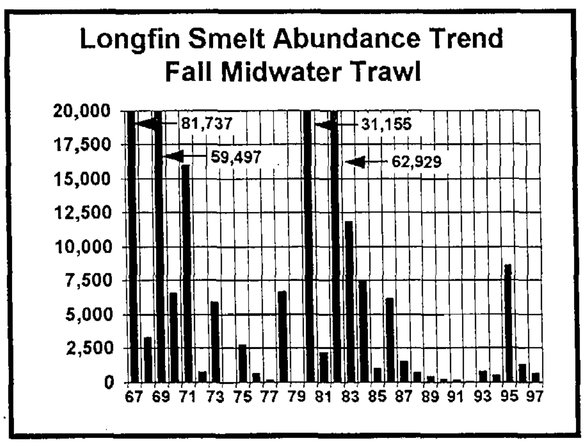
Since longfin smelt spawn primarily as age 2 fish, they tend to maintain strong even-year or odd-year cohorts, depending upon the sequence of wet and dry years. After the extended drought ended in 1978, the longfin smelt even-year cohort was dominant in the 1980s, until the next drought broke in 1993 and allowed the odd-year cohort a recruitment advantage. Abundance is a function of both outflow and habitat conditions and adult population size which is related to fecundity. Peak abundance index levels are not reached until favorable flow conditions persist for 2-3 generations.

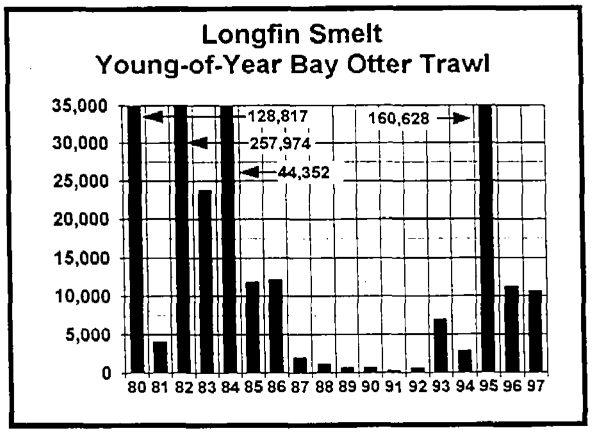


Longfin smelt abundance has been monitored by DFG in the Bay and Delta each fall since_1967. Population rates have fluctuated sharply, with greatest abundance in wetter years in wet-year sequences (1967, 1969, and 1971 from 1967- 1971; and 1980, 1982, and 1983 from 1980-1983). Abundance has been very poor in drought periods (1976-1977 and 1987-1992). Low abundance in 1993, the first wet year following the drought from 1987 to 1992, may reflect a greatly reduced spawning population resulting from drought conditions. Improved abundance in 1995 indicates that they may be recovering from the effects of the drought.

A similar pattern of population abundance is evident since 1980 in DFG's Bay trawling survey and the University of California, Davis' trawl survey in Suisun Marsh. Abundance was high from 1980 through 1984, but declined to very low levels through the 1987-1992 drought and has recovered only slightly since 1995.

The decline in the longfin smelt population has





coincided with a number of changes in the estuary. Related stressors believed to contribute to this decline are listed below.

Low flows in late winter and spring into and through the Delta may reduce survival of eggs and larval longfin smelt spawned in the Delta. Low Delta outflow limits transport of larval and juvenile longfin smelt downstream into quality nursery grounds of Suisun and San Pablo Bays. Low flows are a consequence of climatic conditions (low rainfall and more precipitation as winter rains rather than snow) and upstream reservoir storage of winter and spring runoff in dry and normal years.

Reduced freshwater flows through the Delta and into Suisun Bay may limit production of foodweb organisms during the critical early life stages of longfin smelt. Poor recruitment in drier years reduces the number of adults two years later, thus reducing the future spawning run. Water exports from the Delta during drier years entrain both prespawning adults and planktonic larvae, further reducing their population size. Such entrainment is greatly reduced or absent in wetter years.

The number of adults making the upstream spawning run has dropped to such low levels in recent years that they no longer produce sufficient numbers of eggs to bring about quick recovery in wet years. This may explain why production in 1993 was lower than expected.

Water diversion practices, especially in drier years, reduce larvae (about 5-15 millimeters long) and adult populations and lower reproduction rates. In drier years, the percentage of freshwater diverted is sharply higher than in wetter years.

In dry years, many larval and juvenile longfin smelt rearing in the Delta are drawn south across the Delta toward the south Delta pumping plants by the net southward flow caused by water exports at the pumping plants. Many probably perish before reaching the pumps as a result of poor food supply, poor water quality (mainly high water temperature), and predation in the central and south Delta channels, and intake forebays and structures of the pumping plants. Of those reaching the pumping plants, some are recovered in fish salvage facilities and returned to the Bay, while others are lost in exported water.

Power plants at Pittsburg and Antioch with the largest diversions (up to 3,000 cubic feet per second) operate in the prime nursery area of the western Delta and Suisun Bay. The power plants operate longer in winter and spring of dry years (when less hydroelectric power is produced) to meet regional electricity demands.

Similarly, Delta agricultural diversions are generally confined to late spring through fall; however, spring diversions are generally greater in drier years, when irrigation needs are higher. Although larvae losses to south Delta Central Valley Project and State Water Project pumping plants are generally much lower than losses to more northern and western Delta diversions, they are higher in drier years when Delta outflow is insufficient to move larval longfin smelt out of the Delta into the Bay.

Contaminants in the Delta water may also reduce the survival of longfin smelt. The effect may be indirect through reduced planktonic food supply or direct from toxin-induced egg, larval, or juvenile stress or mortality.

Other more speculative causes of the decline and low abundance of longfin smelt include competition or predation. Recently established non-native fishes, such as gobies introduced from the ballast water of ships from Asia, compete with longfin smelt. Predation in dry years may also be a problem, although it is difficult to quantify the potential adverse effects. Management programs that should be evaluated for potential adverse influence on longfin smelt and other native fish populations include the juvenile striped bass stocking program and salmon hatchery release programs. The striped bass stocking program has released over 11 million juvenile striped bass from 1985 through 1990 into San Pablo and Suisun Bays and Central Valley salmon hatcheries have released millions of hatchery-reared salmon smolts into San Pablo Bay in spring each year. Changes in plankton abundance and community species composition of the Bay and Delta caused by the introductions of non-native species of zooplankton and Asian clams may also have contributed to the decline of longfin smelt by affecting their food supply.

Overall, the longfin smelt are affected by the following factors in approximate order of importance (U.S. Fish and Wildlife Service 1996);

- reductions in Delta outflows,
- entrainment losses at water diversions,
- climatic variations (droughts and extreme floods),
- toxic substances,
- predation, and
- adverse effects of introduced species.

VISION

The vision for longfin smelt is to recover this California species of special concern and restore population distribution and abundance in the Bay-Delta estuary so that it resumes its historical levels of abundance and its role as an important prey species in the Bay-Delta aquatic foodweb.

Achieving consistently high production of longfin smelt in normal and wetter years, which historically produced more abundant juvenile populations (year classes), will be critical to the recovery of longfin smelt. Good wet-year production would be ensured by (1) not allowing production to fall too low in drier years such that numbers of adult spawners in subsequent wet years remains low, (2) maintaining and improving spawning and rearing habitat, and (3) minimizing stressors in wetter years.

Longfin smelt recovery efforts will also focus on enhancing freshwater outflow in dry and normal water year types during winter spawning and early rearing periods. Natural Delta outflows in dry and below- and above- normal water-year types have been reduced, particularly in late winter and spring, and such reductions coincide with the longfin smelt decline. The 1995 Water Quality Control Plan for the Delta provided interim provisions for increasing February-through-June Delta outflows. Additional improvements in late-winter and spring outflows would:

- improve transport of larvae and juveniles from Delta spawning areas to Bay rearing areas,
- limit the extent of total southerly flows toward the south Delta pumps where larvae and juveniles are subject to being exported,
- improve survival and production of longfin smelt by stimulating foodweb productivity, and
- dilute concentrations of contaminants that may be detrimental to longfin smelt or their food supply.

Although deterioration of habitat is not considered a major factor in the decline of longfin smelt, protecting, improving, and restoring shallow-water habitat in the Bay-Delta would help to increase survival and production of longfin smelt. Increasing shallow water habitat would increase brackish water habitat and overall habitat complexity which may be directly related to longfin smelt survival. Freshwater pushes out most marine larvae and most freshwater species are adapted to avoid being advected downstream by spawning later in the year or in backwater areas.

Other than striped bass and salmonids, few predators exploit pelagic, brackish water habitats, especially when the habitat is shifted downstream geographically between low and high outflow years. Increasing habitat complexity through increasing shallow water habitats (including side channels, etc.) and riparian zone width could assist longfin smelt larval dispersal. Presently, many appear to spawn in main channels and larvae are transported in dense pulses down the main channels and are dispersed into the shallows of Suisun and San Pablo bays. Increasing channel "roughness" may act to retain and spread larval pulses and reduce intra-specific competition.

Improved habitat would provide spawning and rearing habitat and increasing foodweb production. The increased spawning area and improved food supply may help to overcome other factors that have little potential for change (e.g., competition and predation from non-native species). Increases in tidal wetlands will provide tidal channels that are important spawning and rearing habitat. Improving and restoring shallow waters and riparian vegetation along levees and channel islands in the Delta will also provide additional important spawning habitat. Habitat improvements are expected also to increase the abundance of plankton, on which longfin smelt feed, and lead to improved survival of larvae and juveniles.

The Recovery Plan for Native Resident Fishes of the Sacramento-San Joaquin Bay-Delta Estuary (Recovery Plan) recommends restoring spawning and rearing habitat in shallow Delta islands (i.e., Prospect Island, Hastings Tract, Liberty Island, New Hope Tract, Brack Tract, and Terminous Tract) (U.S. Fish and Wildlife Service 1996). The Recovery Plan also recommends restoring tidal shallow-water habitat in Suisun Marsh by reclaiming leveed lands.

In addition to improving Delta outflow and habitats, reducing stressors will be important in restoring longfin smelt populations. Water diversions remove many longfin smelt and their food supply from the Bay and Delta, particularly during drier years. Losses to diversions should be reduced.

SPECIES RESTORATION

The basic strategy for the restoration of longfin smelt is to manage the estuary is such a way that it is a better habitat for native fish in general (U.S. Fish and Wildlife Service 1996). Longfin smelt will be considered restored when its population dynamics and distribution pattern within the estuary are similar to those that existed in the 1967-1984 period. This period was chosen because it includes the earliest continuous data on longfin smelt abundances and was a period during which populations stayed reasonably high in most years.

Distributional and abundance criteria can be met in different years. If abundance and distributional criteria are met for a ten-year period, the species will be considered restored.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Restoring longfin smelt in the Central Valley is will involve cooperation with the following programs.

- Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes (U.S. Fish and Wildlife Service 1995a): Its purpose under the federal

Endangered Species Act is to provide a strategy for the conservation and restoration of Delta native fishes. Longfin smelt are identified in this plan as requiring prompt restoration actions. The basic objective of this plan is to establish self-sustaining populations of the species of concern, including longfin smelt, that will persist indefinitely. The vision for longfin smelt includes facilitating implementation of the Recovery Plan.

- The Central Valley Project Improvement Act (PL 102-575): It calls for the doubling of the anadromous fish populations (including striped bass, salmon, steelhead, sturgeon, and American shad) by 2002 (U.S. Fish and Wildlife Service 1995b). This program involves actions that may indirectly benefit longfin smelt.
- The Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1988: DFG is required under State legislation to restore numbers of anadromous fish in the Central Valley (California Department of Fish and Game 1993). Actions include restoring the food supply of anadromous fish; that food supply includes longfin smelt.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Successful restoration of longfin smelt will be closely tied with improving late winter and spring Delta outflow, increasing shallow water and wetland-slough habitat, reducing the effects of Bay-Delta water diversions, and reducing the level of contaminants in Bay-Delta waters. Restoration actions are similar to those prescribed for other native resident and anadromous fish including delta smelt and striped bass.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

> The Strategic Objective is to achieve, first, recovery and then large self-sustaining populations of at-risk species dependent on the Delta, Suisun Bay and Suisun Marsh.

SPECIES TARGET: The recovery goal will be achieved when 1) the fall mid-water trawl surveys in September and October result in the capture of longfin smelt in all zone in 5 out of 10 years, 2) in 2 zones for and additional year, 3) in at least one zone during 3 of the 4 remaining years in the 10 year period with no failure to meet site criteria in consecutive years, and 4) abundance must be equal to or greater that predicted abundance for 5 of the 10 year period.

LONG-TERM OBJECTIVE: Restore longfin smelt abundance to levels that existed in the 1960s and 1970s, as measured over a period of at least 10 years.

SHORT-TERM OBJECTIVE: Achieve the recovery goals for longfin smelt identified in the Delta Native Fishes Recovery Plan.

RATIONALE: The longfin smelt is arguably one of the most endangered fishes in the estuary although the petition for listing it as an endangered species was declined (largely for genetic reasons). Longfin smelt were extremely abundant in the estuary when the fall midwater trawling program began in the 1960s. This period is used as a standard simply because it was during this period that the data available for comparative purposes begin, and the period covers a series of wet and extremely dry years. Evidence suggests that longfin smelt were abundant enough in the 19th century to support a fishery. Because longfin smelt abundance has a strong relationship to X2, future abundance may be tied closely to available fresh water and the ability to manipulate outflows to favor the species. Achieving the long-term objective may be impeded by the presence of several introduced species, notably the clam *Potamocorbula amurensis*. If future investigations determine that substantial reductions in longfin smelt are attributable to the introduced species currently established, then the long-term population abundance objective may need to be scaled back.

STAGE 1 EXPECTATIONS: In 7-10 years, the longfin smelt population indices should stay within the same range that they have been in during the period 1990-1998 unless there is an exceptionally long period of drought. The basic factors limiting their distribution and abundance should be determined.

ADDITIONAL CONSIDERATIONS

The restoration criteria for longfin smelt needs to be reevaluated. The equation used to predict longfin smelt abundance from outflow in the Delta Native Fishes Recovery Plan (U.S. Fish and Wildlife Service

1996) is in error. In addition, the restoration criteria implicitly requires relatively frequent (one of every four years) uncontrolled flows to attain and maintain restoration based on distribution criteria. The required frequency to attain restoration may actually be higher. It may be necessary to concentrate on the lower end of the outflow/abundance relationship and attempt to maintain sufficient outflow for the dominant cohort (i.e., odd year or even year cohort). It might also provide beneficial to consider a January through May period for the increased flow. Based on the dominant cohort, attempt to provide an average February through May outflow of about 12,000 cfs while favoring higher flow of 15,000 or greater in February and possibly in January. If minimum outflows could be provided every other year, sufficient numbers of adults should be present to respond to favorable flow conditions.

Restoration Actions

The following general restoration actions would contribute to the recovery of the longfin smelt population:

- Improve Delta outflow in late winter and spring to improve foodweb productivity and to dispense larvae and juvenile longfin smelt to downstream rearing habitat in Suisun and San Pablo Bays.
- Increase the amount of shallow water spawning habitat in the Delta and rearing habitat in Suisun and San Pablo Bays.
- Relocate or add diversion options for the south Delta pumping plants to (1) alleviate net southerly flows in the Delta in drier years, (2) improve transport of young longfin smelt to the Bay and away from the south Delta pumping plants and Delta agriculture diversions, and (3) increase the foodweb productivity.
- Evaluate and implement options to reduce PG&E power plant diversions from January through July in drier years. Options include limiting power operations during critical periods; improving screening facilities to reduce entrainment of larval and early juvenile longfin smelt, life stages that are presently most vulnerable to the intakes; or retrofitting plants with alternative cooling technologies (e.g., cooling towers).
- Evaluate the need to alter the timing and location for stocking striped bass and hatchery-reared chinook salmon in spring and early summer to avoid important longfin smelt juvenile rearing areas in Suisun and San Pablo Bays.
- Develop and implement a program to reduce the introduction of non-native species to the estuary from released ballast water would help minimize increases in predation and competition.
- Develop and implement a program to reduce contaminant inputs to the Bay-Delta would indirectly improve production of longfin smelt.

MSCS Conservation Measures

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve longfin smelt habitat or population targets.

- Coordinate protection, enhancement, and restoration of occupied longfin smelt habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, the Anadromous Fish Restoration Program, and the U.S. Fish and Wildlife Service recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Improve January and February flows for the longfin smelt during the second and subsequent years of drought periods.
- Provide sufficient Delta outflows for the longfin smelt during December through March.
- Provide suitable water quality and substrates for egg attachment (submerged tree roots, branches, rock, and emergent vegetation) to spawning areas in the Delta and tributaries of northern Suisun Bay.
- Provide unrestricted access to suitable spawning habitat and protect these areas from physical disturbance (e.g., heavy equipment operation) and flow disruption in the period from December to

July by maintaining adequate flow and suitable water quality to attract migrating adults in the Sacramento and San Joaquin River channels and their tributaries, including Cache and Montezuma sloughs and their tributaries.

- Conduct research to determine the relationship between X2 and longfin smelt abundance and distribution.
- Consistent with CALFED objectives, mobilize organic carbon in the Yolo Bypass to improve food supplies by ensuring flow through the bypass at least every other year.
- Consistent with CALFED objectives, operate diversions to minimize adverse affects of diversions on longfin smelt during the peak spawning period (January - March).
- To the extent consistent with CALFED objectives, protect the Sacramento and San Joaquin river and tributary channels from physical disturbance (e.g., sand and gravel mining, diking, dredging, and levee or bank protection and maintenance) and flow disruption (e.g., water diversion that result in entrainment and in-channel barriers or tidal gates) for the period February 1 to August 31.
- Protect critical rearing habitat from high salinity (>2 ppt) and high concentration of pollutants from the beginning of February to the end of August.

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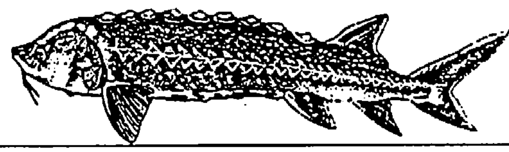

INTRODUCTION

Green sturgeon rear in the Sacramento-San Joaquin estuary and spawn in the Sacramento and San Joaquin rivers and their major tributaries. Sturgeon may leave the Bay-Delta and move along the coast to as far as Alaska. Populations of green sturgeon are found in many of the larger rivers from California north to British Columbia.

The green sturgeon is designated as a species of special concern by the California Department of Fish and Game (DFG) and U. S. Fish and Wildlife Service (USFWS).

Major factors that limit sturgeon populations in the Bay-Delta are adequate streamflows for attracting adults to spawning areas in rivers and transporting young to nursery areas, illegal and legal harvest, and entrainment into water diversions.

RESOURCE DESCRIPTION

Green sturgeon are native to Central Valley rivers and the Bay-Delta and represent an important component of the historic native fish fauna. Throughout recorded history, white sturgeon have been the dominant sturgeon populations in the Bay-Delta system, whereas in smaller systems such as the Eel River, green sturgeon dominate.

Sturgeon are long-lived species. Change in abundance of older fish may reflect the harvest of adults and habitat conditions that occurred decades ago during the larval and early juvenile life stages.

Green sturgeon inhabit both saltwater and fresh water and tolerate a wide range of salinity concentrations. Habitat requirements of green sturgeon are poorly known, but spawning and larval ecology probably are similar to that of white sturgeon which is better known (U.S. Fish and Wildlife Service 1996). Spawning is thought to occur in larger rivers upstream of the Delta. Low river flow during late winter and spring may reduce attraction of sturgeon to specific rivers and reduce spawning success. Stream channelization and flood control measures on large rivers (e.g., levee construction) may affect sturgeon use and spawning success.

Losses of young sturgeon into water diversions reduces sturgeon productivity. However, relative to other species, the percentage of the sturgeon population caught in diversions is low.

Food availability, toxic substances, and competition and predation are among the factors influencing the abundance of sturgeon. Sturgeon are long lived (e.g., some live over 50 years) and may concentrate pollutants in body tissue from eating contaminated prey over long periods. Harvesting by sport fishers also affects abundance of the adult populations. Illegal harvest (poaching) also reduces the adult population.

VISION

The vision for green sturgeon is to recover this California species of special concern and restore population distribution and abundance to historical levels.

Restoration of this species would contribute to overall species richness and diversity, and reduce conflict between the need for protection for these species and other beneficial uses of water in the Bay-Delta.

Green sturgeon would benefit from improved ecosystem processes, including adequate streamflow to attract adults to spawning habitat, transport larvae and early juveniles to productive rearing habitat, and maintain productivity and suitability of spawning and rearing habitat (including production of food). Ecosystem processes that need improvement include streamflows, stream and channel configurations, and migration barriers (e.g., dams). Additional streamflow during late winter and spring would attract sturgeon to rivers and maintain spawning flow requirements.

Green sturgeon would benefit from restoring spawning and rearing habitat. Habitat restoration may be achieved by adding and modifying physical habitat and increasing freshwater flow during critical periods. Juvenile sturgeon frequent Delta sloughs and may benefit from increases in slough habitat. Spawning habitat includes upstream river reaches that contain appropriate substrate (e.g., gravel, rock). Rearing habitat includes areas in the Sacramento and San Joaquin Rivers and the Delta that provide protective, food-rich habitats such as the shallow shoals and bays of the Bay-Delta.

Reducing stressors is a component of restoring white and green sturgeon populations. Reducing losses to diversions from the Sacramento-San Joaquin Delta estuary would increase survival of young sturgeon. Green sturgeon would also benefit from actions to reduce pollutant input to streams and rivers in the Sacramento-San Joaquin River basin.

SPECIES RESTORATION

The primary restoration objective for green sturgeon is to maintain a minimum population of 1,000 fish over 1 meter total length each year, including 500 females over 1.3 meters total length (minimum size at maturity), during the period (presumably March-July) when spawners are present in the estuary and the Sacramento River (U.S. Fish and Wildlife Service 1996). The restoration of green sturgeon should not be a the expense of other native fishes, including white sturgeon. The 1,000 number was determined as being near the median number of green sturgeon estimated to be in the estuary during the 1980s. The total size of the adult green sturgeon population that uses the estuary may be larger than 1,000 because non-spawning adults may be in the ocean.

Restoration will be measured by determining population sizes from tagging programs or other suitable means. The present sturgeon tagging and recovery program, which focus on white sturgeon, are inadequate for determining accurately the abundance of green sturgeon. Thus, the first restoration criterion will be establishment of an adequate monitoring program so that accurate population estimation can be conducted on a more regular basis.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore green sturgeon in the Central Valley would involve cooperation and support from other programs underway to restore sturgeon and other important fish.

- The Central Valley Project Improvement Act (CVPIA) (PL 102-575) calls for implementing changes in flows and project facilities and operations by 2002 that lead to doubling of the sturgeon populations.
- The Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1988 requires DFG to restore historical numbers of sturgeon in the Central Valley.
- The Four Pumps (SWP) and Tracy (CVP) Fish Agreements provide funds to DFG for sturgeon restoration.
- The Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes (USFWS) identifies recovery actions for green sturgeon.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of green sturgeon populations are integrally linked with restoration of river floodplain and stream meander habitat, improvements in Central Valley streamflows, improvements in habitat, and reductions in losses to water diversions and illegal harvest.

OBJECTIVE, TARGETS ACTIONS, AND MEASURES

> The Strategic Objective is to achieve, first, recovery and then large self-sustaining populations of at-risk native species dependent on the Delta, Suisun Bay and Suisun Marsh.

SPECIES TARGET: The recovery goal will be achieved when 1) the median population of mature fish (over 1 meter in length) has reached 1,000 fish, including 500 females over 1.3 meters in total length, over a 50 years period or for 5 generations.

LONG-TERM OBJECTIVE: Increase the population of green sturgeon utilizing the Sacramento-San Joaquin estuary and its tributaries so that the recreational fishery benefits.

SHORT-TERM OBJECTIVE: Continue the efforts established under Stage 1 Expectations and implement findings of habitat needs.

RATIONALE: The green sturgeon is relatively uncommon in the Bay-Delta system compared to the white sturgeon and probably always has been. However, the population appears to be one of only three still in existence in North America, so it needs special consideration. Very little is known about the requirements of this species in the system, and the recovery goals identified in the Delta Native Fishes Recovery Plan are based on knowledge gained from their incidental catch in white sturgeon studies and fisheries. Thus, restoration and management of this species requires much better knowledge than currently exists. Because it is so long lived (50+ years) and current exploitation levels seem to be low, there is time to conduct systematic research on its biology to determine the best ways to increase its populations.

STAGE 1 EXPECTATIONS: A better understanding will have been developed about the life history and usage of the Sacramento-San Joaquin estuary and its watershed as spawning and rearing habitats. In addition, a program will have been implemented to monitor the ocean migration and its usage in the life history of the species.

RESTORATION ACTIONS

The following general targets and restoration actions would contribute to the recovery of green sturgeon.

- Restore population to levels of the 1960s,
- Improve flow in Sacramento River in spring,
- Reduce the rate of illegal harvest,
- Reduce the percentage lost of sturgeon to water diversions to that of the 1960s,

The general programmatic actions to assist in the recovery of green sturgeon include:

- Improve the aquatic foodweb,
- Improve spring flows in Sacramento River and major tributaries,
- Restore natural meander belts and add gravel substrates in upstream spawning areas,
- Increase Delta outflow in spring of dry and normal years,
- Improve water quality of Bay-Delta,
- Provide greater enforcement to reduce poaching,
- Reduce losses of eggs, larvae, and juvenile sturgeon at water diversions,
- Upgrade fish protection facilities at diversion facilities in the Delta,
- Restore tidally influenced Delta and estuarine habitat such as tidal perennial aquatic habitat and sloughs.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve green sturgeon habitat or population targets.

- Coordinate protection, enhancement, and restoration of occupied and historic green sturgeon habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, the Anadromous Fish Restoration Program, the U.S. Fish and Wildlife Service recovery plans, the SB 1086 program, and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Provide inflows to the Delta from the Sacramento River greater than 25,000 cfs during the March to May spawning period in at least 2 of every 5 years.
- Identify and implement measures to eliminate stranding of green sturgeon in the Yolo Bypass or to return stranded fish to the Sacramento River.
- Conduct research in the MSCS focus area to determine green sturgeon habitat requirements, distribution, spawning habitat flow

requirements, and factors limiting population abundance.

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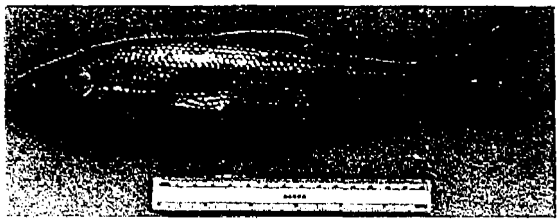


INTRODUCTION

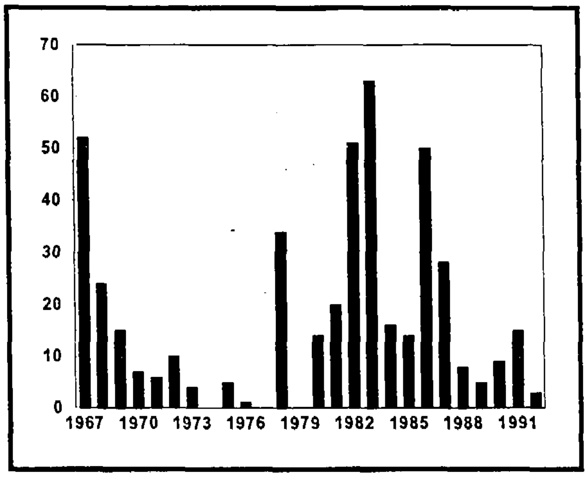
The splittail is a native resident fish of the lower reaches of the Sacramento and San Joaquin rivers. It has been listed under the federal Endangered Species Act and is a candidate for listing under the California Endangered Species Act. The splittail supports a small winter sport fishery in the lower Sacramento River.

Major factors that limit its contribution to the health of the Bay-Delta include loss of floodplain spawning and rearing habitat, and low streamflows that limit floodplain inundation and transport young to downstream nursery areas. Recent information suggests that losses to water diversions do not have an important effect on the population (Sommer et al. 1997).

RESOURCE DESCRIPTION

Splittail are endemic to the Sacramento-San Joaquin Delta estuary and to the lower reaches of the Sacramento and San Joaquin rivers. Splittail represent an important component of the historical native fish fauna. Splittail tolerate a wide range of salinity, but are most abundant in shallow areas where salinity is less than 10 parts per thousand (ppt). Spawning occurs in fresh water, primarily in floodplain areas upstream of the Delta including the Mokelumne, Feather and American rivers, and downstream of the Delta in the Napa and Petaluma rivers (Sommer et al. 1997). Spawning habitat includes shallow edgewaters and seasonally flooded riparian zones and flood bypass areas that provide spawning substrate (e.g., submerged vegetation). Rearing habitat includes shallow- fresh- and brackish water (less than 10 ppt salinity) habitat that provide a protective, food-rich environment.

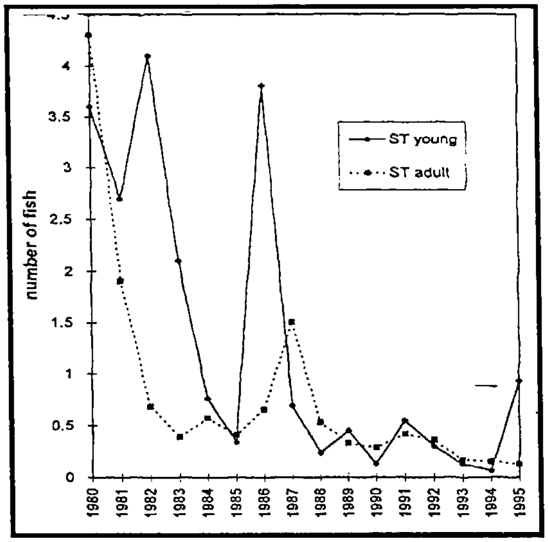
The population abundance of splittail is highly variable. Year-class abundance varies greatly. Low year-class success occurred throughout the 1987-1992 drought years. Age-0 abundance declined in the estuary during the 6 year drought and typically declines in dry years (Sommer et al. 1997).



Abundance Data for Splittail from DFG Fall Mid Water Trawl Survey (USFWS 1996)

Floodplain inundation is a significant element required to maintain strong year classes (Sommer et al. 1997). Access to habitat throughout the geographic range of splittail has been greatly diminished by human-caused actions. Restrictions to the floodplain, loss of marshes, and reduced winter-spring river flows from flood control and water supply development have reduced the species' range and abundance. In addition, water quality (e.g., high temperature and dissolved solids) reduce the use of the lower San Joaquin River by splittail.

Splittail have limited productivity particularly in periods of drought, primarily from low freshwater inflow to the Bay-Delta and modification of habitat by past and ongoing human actions. Dams and levees restrict access to historical, seasonally flooded spawning and rearing habitat. Abundant year classes are generally associated with winter and spring flows sufficient to flood peripheral areas of the Delta and lower river reaches, including the flood bypass system of the Sacramento River and the floodplain of the San Joaquin River. Flood control reservoirs reduce flooding in the Sacramento, San Joaquin, American, Feather, Mokelumne, Stanislaus, Tuolumne, Merced, and Calaveras rivers.



Index of Adult and Juvenile Splittail
in Suisun Marsh Trawl Survey

Levee construction in the 1800s created narrow channels and eliminated vast areas of fluvial marsh and seasonal wetlands that are important as spawning and rearing habitat for splittail.

Food availability, toxic substances, and competition and predation (particularly from striped bass and other introduced species) are among the factors limiting splittail abundance. In addition, harvest for food and bait by sport anglers may inhibit recovery of the splittail population.

VISION

The vision for splittail is to recover this federally listed threatened species in order to contribute to the overall species richness and diversity and to reduce conflict between protection for this species and other beneficial uses of water in the Bay-Delta.

Splittail would benefit from improvements in spawning and rearing habitat, and late winter and spring river flows. Increases in the frequency of floodplain inundation, improved access to floodplain areas, and increased freshwater flows would contribute most to their recovery. Additional freshwater flow could be provided during late winter and spring to inundate floodplains and attract adults to upstream spawning areas, transport young to downstream nursery areas in the Bay-Delta, and maintain low salinity habitat in the western Delta and Suisun Bay.

Restoring splittail will require restoring seasonally flooded spawning and rearing habitat. Habitat restoration may be achieved by adding and modifying physical habitat and additional freshwater flow during critical periods. Actions include breaching levees to inundate existing islands, setting levees back to increase shallow-water habitat along existing channels, protecting existing shallow-water habitat from erosion, and filling deep water areas with sediments to create shallow-water habitat.

Splittail have a high fecundity which, when combined with years of high flows, allows the population to benefit from high recruitment rates.

SPECIES RECOVERY

The objective is to recover splittail without causing adverse impact to other listed species. Splittail will be considered out of danger when their population dynamics and distribution patterns within the estuary are similar to those that existed from 1967-1983. This period was chosen because it includes the earliest continuous data on splittail abundances and was a period when splittail populations remained reasonably high in most years within the estuary (U.S. Fish and Wildlife Service 1996).

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore splittail would involve cooperation and support from other established programs that are protecting and improving conditions for delta smelt, striped bass, and other species.

- Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes (U.S. Fish and Wildlife Service 1996) will be considered in developing program actions.
- Central Valley Project Improvement Act (CVPIA) will implement actions that will benefit splittail, including changing timing of diversion, restoring habitat, and dedicating flow during critical periods for co-occurring species.

- State Water Resources Control Board (SWRCB) will implement the Water Quality Control Plan for the San Francisco/Sacramento-San Joaquin Delta estuary, which includes provisions to limit entrainment in diversions and protect habitat conditions for splittail, chinook salmon, striped bass, and other species.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Successful restoration of splittail will be closely tied with improving freshwater inflow, improved access to floodplain spawning and rearing habitats, floodplain inundation, and wetland restoration. Restoration actions are similar to those prescribed for other native resident fishes including delta smelt.

OBJECTIVES, TARGETS ACTIONS, AND MEASURES

> The Strategic Objective is to achieve, first, recovery and then large self-sustaining populations of at-risk native species dependent on the Delta, Suisun Bay and Suisun Marsh.

SPECIES TARGET: Species recovery objectives will be achieved when 2 of the following 3 criteria are met in at least 4 of every 5 years for a 15-year period: 1) the fall mid-water trawl survey numbers must be 19 or greater for 7 of 15 years, 2) Suisun Marsh catch per trawl must be 3.8 or greater and the catch of young-of-year must exceed 3.1 per trawl for 3 of 15 years, and 3) Bay Study otter trawls must be 18 or greater AND catch of young-of-year must exceed 14 for 3 out of 15 years.

LONG-TERM OBJECTIVE: Restore the splittail so that it is one of the most abundant fish species in the Sacramento-San Joaquin estuary and its tributaries.

SHORT-TERM OBJECTIVE: Achieve the recovery goals for splittail identified in the Delta Native Fishes Recovery Plan.

RATIONALE: The splittail was once widespread in lowland waters of the Central Valley but is today largely confined to the estuary, except during wet years. The splittail population dropped to a low point in the estuary during the drought of the 1980s but rebounded to high levels in the estuary during wet years of the 1990s. It is likely that reproductive success of this species is tied to the timing and duration of flooding of the Yolo and Sutter Bypasses and to flooding of riparian zones along the major rivers of the Central Valley, so a return to its former abundance and distribution will require special management of these areas.

STAGE 1 EXPECTATIONS: At least one additional strong year class should have developed to maintain splittail populations, while factors limiting splittail spawning and recruitment success are determined and accounted for in a management plan.

RESTORATION ACTIONS

The targets for splittail include achieving a fall mid-water trawl index consistently of 20 units or higher, and a Suisun Marsh trawl index consistently of 4 units or higher.

The following general actions would assist in the recovery of splittail:

- improve late winter and spring freshwater flows,
- increase flooded and shallow water spawning habitat in rivers and Bay-Delta,
- reduce pollutant input to streams and rivers in the Sacramento-San Joaquin River basin,
- prevent introduction of non-native species,
- High water temperatures and dissolved solids also reduce splittail use of the lower San Joaquin River.

MSCS CONSERVATION MEASURES

The following conservation measures are included in the Multi-Species Conservation Strategy (2000) which provide additional detail to ERP actions that would help achieve splittail habitat or population targets.

- Coordinate protection, enhancement, and restoration of occupied and historic Sacramento splittail habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, the

Anadromous Fish Restoration Program, the U.S. Fish and Wildlife Service recovery plans, the SB 1086 program, and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.

- To the extent consistent with CALFED objectives, remove diversion dams that block splittail access to lower floodplain river spawning areas.
- Minimize changes in the timing and volume of freshwater flows in the rivers to the Bay-Delta.
- To the extent consistent with CALFED objectives, direct ERP actions towards setting back levees in the south Delta to increase shallow water habitat.
- To the extent consistent with CALFED objectives, reduce the extent of reversed flows in the lower San Joaquin and Delta during the period from February through June.
- Reduce loss of splittail at south Delta pumping plants from predation and salvage handling and transport.
- Reduce the loss of young splittail to entrainment into south Delta pumping plants.
- To the extent practicable, reduce the loss of splittail at 1,800 unscreened diversions in the Delta.
- Reduce losses of adult splittail spawners during their upstream migration to recreational fishery harvest.
- To the extent consistent with CALFED objectives, improve Delta water quality particularly in dry years when pesticide levels and total dissolved solids are high.
- To the extend consistent with CALFED objectives, reduce the concentrations of pollutants in the Colusa Basin Drain and other agricultural drains into the Bay-Delta and its watershed.
- Modify operation of the Delta Cross Channel to minimize potential to increase exposure of splittail population in the Delta to the south Delta pumping plants.
- Modify operation of the barrier at the Head of Old River to minimize the potential for drawing splittail toward the south Delta pumping plants.
- To the extent practicable, design and construct overflow basins from existing leveed lands in stages using construction design and operating schemes and procedures developed through pilot studies and project experience to minimize the potential for stranding as waters recede from overflow areas.
- Consistent with CALFED objectives, design modifications to South Delta channels to improve circulation and transport of north of Delta water to the south Delta pumping plants to ensure habitat supports splittail and not to increase transport of splittail to the south Delta pumping plants.
- To the extent practicable design seasonal wetlands that have hydrological connectivity with occupied channels to reduce the likelihood for stranding and to provide the structural conditions necessary for spawning.
- To the extent consistent with CALFED objectives, protect spawning areas by providing suitable water quality (i.e., low concentrations of pollutants) and substrates for egg attachment (e.g., submerged tree roots and branches and emersed and submerged vegetation).
- Avoid or minimize adverse effects on rearing habitat from physical disturbance (e.g., sand and gravel mining, diking, dredging, and levee or bank protection and maintenance) and flow disruption (e.g., water diversions, in-channel barriers, or tidal gates).
- To the extent consistent with CALFED objectives, maintain a low salinity zone in historical occupied habitat areas of the Bay and Delta from February 1 through August 31.
- To the extent consistent with CALFED objectives, provide unrestricted access of adults to spawning habitat from December to July by

maintaining adequate flow and water quality, and minimizing disturbance and flow disruption.

- Expand the IEP monitoring efforts in the south Delta for Sacramento splittail.
- To the extent consistent with CALFED objectives, initiate implementation of the U.S. Fish and Wildlife Service's "Rainbow Report" or similar documentation to provide increased water quality in the south Delta and eliminate or reduce the need for installation of barriers.
- To the extent consistent with CALFED objectives, reduce the effects on splittail from changes in reservoir operations and ramping rates for flood control.
- To the extent consistent with CALFED objectives, reduce the loss of freshwater and low-salinity splittail habitat in the Bay-Delta as a result of reductions in Delta inflow and outflow.
- Consistent with CALFED objectives, increase the frequency of flood bypass flooding in non-wet years to improve splittail spawning and early rearing habitat.
- To the extent consistent with CALFED objectives, ensure that the Yolo and Sutter Bypasses are flooded during the spawning season at least once every 5 years.
- To the extent consistent with CALFED objectives, improve the frequency, duration, and extent of bypass flooding in all years.
- Develop a water management plan to allocated multiyear water supply in reservoirs to protect drought year supplies and sources of winter-spring Delta inflow and outflow needed to sustain splittail and their habitat.

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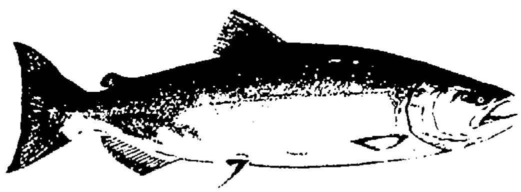


INTRODUCTION

Chinook salmon are medium- to large-bodied fish that spawn in freshwater, migrate to the ocean as juveniles, achieve significant growth, and return to freshwater at varying degrees of sexual maturity. Four runs of chinook salmon are present in the Central Valley, distinguished by their timing of reentry to fresh water: fall, late-fall, winter, and spring (Boydstun et al. 1992). Winter-run chinook salmon were formally listed as an endangered species under the California Endangered Species Act (CESA) in 1989, and as endangered under the federal Endangered Species Act (ESA) in 1994 (National Marine Fisheries Service [NMFS] 1997). Spring-run were listed as a threatened species under CESA in 1998 and ESA in 1999. The NMFS has reviewed the status of the Central Valley fall-run chinook salmon ESU, including late-fall-run, and determined that listing is not warranted at this time, but will continue to consider it a candidate under the ESA.

Listing status of Central Valley chinook salmon populations.

Chinook Stock	Listing Status
Winter-run	Endangered - ESA Endangered - CESA
Spring-run	Threatened - ESA Threatened - CESA
Late-fall-run and Fall-run	Candidate - ESA

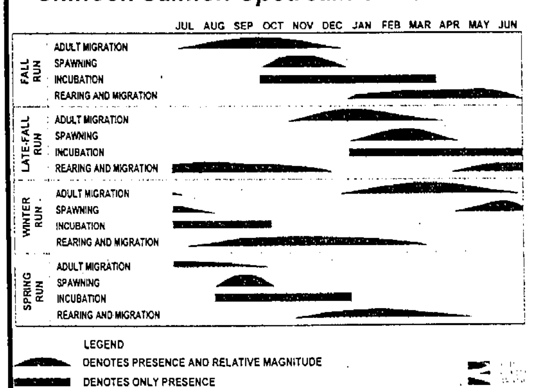
Listing of the winter-run chinook population reflected poor ecological health of the Bay-Delta watershed including the Sacramento River and placed additional regulatory controls on water management operations in the Central Valley. Water management regulations for winter-run chinook salmon affect the magnitude of flow by season in the Sacramento River and the volume of carryover storage in Shasta Reservoir for temperature control in the upper Sacramento River. The regulations also constrain the timing of water diversions at various location in the Sacramento River.

The key to improving chinook salmon populations will be maintaining populations through periods of drought by improving streamflow magnitude, timing, and duration; reducing the effects of the CVP/SWP export pumps in the southern Delta which alter Delta hydrodynamics, juvenile rearing and migration patterns, and cause entrainment at the facilities; and reducing stressors such as unscreened water diversions, high water temperatures, and harvest of naturally spawned salmon.

RESOURCE DESCRIPTION

Chinook salmon represent a highly valued biological resource and a significant biological legacy in the Central Valley of California. Central Valley chinook salmon comprise numerous individual stocks, including the Sacramento fall-run, late-fall-run, spring-run, winter-run, and San Joaquin fall-run. The continued existence of Central Valley chinook salmon is closely linked to overall ecosystem integrity and health (Mills et al. 1996).

Life History Sacramento River Chinook Salmon Upstream of Red Bluff

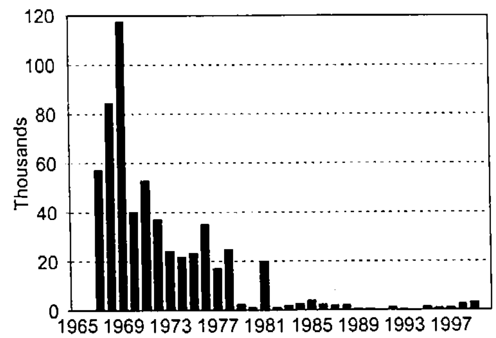


Because of their life cycle, typical of all Pacific salmon, Central Valley chinook salmon require high-quality habitats for migration, holding, spawning, egg incubation, emergence, rearing, and emigration to the ocean. These diverse habitats are still present throughout the Central Valley and are successfully maintained to varying degrees by existing ecological processes. Human-caused actions (stressors) have diminished the quality and accessibility of habitats used by chinook salmon. These habitats can be restored through a comprehensive program that strives to restore or reactivate ecological processes, functions, and habitat elements on a systematic basis. Recovery will require reducing or eliminating known sources of mortality and other stressors that impair the survival of chinook salmon. The restoration approach must fully consider the problems and opportunities within each individual watershed and must be fine-tuned to meet the requirements of locally adapted stocks.

The National Marine Fisheries Service (1998), in its status review of west coast chinook stocks, identified major chinook groupings based on preliminary data regarding ecological, geographical, and genetic differences among chinook stocks. These major groups included the Sacramento River winter-run evolutionarily significant unit (ESU), Central Valley spring-run ESU, and the Central Valley fall-run ESU. The fall-run ESU includes Sacramento and San Joaquin fall-run chinook, and late-fall-run chinook.

SACRAMENTO RIVER WINTER-RUN ESU. During the listing process for winter-run chinook, both the California Department of Fish and Game and NMFS cited a list of factors considered important to the decline of winter-run chinook. These include the loss of juveniles to entrainment at poorly or unscreened diversions and loss to the state and Federal water project pumps in the Delta. Impacts at other State and Federal water project facilities such as Red Bluff Diversion Dam, and Keswick and Shasta dam operation were considered major factors.

This ESU includes chinook salmon entering the Sacramento River from November to June, an entry pattern not shared with any other chinook population. Winter-run spawn from late-April to mid-August, with a peak in May and June. In general, winter-run exhibit an ocean-type life-history strategy, with smolts migrating to the ocean after five to nine months of residence in freshwater (Johnson et al. 1992). DNA analysis indicates substantial genetic differences between winter-run and other chinook salmon in the Sacramento River.

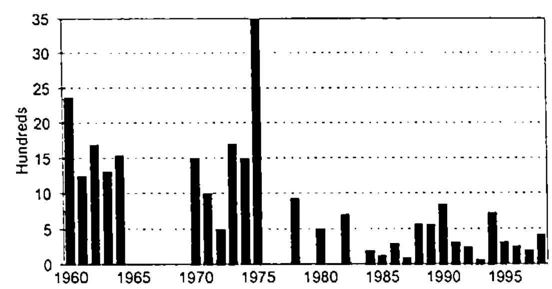


Sacramento River Winter-run Chinook Salmon Returns 1967-1999 (CDFG 1999).

Historically, winter-run populations existed in the upper Sacramento, Pit, McCloud, and Calaveras rivers. There also are data that suggest winter-run inhabited Battle Creek prior to its development for hydropower production. Construction of dams on these rivers in the 1940s displaced the Sacramento River population to areas the main stem Sacramento River below Shasta Dam.

CENTRAL VALLEY SPRING-RUN ESU. Spring-run chinook were the dominant run in the Sacramento and San Joaquin river systems prior to the construction of dams and water development projects. Spring-run chinook have been eliminated from the San Joaquin Basin but are still present in some of the tributary streams of the Sacramento River. Mill, Deer, and Butte creeks consistently support spawning populations of spring-run chinook salmon. Several other tributaries occasionally have spring run present. These include Big Chico, Antelope, and Beegum creeks. There may be some spring run in the Feather River, but these fish have likely interbred with fall-run chinook. The status of spring-run chinook in the Yuba River is uncertain, but a small population may exist (California Department of Fish and Game 1998).

This ESU includes chinook salmon entering the Sacramento River from March to July and spawning



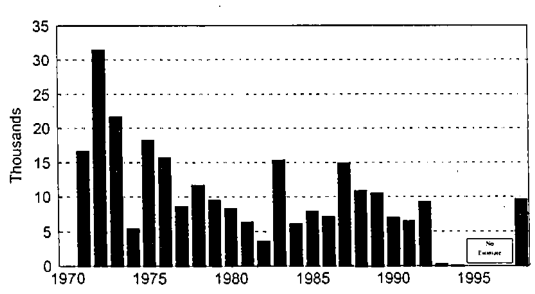
Spring-run Chinook Salmon Returns to Mill Creek, 1970-1998 (CDFG 1999).

from late August through early October, with a peak of spawning in September. Spring-run chinook exhibit an ocean-type life history, and emigrate from their natal streams as fry, subyearlings, and yearlings (National Marine Fisheries Service 1998).

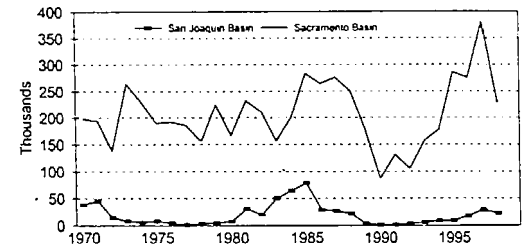
CENTRAL VALLEY FALL-RUN ESU. Fish in this ESU (fall-run and late-fall-run) enter freshwater from July through April and spawn from October through February. Both runs are ocean-type chinook, emigrating predominantly as fry and subyearlings.

Fall-run are the most abundant run in the Central Valley and populations are supported by an extensive State and Federal hatchery propagation program. Collectively, hatchery and naturally produced fall-run chinook maintain strong ocean sport and commercial troll fisheries as well as inland fisheries.

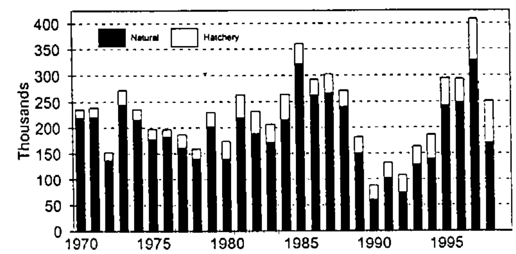
Overall, the abundances of stocks have varied annually since 1970 and exhibited depressions in adult returns during and following the 1976-1977 and 1987-1992 droughts (Mills and Fisher 1994). Low flows and reservoir storage levels during droughts caused high water temperatures, poor spawning and rearing habitat conditions, high predation rates, and high diversion losses, which in turn reduced salmon survival.



Late-fall-run Chinook Returns, 1971-1998 (CDFG 1999).



Comparison of Fall-run Chinook Salmon Returns to the San Joaquin and Sacramento Basins, 1970-1998 (CDFG 1999).



Total Returns of Central Valley Fall-run Chinook Salmon, 1970-1998 (CDFG 1999).

Chinook salmon are found in virtually all 14 ecological zones that comprise the ERP Study Area and many of their respective ecological units. Overall, the decline of the chinook salmon population resulted from the cumulative effects of degraded spawning, rearing, and migration habitats in the Sacramento and San Joaquin basins and the Sacramento-San Joaquin Delta. Specifically, the decline was most likely caused by a combination of factors that reduced or eliminated important ecological processes and functions, such as:

- excessively warm water temperatures during the prespawning, incubation, and early rearing periods of juvenile chinook;
- impaired or blocked passage of juveniles and adults at diversion and water storage dams;
- loss of natural emigration cues when flow regimes are altered as a result of the export of water from large diversions in the south Delta;
- heavy metal contamination from sources such as Iron Mountain Mine;

- entrainment at a large number of unscreened and poorly screened diversions; and
- degradation and loss of woody debris, shaded riverine aquatic (SRA) habitat, riparian corridors and forests, and floodplain functions and habitats from such factors such as channelization, levee construction, and land use.

Climatic events and human activity have exacerbated these habitat problems. Lengthy droughts have led to low flows and higher temperatures. Periodic El Niño conditions in the Pacific Ocean have reduced salmon survival by altering ocean current patterns. Ocean and inland recreational and commercial salmon fisheries have probably impaired efforts to rebuild salmon stocks.

Other human activities also have contributed to the decline of the chinook, although perhaps to a lesser degree. These activities include:

- construction and operation of various smaller water manipulation facilities and dams;
- levee construction and marshland reclamation causing extensive loss of rearing habitats in the lower Sacramento River, San Joaquin River, and Sacramento-San Joaquin Delta; and
- the introduction of predatory species.

Past regulatory efforts have not adequately maintained some chinook stocks as healthy populations. As a result, the winter-run population was protected under the State and federal ESAs to save it from extinction. The spring-run chinook salmon also was listed, but as threatened in recognition of substantial restoration efforts underway. Since the listing of winter-run chinook, some significant habitat improvements have been made to help preserve this and other chinook populations. These include improved water temperatures and flow management for spawning, incubation, and rearing; improved passage of juveniles and adults at diversions and dams on the upper Sacramento River; reduced diversions during periods when juveniles are most susceptible to entrainment; and the installation of positive-barrier fish screens on the larger water diversions along the Sacramento River. Additional measures that focus on reactivating or improving ecological processes and functions that create and maintain habitats will be necessary for recovery of Central Valley chinook salmon.

Rebuilding chinook populations to a healthy state will require a coordinated approach to restoring ecosystem processes and functions, restoring habitat, reducing or eliminating stressors on a site-specific basis, and improving management and operation of the five salmon hatcheries in the Central Valley.

VISION

The vision for Central Valley chinook salmon is to recover all stocks presently listed or proposed for listing under the ESA and CESA, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that fully use existing and restored habitats.

This vision will contribute to the overall species diversity and richness of the Bay-Delta system and reduce conflict between protection for this species and other beneficial uses of water and land in the Central Valley.

This vision is consistent with restoring the Sacramento River winter-run and spring-run chinook salmon to levels that will allow them to be removed from the State and federal endangered species lists; increasing populations of other chinook stocks to levels that eliminate any future need for protection under ESA and CESA; and providing population levels for all chinook stocks that sustain recreational and commercial fisheries and other scientific, educational, and nonconsumptive use of these valuable resources.

Within the broad context of ecosystem restoration, chinook salmon will benefit from a wide variety of actions, many of which are being implemented for other ecological purposes or which are not specific to chinook salmon. For example, restoring riparian woodlands along the Sacramento River between Keswick Dam and Verona will focus on natural stream meander, flow, and natural revegetational/successional processes. These factors will be extremely important in providing SRA habitat, woody debris, and other necessary habitats required by food organisms and juvenile and adult salmon populations.

Another example is to reactivate tidal flows into fresh and brackish marshes. Reactivating the tidal exchange in marshes will increase the production of lower trophic organisms, thereby improving the foodweb. Reactivating tidal exchange will also substantially increase the complexity of nearshore habitats in the lower mainstem rivers, the Delta, and the Bay, which will be valuable habitats for juvenile salmon.

Operating the water storage and conveyance systems throughout the Central Valley for their potential ecological benefits can be one of the more important elements in restoring a wide spectrum of ecological resources, including chinook salmon.

Harvest management will play an important role in restoring healthy salmon populations. Harvest management recommendations focus on rebuilding naturally spawning stocks.

Ecological processes selected for restoration include those that create and maintain critical habitat elements. Lack of adequate corridors between upstream holding, spawning, and rearing habitat in certain tributary streams has impaired or reduced the reproductive potential of some stocks such as spring-run chinook salmon.

Unscreened diversions are widespread in the Central Valley and are a known source of mortality to chinook salmon.

Many action-oriented activities are underway in the Central Valley that will assist in achieving the vision for chinook salmon. Some are short-term actions and some are long-term evaluations. All are designed to eliminate stressors and improve ecological processes and habitats.

VIABLE SALMONID POPULATIONS AND RECOVERY

The National Marine Fisheries Service has introduced a new and robust approach to define the recovery of chinook salmon and steelhead stocks (National Marine Fisheries Service 2000). Although this approach is still in the draft stage, it will be finalized and adopted as an important planning tool to ensure the recovery of listed stocks. This "viable salmonid population (VSP)" approach is designed to provide an explicit framework to identify biological requirements that will contribute to assessing management and conservation actions. The VSP introduces four sets of guidelines to determine a stocks viability.

- Population Size (viable and critical levels)
- Productivity
- Spatial Structure
- Diversity.

The VSP approach has numerous meaningful benefits for the ERP including a more accurate depiction of stock status, improved means to assess needed recovery actions, a method to evaluate completed recovery actions, a means by which to assess progress toward recovery, and a framework to organize or redefine existing recovery and management goals for chinook salmon.

The proposed MSCS species goal prescription for chinook salmon is presented later in this section, after many of the existing agency recovery goals and management objectives for chinook salmon are presented. In the longer-term, these existing goals and objective will likely be modified to be in agreement with the VSP approach. None-the-less, legislative and congressional intent through state and federal law will continue to set certain types of management goals for chinook. The CVPIA, for example, requires the doubling of natural production of Central Valley chinook salmon over the average of 1967-1991. The VSP approach can encompass the goal of such congressional actions while promoting the recovery of listed species.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

There are three major programs to restore chinook salmon populations in the Central Valley.

- Central Valley Project Improvement Act: The Secretary of the Interior is required by the Central Valley Project Improvement Act to double the natural production of Central Valley anadromous fish stocks by 2002 (U.S. Fish and Wildlife Service 1997).

- Endangered Species Recovery Plan: The National Marine Fisheries Service is required under the federal ESA to develop and implement a recovery plan for the endangered winter-run chinook and the threatened spring-run chinook salmon and to restore these stocks to levels that will allow their removal from the list of endangered species.

- Salmon, Steelhead Trout and Anadromous Fisheries Program Act: The California Department of Fish and Game (DFG) is required under State legislation (the Salmon, Steelhead Trout and Anadromous Fisheries Program Act of 1988) to double the numbers of salmon that were present in the Central Valley in 1988 (Reynolds et al. 1993).
- California Endangered Species Act which can provide specific criteria for down listing, delisting, and recovery of listed species.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Chinook salmon are closely dependent on ecological processes and habitats and adversely affected by a variety of stressors.

Important ecological processes the directly influence the health of chinook salmon or its habitat include:

- Central Valley streamflows,
- Coarse sediment supply,
- Stream meander,
- Floodplain and flood processes,
- Stream temperatures,
- Bay-Delta hydraulics, and
- Bay-Delta aquatic foodweb.

Habitats used by chinook salmon during their juvenile or adult life stages include:

- Tidal perennial aquatic habitat,
- Delta sloughs,
- Midchannel islands and shoals,
- Freshwater and essential fish habitats,
- Saline and fresh emergent wetlands, and
- Riparian and riverine aquatic habitats.

Stressors that adversely affect chinook salmon or its habitats include:

- Water diversions,
- Dams and other structures,
- Levees, bridges, and bank protection,
- Dredging and sediment disposal,
- Gravel mining,
- Predation and competition,
- Contaminants,
- Harvest,
- Some aspects of artificial propagation programs, and
- Disturbance.

OBJECTIVES, TARGETS, ACTIONS, AND MEASURES

WINTER-RUN CHINOOK SALMON

> The Strategic Objective is to achieve, first, recovery and then large self-sustaining populations of at-risk native species dependent on the Delta, Suisun Bay and Suisun Marsh.

SPECIES TARGET: The mean annual spawning abundance over any 13 consecutive years will be 10,000 females. The geometric mean of the Cohort Replacement Rate over those same 13 years will be greater than 1.0. Estimates of these criteria will be based on natural production alone and will not include hatchery-produced fish. If the precision for estimating spawning run abundance has a standard error greater than 25%, then the sampling period over which the geometric mean of the Cohort Replacement Rate is estimated will be increased by 1 additional year for each 10% of additional error over 25%.

LONG-TERM OBJECTIVE: Create self-sustaining populations of winter-run chinook salmon in both the mainstem Sacramento River and in Battle Creek at abundance levels equal to or greater than those identified in the proposed Recovery Plan for Sacramento River Winter-run Chinook Salmon (National Marine Fisheries Service 1997).

SHORT-TERM OBJECTIVE: Achieve recovery as defined in the NMFS proposed Recovery Plan for Sacramento River Winter-run Chinook Salmon.

RATIONALE: Winter-run chinook salmon are unique to the Sacramento River and are adapted to

RATIONALE: Winter-run chinook salmon are unique to the Sacramento River and are adapted to spawn in the cold, spring-fed rivers now located above Shasta Dam. They are presently maintained in artificial cold-water habitat below Keswick Dam in the Sacramento River and in a special hatchery program. Because they are so vulnerable to disasters (e.g., a toxic spill from Iron Mountain mine, just upstream), at least one other naturally reproducing population needs to be established to reduce the probability of extinction. Battle Creek, a cold-water stream to which winter-run chinook have been deliberately denied access in the past, is the best and probably only site available for such restoration. It is unlikely, however, that winter-run chinook salmon will ever be much more abundant than specified in the recovery plan goals because available habitat is so limited.

STAGE 1 EXPECTATIONS: The cohort replacement rate (the number of future spawners produced by each spawner) in 7-10 years should continue to exceed 1.7 (as it has in recent years), and average abundance should increase. Battle Creek restoration should have proceeded to a point where a determination can be made regarding the benefits of re-introducing winter-run chinook. The determination will be based on genetic considerations. The probability of extinction of winter-run chinook will have been recalculated using assumptions regarding the establishment of an additional self-sustaining winter-run chinook population.

SPRING-RUN CHINOOK SALMON

> The Strategic Objective is to achieve, first, recovery and then large self-sustaining populations of at-risk native species dependent on the Delta, Suisun Bay, and Suisun Marsh.

SPECIES TARGETS: The Central Valley spring-run chinook salmon Evolutionarily Significant Unit (ESU) will be regarded as restored when the ESU meets specific viability criteria to be established in the NMFS recovery plan for Central Valley salmonids. Viability of the Central Valley spring-run ESU will be assessed according to the "Viable Salmonid Populations" (VSP) framework developed by the NMFS (in review). The framework deals with four population characteristics:

1. ABUNDANCE: populations are large enough to resist extinction due to random environmental, demographic and genetic variation.

2. PRODUCTIVITY: populations have enough reproductive capacity to ensure resistance to episodes of poor freshwater or ocean conditions and the ability to rebound rapidly during favorable periods, without the aid of artificial propagation.

3. SPATIAL DISTRIBUTION: populations are distributed widely and with sufficient connectivity such that catastrophic events do not deplete all populations and stronger populations can rescue depleted populations.

4. DIVERSITY: populations have enough genetic and life history diversity to enable adaptation to long-term changes in the environment. Populations achieve sufficient expression of historic life history strategies (migration timing, spawning distribution), are not negatively impacted by outbreeding depression resulting from straying of domesticated hatchery fish, and are not negatively impacted by inbreeding depression due to small population size and inadequate connectivity between populations.

The NMFS recovery planning for Central Valley salmonids will proceed in two phases. The first phase will be conducted by a technical recovery team (TRT) that will produce numeric recovery criteria for populations and the ESU following the VSP framework, factors for decline, early actions for recovery, and provide plans for monitoring and evaluation. The TRT will review existing salmonid population recovery goals and management programs being implemented by federal and State agencies and will coordinate with agency scientists, CALFED staff and Central Valley science/restoration teams such as the Interagency Ecological Program work teams during this first phase. TRT products will be peer-reviewed and made available for public comment.

The second phase will be identification of recovery measures and estimates of cost and time required to achieve recovery. The second phase will involve participation by agency and CALFED staff as well as involvement by a broad range of stakeholders, including local and private entities, with the TRT providing technical guidance on biological issues.

LONG-TERM OBJECTIVE: Restore wild, naturally reproducing populations of spring-run chinook salmon to numbers or spawning densities in the Sacramento River system equal to those that existed in the 1940s, as measured over a period of at least 25 years.

SHORT-TERM OBJECTIVE: Develop and implement a recovery plan and achieve recovery levels.

RATIONALE: Spring-run chinook salmon were historically the most abundant run of salmon in central California. Unfortunately, they spawned primarily in stream reaches that are now above major dams. The biggest declines in their abundance occurred after Shasta and Friant dams were built (1944 and 1942, respectively). A run of 50,000 spring-run chinook salmon alone was stranded when Friant Dam shut off San Joaquin River flows. Attempts to rear spring-run chinook salmon in hatcheries have largely failed, and both hatchery and wild populations in the Sacramento River proper are hybridized with fall-run chinook. The only streams maintaining small runs of wild, unhybridized spring-run chinook salmon are Deer, Mill, Butte and Big Chico Creeks. Spring-run chinook have been listed as threatened by the California Fish and Game Commission (September 1998) and were federally listed as endangered in 1999. It is uncertain whether additional subpopulations can be reestablished in other Sacramento River basin streams or in the San Joaquin River basin, but the possibilities need to be investigated. If establishing additional subpopulations is impossible, the long-term objective may have to be modified downward.

STAGE 1 EXPECTATIONS: Better methods for estimating population sizes should be developed. Populations in Deer, Mill, and Butte creeks should not fall below numbers found in the streams in 1990-1998, with a cohort replacement rate greater than 1. Factors limiting survival of out-migrating smolts should be determined. The ability of Big Chico Creek to sustain a spring-run chinook population should be evaluated and measures taken to improve its capacity to support salmon. The potential for other streams, including Battle Creek, to support runs of spring-run chinook salmon should be evaluated. The potential for using artificial propagation as a tool to expedite reintroduction to former habitat will have been evaluated and, if deemed appropriate by the resource agencies, a propagation program should be implemented.

LATE-FALL-RUN CHINOOK SALMON

> The Strategic Objective is to achieve, first, recovery and then large self-sustaining populations of at-risk native species dependent on the Delta, Suisun Bay, and Suisun Marsh.

SPECIES TARGETS: Achieve species recovery by 1) increasing the number of wild spawning fish in the Sacramento River to a mean number of 22,000 fish and maintain the population such that it does not drip below 15,000 fish for 15 years, 3 of which are dry or critical and 2) achieving juvenile survival rates that approach pre-CVP and SWP levels following years when the adult populations are fewer that 15,000 fish in the Sacramento River (U.S. Fish and Wildlife Service 1996).

Note: The Central Valley fall/late fall-run ESU is a candidate species, not a threatened or endangered species, under the ESA. The NMFS recovery plan for Central Valley salmonids will therefore not include formal recovery goals for populations in this ESU. The recovery plan for Central Valley salmonids will identify factors of concern and measures to ensure the long-term conservation of the Central Valley fall/late fall-run ESU and recovery actions proposed for listed ESUs will be evaluated to ensure that they do not place non-listed species at significant risk. CALFED, DFG and the NMFS will work together to identify restoration goals following the VSP framework in a process separate from the NMFS recovery planning process. These goals will aim to ensure the long-term viability of Sacramento and San Joaquin fall-run and Sacramento late fall-run chinook salmon.

LONG-TERM OBJECTIVE: Restore wild, naturally reproducing populations of late-fall-run chinook salmon to numbers or spawning densities in the Sacramento River equal to those that existed in 1967-1976, as measured over a period of at least 25 years, and reestablish a self-sustaining population in the San Joaquin River drainage.

SHORT-TERM OBJECTIVE: Develop and implement a recovery plan and achieve recovery levels.

RATIONALE: Late-fall-run chinook salmon have long been recognized as a distinct run in the Sacramento River and, formerly, in the San Joaquin River. Their numbers in the Sacramento River were not quantified until Red Bluff Diversion Dam was completed in 1967. The dam was a major factor contributing to their most recent decline. The NMFS does not distinguish late-fall-run from fall-run chinook salmon in its listing proposal (National Marine Fisheries Service, 1998), but the two forms represent distinct life history patterns in the Sacramento River and therefore need to be managed separately. Late-fall-run chinook were mainstem spawners and probably were separated from their principal spawning grounds by Shasta and Friant dams. Restoration may be possible in rivers that have had their flow regimes adjusted to accommodate the oversummering of juveniles (e.g., Tuolumne River).

STAGE 1 EXPECTATIONS: Late-fall-run chinook salmon numbers should not fall lower than they have been in the 1990s. Factors limiting their abundance should be determined, and methods to determine their abundance should be developed.

FALL-RUN CHINOOK SALMON

> The Strategic Objective is to achieve, first, recovery and then large self-sustaining populations of at-risk native species dependent on the Delta, Suisun Bay, and Suisun Marsh.

SPECIES TARGETS:

SAN JOAQUIN FALL RUN: Achieve species recovery by 1) increasing the number of naturally spawning fish in the Stanislaus, Tuolumne, and Merced rivers to a median number of 20,000 fish and maintaining a three-year running average that does not drop below 3,000 fish for 15 years, three of which are dry and critical and 2) achieving smolt survival rates that approach pre-CVP and SWP levels when adult numbers decline to fewer that 3,000 natural spawning fish.

SACRAMENTO FALL RUN: Restore self-sustaining populations to all their native streams.

NOTE: The Central Valley fall/late fall-run ESU is a candidate species, not a threatened or endangered species, under the ESA. The NMFS recovery plan for Central Valley salmonids will therefore not include formal recovery goals for populations in this ESU. The recovery plan for Central Valley salmonids will identify factors of concern and measures to ensure the long-term conservation of the Central Valley fall/late fall-run ESU and recovery actions proposed for listed ESUs will be evaluated to ensure that they do not place non-listed species at significant risk. CALFED, DFG and the NMFS will work together to identify restoration goals following the VSP framework in a process separate from the NMFS recovery planning process. These goals will aim to ensure the long-term viability of Sacramento and San Joaquin fall-run and Sacramento late fall-run chinook salmon.

LONG-TERM OBJECTIVE: Restore self-sustaining populations of fall-run chinook salmon to all their native streams, except those above Shasta Reservoir.

SHORT-TERM OBJECTIVE: Recover San Joaquin fall-run chinook salmon to levels identified in the Delta Native Fishes Recovery Plan, and in the Sacramento River, have wild salmon spawners number 75,000-100,000 fish each year, assuming that salmon of wild origin make up 50% of the fall run.

RATIONALE: When Shasta and Friant dams were built, implicit promises were made that fisheries for salmon would not decline. It was assumed that hatcheries and habitat improvements would make up for any losses caused by the dams. The hatchery system has been at best a partial success even though it has focused heavily on fall-run chinook salmon. Because of the hatcheries, the status of wild populations in the Central Valley is uncertain, and concerns exist about genetic and other effects of hatchery programs on the wild-spawning stocks.

Much of the habitat previously available for wild-spawning fish is permanently disconnected from the migration corridors. However, the remaining habitat or the "new" habitat in the tailwaters of large dams should be usable for spawning at densities (fish per unit of habitat, either area or distance) as great as those that existed before the construction of Shasta, Friant, and other dams. The objective, therefore, is to restore the spawning densities of fall-run chinook salmon to values existing before Shasta and Friant Dams were built. The restoration of salmon to pre-dam densities using primarily currently available habitat depends on assumptions about habitat quality and the biology of the fish that need to be tested.

STAGE 1 EXPECTATIONS: Numbers of wild fall-run chinook salmon should not fall lower than they have been in the 1990s. Factors limiting their abundance in each major river should be determined, including the impact of hatchery fish. Programs (e.g., mass marking of hatchery juveniles) should be instituted to allow hatchery fish to be distinguished from wild fish, and surveys should be made to determine the contribution of hatchery fish to natural spawning.

RESTORATION ACTIONS

The overall target for chinook salmon is presented as a strategy to increase the survival and return of each generation. ERP's approach is to contribute to managing and restoring each stock with the goal of maintaining cohort replacement rates of much greater than 1.0 while the individual stocks are rebuilding to desired levels. When the stocks approach the desired population goals, ERP will contribute to maintaining a cohort replacement rate of 1.0. In practical application, management and restoration goals need to be developed on a stream-specific basis and include all runs of chinook salmon.

The strategy for achieving the chinook salmon vision includes protecting existing populations, restoring ecological processes, improving habitats, and reducing stressors. The following actions would improve chinook salmon populations:

- Restore ecological processes in the Central Valley. Chinook salmon are dependent on adequate streamflows; gravel recruitment, transport, and cleansing; low water temperatures; and channel configurations.
- Maintain adequate streamflows to improve gravel recruitment, transport, and cleansing; water temperatures; and channel conditions. Improved streamflow would also provide attraction flows for adult salmon migrating upstream to spawning grounds through the Bay, Delta, and lower rivers. Flows also support downstream transport for juvenile salmon migrating to the ocean and minimize losses to diversions and predators. Short-term improvements in flows may be possible with existing supplies. Necessary changes in streamflows may require long-term water supply improvements.
- Restore habitats required by chinook salmon. Where ecological processes cannot restore habitats to the desired level, habitats can be improved using direct measures. Important habitat components for chinook salmon include spawning gravel, water temperatures, and access to spawning habitats. In the short term, gravel can be introduced to rivers where needed. Fish passage facilities can be upgraded where deficient. Generally, habitat quality and availability along the lower reaches of the major rivers and in the Delta have been greatly diminished by the construction of levees; construction of levees that isolated rivers from their floodplains; and removal or other loss of riparian, shaded riverine, and woody debris habitats. A major long-term commitment will be required to restore the habitats in these areas.
- Protect existing populations in the Central Valley. The ERP focuses on supporting efforts to protect existing natural populations of chinook salmon by limiting harvest of naturally spawned fish while emphasizing the harvest of hatchery-produced fish. A short-term action would be to evaluate mass marking of all hatchery-produced chinook salmon and limiting harvest to only marked salmon. Another short-term action would be to promote hatchery practices that embody the concepts of genetic conservation.
- Eliminate stressors that cause direct or indirect mortality of chinook salmon. Important stressors on chinook salmon include insufficient streamflow, high water temperatures, blockages at diversion dams, predation near human-constructed structures, contaminants, unscreened diversions, and harvest. ERP focuses on reducing each of these stressors in the short term and

eliminating the conditions that bring about the stress factors in the long term by restoring natural processes and eliminating stressors where feasible.

MSCS Conservation Measures

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve chinook salmon habitat or population targets.

- Coordinate protection, enhancement, and restoration of occupied and historic chinook salmon habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, the Anadromous Fish Restoration Program, the U.S. Fish and Wildlife Service recovery plans, the SB 1986 program, and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Implement management measures identified in the proposed recovery plan for the Sacramento River winter-run chinook salmon.
- Implement applicable management measures identified in the restoration plan for the Anadromous Fish Restoration Program and the recovery plan for the native fishes of the Sacramento/San Joaquin Delta.
- Operate hatcheries such that the maintenance, and expansion of natural populations are not threatened by the release of hatchery fish.
- Manage operations at the Red Bluff diversion dam to improve fish passage, reduce the level of predation on juvenile fish, and increase fish survival.
- To the extent consistent with CALFED objectives, manage export flows from the San Joaquin River to improve conditions for upstream migration of adult fish (i.e., attraction flows).
- To the extent consistent with CALFED objectives, operate physical barriers in the Delta in a manner to assist in achieving recovery goals.
- Continue research to determine causes for low outmigration survival of fish from the San Joaquin River in the south Delta and identify and implement measures to improve outmigration survival.

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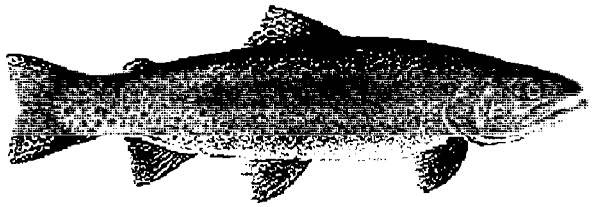


INTRODUCTION

Steelhead trout are an anadromous form of rainbow trout. This species spawns in freshwater, and its juveniles rear in cool water for a year or more before migrating to the ocean. Steelhead spend one to three years in the ocean before maturing and returning to freshwater to spawn. While they rear in fresh water, young steelhead are susceptible to mortality resulting from elevated water temperatures and a variety of other adverse environmental and habitat factors.

Steelhead is one of the listed species for which actions are developed to achieve its recovery.

The California Fish and Wildlife Plan estimated that there were 40,000 adult steelhead in the Central Valley drainages in the late 1950s, and Hallock et al. (1961) estimated that the average annual steelhead run size was 20,540 adults in the Sacramento River system above the mouth of the Feather River. In the early 1960s, It is estimated that 30,000 adult steelhead returned to Central Valley rivers and streams (Mills et al. 1996, Mills and Fisher 1994).

In the early 1990s, the total (hatchery and wild) annual run size for the entire system was roughly estimated to be no greater than 10,000 adult fish (McEwan and Jackson 1996). A more reliable indicator of the magnitude of the decline of Central Valley hatchery and wild stocks is the trend reflected in the Red Bluff Diversion Dam (RBDD) counts: numbers declined from an average annual count of 11,187 adults for the ten-year period beginning in 1967, to 2,202 adults annually in the early 1990s. The average escapement estimates for wild (natural spawners) above RBDD for the same time periods was 6,819 and 893, respectively (McEwan and Jackson 1996).

Hallock et al. (1961) reported that the composition of naturally produced steelhead in the population estimates for the 1953-54 through 1958-59 seasons averaged 88%. This is probably not reflective of present composition in the Central Valley system, due to the large-scale loss of spawning and rearing habitat and increases in hatchery production. During the time period of the Hallock et al. study, only Coleman and Nimbus hatcheries were in operation. Today, four Central Valley steelhead hatcheries (Mokelumne River, Feather River, Coleman and Nimbus hatcheries) collectively produce approximately 1.5 million steelhead yearlings annually.

Historically, steelhead ranged throughout the Sacramento River system (including both east- and west-side tributaries) and the San Joaquin River system. Historical documentation exists that show steelhead to have been widespread throughout the San Joaquin River system, At present, naturally spawning populations of steelhead are known to occur in the upper Sacramento River and tributaries, Mill, Deer, and Butte creeks, and the Feather, Yuba, American, and Stanislaus rivers. However, the presence of naturally spawning populations appears to correlate well with the presence of fish monitoring programs, and recent implementation of monitoring programs has found steelhead in streams previously thought not to contain a population, such as Auburn Ravine, Dry Creek, and the Stanislaus River. It is possible that naturally spawning populations exist in many other streams but are undetected due to lack of monitoring or research programs (IEP Steelhead Project Work Team 1999).

RESOURCE DESCRIPTION

Rainbow trout exhibit one of the most complex life histories of any salmonid species. Those that exhibit anadromy (i.e., migrate as juveniles from fresh water to the ocean and then return to spawn in fresh water as adults) are called steelhead. Rainbow trout populations appear to be structured around several key life-history traits and a continuum of migratory behaviors, the two extremes being anadromy (strongly migratory) and residency (non-migratory). Within these extremes are potamodromous (river migratory), and possibly estuarine and coastal forms. All of the life-history forms within a particular stream comprise a single, interbreeding population.

This complexity of life history forms can also be found in individual behaviors. A rainbow trout can mature in fresh water and spawn, then migrate to the ocean and return to spawn in subsequent years as a steelhead. More importantly, there is evidence that progeny can exhibit a different life-history strategy than that of their parents (e.g., offspring of steelhead can adopt a resident lifestyle and the offspring of resident trout can migrate to the ocean and become steelhead) (IEP Steelhead Project Work Team 1999).

A complex structure and flexibility in reproductive strategies among a single population may be necessary for the long-term persistence of the population in environments that are frequently suboptimal and not conducive to consistent, annual recruitment of migrants to the ocean. It was not uncommon, even under unimpaired conditions, for the lower reaches of many Central Valley streams to become intermittent during the dry season (and longer), isolating individuals in the perennial headwaters, and these conditions may have persisted for years.

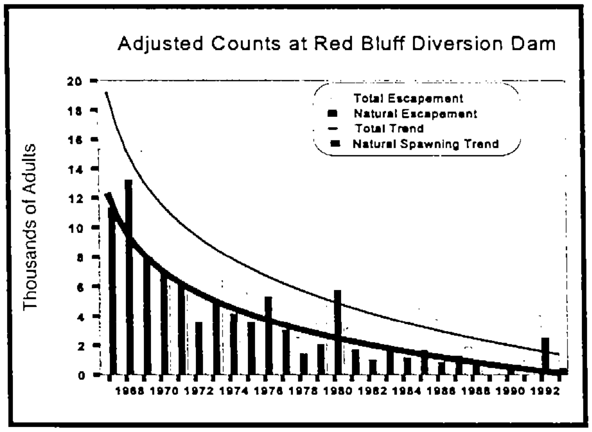
Having several different life-history strategies among a single population effects "bet-hedging" against extinction. If ecological conditions are not conducive for a particular life history form to survive and reproduce, the population would be sustained by other life history forms that could successfully reproduce (usually the resident fish). However, for this mechanism to be effective in sustaining the population, the ecological linkages between the various life-history forms, and the habitat linkages between the lower river reaches and the headwaters, must be maintained. The large-scale disruption of this linkage that has occurred in the Central Valley through the placement of impassable dams on many streams may go a long way in explaining the significant decline of Central Valley steelhead stocks.

Generally, juvenile steelhead typically migrate to ocean waters after spending 1-3 years in fresh water. Most Central Valley steelhead migrate to the ocean after spending two years in fresh water (Hallock et al. 1961). They reside in marine waters for typically 2 or 3 years before returning to their natal stream to spawn as 3- to 5-year-old fish. Unlike Pacific salmon, steelhead are iteroparous (i.e., they are capable of spawning more than once before they die). However, post-spawning survival rates are generally low, thus the percentage of adults in the population that spawn more than once is low.

Biologically, steelhead can be categorized into two reproductive ecotypes according to their state of sexual maturity at the time of river entry, the duration of their spawning migration, and behavior. These two ecotypes are termed *stream maturing* and *ocean maturing* (also known as *summer steelhead* and *winter steelhead*, respectively). Stream maturing steelhead enter fresh water in a sexually immature condition and require several months to mature and spawn. Ocean-maturing steelhead enter fresh water with well-developed gonads and spawn shortly thereafter. Central Valley steelhead stocks are of the ocean-maturing type and are called winter steelhead. Some evidence suggests that summer steelhead were once present but that construction of large dams on major tributaries, which would have blocked adults from reaching the deep pools they need to oversummer, most likely eliminated these populations.

The National Marine Fisheries Service (NMFS) has identified steelhead populations in the Central Valley as composing a single evolutionarily significant unit (ESU). ESUs are defined using a variety of physical and biological data, including the physical environment (geology, soil type, air temperature, precipitation, riverflow patterns, water temperature, and vegetation); biogeography (marine, estuarine, and freshwater fish distributions); life history traits (age at smolting, age at spawning, river entry timing, spawning timing); and genetic uniqueness.

The Central Valley steelhead ESU comprises the Sacramento River and its tributaries and the San Joaquin River and its tributaries downstream of the confluence with the Merced River (including the Merced River). Recent data from genetic studies show that samples of steelhead from Deer and Mill creeks, the Stanislaus River, Coleman National Fish Hatchery on Battle Creek, and Feather River Hatchery are well differentiated from all other samples of steelhead from California (Busby et al. 1996; NMFS 1997).



In reviewing the status of steelhead, NMFS (1996a) concluded that the Central Valley ESU is in danger of extinction due to the following:

- water diversion and extraction
- mining
- agriculture
- urbanization
- habitat blockages
- logging
- harvest
- hydropower development, and
- hatchery introgression.

Steelhead are somewhat unique in that they depend on essentially all habitats of a river system. Steelhead use the estuary for rearing and adapting to saltwater. The main channel is used for migrating between the ocean and upstream spawning and rearing areas. The tributaries are used for spawning and rearing. They are, therefore, found in virtually all ecological management zones and many of their respective ecological management units.

Overall, the decline of the steelhead trout population resulted from the cumulative effects of degrading habitats and environmental processes and functions. These factors include constructing dams on the larger rivers and streams which eliminated access to critical habitat for adults and juveniles; excessively warm water temperatures during the rearing period of juvenile steelhead; interrupting or blocking the free passage of juveniles and adults at diversion dams; loss of natural emigration cues due to altered flow regimes resulting from the export of water from large diversions in the south Delta; unscreened and poorly screened diversions which entrain fish as they are migrating; and channelization, levee construction, and land use which have led to degradation and loss of woody debris, shaded riverine aquatic, riparian corridors and forests, and floodplain functions and habitats. The single, most limiting factor for the decline of Central Valley steelhead is elimination of access to an estimated 82% to 95% of historical spawning and rearing habitat (Reynolds et al. 1993; Yoshiyama et al. 1996).

A host of other factors has also contributed to the decline of the steelhead trout, but perhaps to a lesser degree. These include the various smaller water diversion facilities and dams; extensive loss of rearing habitats in the lower Sacramento River, San Joaquin River, and Sacramento-San Joaquin estuary through levee construction and marshland reclamation; and the interaction with and predation by non-native species.

VISION

The vision for Central Valley steelhead trout is to recover this species listed as threatened under the ESA and achieve naturally spawning populations of sufficient size to support inland recreational fishing and that fully use existing and restored habitat areas.

Achieving this vision will primarily require restoring degraded spawning and rearing habitats and enhancing fish passage to historical habitat. Reestablishing the ecological linkage between headwaters and lower reaches by restoring steelhead access to historical habitats above dams is the most important element to achieve the vision.

This vision is consistent with restoring populations of steelhead to levels that eliminate the need for any future protection under the State and federal Endangered Species Acts (ESAs). To achieve this vision, ecological functions and processes that create and sustain steelhead habitats would be maintained and restored and stressors and known sources of mortality would be reduced or eliminated.

The strategy for attaining this vision is to restore degraded spawning and rearing habitat in tributaries; restore access to historical habitat that is partially or completely blocked; dedicate more water in storage to provide adequate tailwater habitat conditions (primarily water temperature) year-round below dams; support angling regulations consistent with restoring ecosystem processes and functions; support additional research to address large deficiencies in information regarding steelhead freshwater and ocean life history, behavior, habitat requirements, and other aspects of steelhead biology; and provide opportunities for angling and nonconsumptive uses.

In addition, the strategy includes operating Central Valley hatcheries to protect and maintain the existing genetic diversity of naturally spawning populations and provide hatchery-produced fish for a healthy recreational fishery.

NMFS has recommended general conservation measures for steelhead throughout their Pacific coast range. These conservation measures, when applied to the Central Valley, include the following:

- Implement land management practices that protect and restore habitat. Existing practices that may affect steelhead include timber harvest, road building, agriculture, livestock grazing, and urban development.
- Review existing harvest regulations to identify any changes that would further protect Central Valley steelhead.
- Incorporate practices to minimize impacts on native populations of steelhead into hatchery programs.
- Make provisions at existing dams to allow the upstream passage of adult steelhead.
- Provide adequate headgate and staff gage structures at water diversions to control and effectively monitor water usage, and enforce water rights.
- Screen irrigation diversions affecting downstream migrating steelhead.

Within the broad context of ecosystem restoration, steelhead restoration will include a wide variety of efforts, many of which are being implemented for other ecological purposes or which are not specific to steelhead trout. For example, restoration of riparian woodlands along the Sacramento River between Keswick Dam and Verona will focus on natural stream meander, flow, and natural revegetation/successional processes. These will be extremely important in providing shaded riverine aquatic habitat, woody debris, and other necessary habitats required by lower trophic organisms and juvenile and adult steelhead populations.

Operation of the Central Valley water storage and conveyance systems for their potential ecological benefits can be one of the more important elements in restoring a wide spectrum of ecological resources, including steelhead trout.

Inadequate connectivity between upstream holding, spawning, and rearing habitat in certain tributary streams has impaired or reduced the reproductive potential of most steelhead stocks. Providing stream flows, improving fish ladders, and removing dams will contribute greatly to efforts to rebuild steelhead populations.

One critical effort will be to conduct the necessary evaluations and analyses to determine the potential benefits and consequences of reintroducing certain steelhead stocks above major dams to provide access to historic spawning and rearing areas. The potential transfer of adult fish above the dams may be straightforward, but the successful emigration downstream by juveniles cannot be ensured. Juvenile salmonid passage at large dams in the Columbia River basin has had little success and the viability of this option to protect and restore naturally spawning steelhead trout in the Central Valley is unknown.

VIABLE SALMONID POPULATION AND RECOVERY

The National Marine Fisheries Service has introduced a new and robust approach for defining the recovery of chinook salmon and steelhead stocks (NMFS 2000). Although this approach is still in the draft stage, it will be finalized and adopted as an important planning tool to ensure the recovery of listed stocks. This "viable salmonid population (VSP)" approach is designed to provide an explicit framework to identify biological requirements that will contribute to assessing management and conservation actions. The VSP introduces four sets of guidelines to determine a stocks viability.

- Population size (viable and critical levels)
- Productivity
- Spatial structure, and
- Diversity.

The VSP approach has numerous meaningful benefits for the ERP including a more accurate depiction of stock status, improved means to assess needed recovery actions, a method to evaluate completed recovery actions, a means by which to assess progress toward recovery, and a framework to organize or redefine existing recovery and management goals for steelhead trout.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

- The U.S. Fish and Wildlife Service's goal, as established by the Central Valley Project Improvement Act, is to double the natural production of Central Valley anadromous fish stocks by 2002 (USFWS 1997).
- The California Department of Fish and Game is required under State legislation (The Salmon, Steelhead Trout and Anadromous Fisheries Program Act of 1988) to attempt to double the numbers of steelhead estimated to have been present in the Central Valley in 1988 (McEwan and Jackson 1996, Reynolds et al. 1993, and McEwan and Nelson 1991).
- Endangered Species Recovery Plan: The National Marine Fisheries Service is required under the federal ESA to develop and implement a recovery plan threatened Central Valley steelhead ESU and to restore this stock to levels that will allow their removal from the list of endangered species (NMFS 1997).
- California Endangered Species Act which can provide specific criteria for down listing, delisting, and recovery of listed species.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Steelhead trout are closely dependent on ecological processes and habitats and adversely affected by a variety of stressors. Many of the stressors affecting abundance, persistence, and recovery of steelhead were initially identified as stressors that constrain Central Valley chinook salmon populations, and were applied secondarily to steelhead because they are an anadromous fish with a generally similar life history. For the most part, stressors that affect chinook salmon also affect steelhead. However, because of the focus on chinook salmon, it is often assumed that steelhead have been affected by the identified stressors *to the same degree* as chinook salmon, hence it is a common misconception that alleviation of the stressor to the level that it no longer impacts a chinook salmon population will result in steelhead population increases. In reality, some stressors cause greater impacts on steelhead populations than they do on chinook salmon populations. For example, high water temperatures affect juvenile steelhead to a greater degree than juvenile fall-run chinook salmon because most fall-run chinook have emigrated to the ocean by early summer before high water temperatures occur, and steelhead must rear through summer and fall when water temperatures are more likely to become critical.

Important ecological processes the directly influence the health of steelhead trout or its habitat include:

- Central Valley streamflows,
- Coarse sediment supply,
- Stream meander corridors,
- Floodplain and flood processes,
- Stream temperatures,
- Bay-Delta hydraulics, and
- Bay-Delta aquatic foodweb.

Habitats used by steelhead trout during their juvenile or adult life stages include:

- Tidal perennial aquatic habitat,
- Delta sloughs,
- Midchannel islands and shoals,
- Saline and fresh emergent wetlands,
- Riparian and riverine aquatic habitats, and
- Freshwater Fish Habitats.

Stressors that adversely affect steelhead trout or its habitats include:

- Water diversions,
- Dams and other structures,
- Levees, bridges, and bank protection,
- Dredging and sediment disposal,
- Gravel mining,
- Predation and competition,
- Non-native wildlife,
- Contaminants,
- Harvest, and
- Artificial propagation programs.

Objective, Targets, Actions, and Measures

> The Strategic Objective is to achieve, first, recovery and then large self-sustaining populations of at-risk native species dependent on the Delta, Suisun Bay, and Suisun Marsh.

Species Targets: The Central Valley steelhead Evolutionarily Significant Unit (ESU) will be regarded as restored when the ESU meets specific viability criteria to be established in the NMFS recovery plan for Central Valley salmonids. Viability of the Central Valley steelhead ESU will be assessed according to the "Viable Salmonid Populations" (VSP) framework developed by the NMFS (in review). The framework deals with four population characteristics:

1. Abundance: populations are large enough to resist extinction due to random environmental, demographic and genetic variation.

2. Productivity: populations have enough reproductive capacity to ensure resistance to episodes of poor freshwater or ocean conditions and the ability to rebound rapidly during favorable periods, without the aid of artificial propagation.

3. Spatial Distribution: populations are distributed widely and with sufficient connectivity such that catastrophic events do not deplete all populations and stronger populations can rescue depleted populations.

4. Diversity: populations have enough genetic and life history diversity to enable adaptation to long-term changes in the environment. Populations achieve sufficient expression of historic life history strategies (migration timing, spawning distribution), are not negatively impacted by outbreeding depression resulting from straying of domesticated hatchery fish, and are not negatively impacted by inbreeding depression due to small population size and inadequate connectivity between populations.

The NMFS recovery planning for Central Valley salmonids will proceed in two phases. The first phase will be conducted by a technical recovery team (TRT) that will produce numeric recovery criteria for populations and the ESU following the VSP framework, factors for decline, early actions for recovery, and provide plans for monitoring and evaluation. The TRT will review existing salmonid population recovery goals and management programs being implemented by federal and State agencies and will coordinate with agency scientists, CALFED staff and Central Valley science/restoration teams such as the Interagency Ecological Program work teams during this first phase. TRT products will be peer-reviewed and made available for public comment.

The second phase will be identification of recovery measures and estimates of cost and time required to achieve recovery. The second phase will involve participation by agency and CALFED staff as well as involvement by a broad range of stakeholders, including local and private entities, with the TRT providing technical guidance on biological issues.

Long-Term Objective: Restore self-sustaining populations of steelhead to all streams that historically supported steelhead populations and contain suitable habitat, or could contain suitable habitat with the implementation of reasonable restoration and protection measures. Numbers of fish of natural origin should exceed in most years the estimated population level in the early 1960s: 40,000 adult spawners annually.

Short-Term Objective: Determine the abundance, distribution, and structure of existing steelhead populations, and develop and implement restoration measures and protections that have a relatively high degree of certainty of increasing number and size of naturally spawning populations.

Rationale: Because dams have been constructed at low elevations on all major tributaries of the Sacramento and San Joaquin rivers, steelhead have been denied access to most of their historical spawning and rearing habitats in upstream areas. It was generally assumed that hatchery production would make up for any losses caused by the dams; however, hatchery production of steelhead has been limited by numerous problems. For example, one major hatchery (Nimbus) raises steelhead derived from fish imported from the Eel River and other sources because native steelhead were in short supply). Because of the hatcheries and changes to the rivers, the exact status of wild populations in the Central Valley is unclear, but the populations are certainly at low levels. The largest remaining populations of wild steelhead appear to be in the upper Sacramento River and its tributaries, but the status of these runs is unknown. Because of the severe decline of Central Valley steelhead, the NMFS has listed them as threatened under the federal Endangered Species Act. The objective, therefore, is designed to restore the numbers and spawning densities of wild steelhead to a point where the species can remain viable and can sustain a substantial sport fishery. The restoration of steelhead to reasonably high numbers and densities in currently available habitat depends on assumptions about habitat quality and the biology of the fish that need to be tested. It is likely that restoration of this fish will require providing it with access to upstream areas now blocked by dams.

STAGE 1 EXPECTATIONS: Central Valley steelhead numbers should not fall lower than they have been in the 1990s. Ongoing efforts to provide passage at impassable dams on key tributaries such as Battle, Clear, and Butte creeks should be accelerated. Water operations should provide temperatures adequate for summer rearing in reaches below the major reservoirs. Now that a hatchery marking program has been implemented so that hatchery and wild fish can be differentiated, information on the status of natural stocks can be obtained. Chinook salmon emigration studies should be augmented so that information regarding steelhead is obtained, and monitoring of adult spawner escapement on all major tributaries should be implemented. Use of the steelhead life-stage assessment protocol (see below) by the anadromous fish monitoring programs will provide valuable information on natural steelhead distribution (IEP Steelhead Project Work Team 1999).

RESTORATION ACTIONS

The following actions would help to achieve the short- and long-term restoration of Central Valley steelhead populations:

- Implement a coordinated approach to restore ecosystem processes and functions, including restoring access to historical habitat presently blocked by dams.
- Implement measures to restore habitat when restoration of ecosystem processes and functions is not feasible. This includes providing adequate flows and water temperatures in tailwater habitats below the major reservoirs.
- Protect spawning and rearing habitat in upper tributary watersheds.
- Improve riparian corridors in lower tributaries and rivers.
- Improve estuary habitat.
- Manage and operate the four hatcheries in the Central Valley that propagate steelhead in order to protect the genetic diversity of naturally and hatchery produced stocks and to minimize ecological impacts of hatchery releases on natural populations.
- Provide sufficient flows in lower tributaries for immigration and emigration to improve migration success.
- Reduce losses to unscreened diversions.
- Increase the scope of catch-and-release recreational fisheries for naturally produced steelhead. (Note: The Fish and Game Commission has adopted more stringent angling regulations for the Central Valley, including the elimination of retention of unmarked {wild} steelhead except for a limited area in the upper Sacramento River.)
- Implement programmatic actions proposed in the 14 ecological management zone visions to help achieve steelhead targets by creating and sustaining improved habitat conditions and reducing sources of mortality.

OTHER ISSUES AND INFORMATION NEEDS

The Comprehensive Monitoring, Assessment, and Research Program (CMARP - see Overview section) identifies six major knowledge gaps and monitoring needs for steelhead (CMARP Steering Committee 1999). In addition, a conceptual model was developed for Central Valley steelhead and has been incorporated into the CMARP plan as a technical appendix (IEP Steelhead Project Work Team 1999). These documents describe past research and monitoring projects for steelhead, identify what is known about their life history and status, review the adequacy of existing anadromous fish monitoring projects in terms of their ability to obtain steelhead information, and recommend new monitoring and assessment programs or enhancements to ongoing anadromous fish monitoring programs that will address the identified knowledge gaps.

The knowledge gaps are the result of institutional and natural constraints to steelhead monitoring and research. Institutional constraints are the result of the narrow focus of most anadromous fish monitoring programs: because chinook salmon are commercially exploited, highly visible, and politically sensitive, they have received the majority of limited monitoring funds and effort. This narrow focus was reinforced by the belief among resource agencies that steelhead suffer from the same level of impacts as do chinook salmon, and assessment of impacts would be similar for steelhead.

Natural constraints result from life-history traits that are common to all Central Valley steelhead that make them difficult to monitor and assess. Adults tend to migrate during high flow periods, which make it difficult to observe them and difficult to maintain counting weirs and other monitoring equipment and structures. Carcass surveys, a reliable method to estimate chinook salmon spawning escapement, is not applicable to steelhead because many survive spawning and most others do not die on the spawning grounds. Although steelhead redds can be discerned from salmon redds, they are difficult to observe because steelhead spawn at higher flows than do chinook salmon. Trap efficiencies are lower for juvenile steelhead because emigrating juveniles can more readily escape trapping because of their larger size, relative to chinook salmon.

In addition to the CMARP documents, NMFS has provided additional information regarding factors influencing the decline of steelhead, ongoing steelhead conservation efforts, and areas where clarification and additional studies are needed to provide better assurances that the actions proposed for steelhead restoration are adequate (National Marine Fisheries Service 1996a and 1996b). Information needs corresponding to the major knowledge gaps identified by the CMARP documents and other issues identified by the NMFS are described below:

CURRENT DISTRIBUTION, ABUNDANCE AND LIFE-HISTORY CHARACTERISTICS OF NATURALLY SPAWNING POPULATIONS

Existing monitoring projects have shown that naturally spawning steelhead populations exist in the upper Sacramento River and tributaries, Mill, Deer, and Butte creeks, and the Feather, Yuba, American, and Stanislaus rivers. It is possible that naturally spawning populations exist in many other streams but are undetected due to lack of monitoring or research programs.

From 1967 to 1993, run size estimates were generated for steelhead using counts at the fishway on the Red Bluff Diversion Dam (RBDD). From these counts, estimates of natural spawning escapement for the upper Sacramento River above RBDD were made. Because of impacts to winter-run chinook salmon, the operation of RBDD was changed so that the dam gates were raised earlier in the season, and this eliminated the ability to generate run-size estimates.

Beginning with broodyear 1997, all steelhead produced in Central Valley hatcheries were marked with an adipose fin clip. This program will continue as a permanent hatchery practice at these hatcheries. Marked juvenile fish were captured in smolt emigration studies beginning in 1998 and marked adult steelhead began returning in winter 1999.

The IEP Steelhead Project Work Team has developed a steelhead life-stage assessment protocol that classifies rainbow trout by developmental life stage and includes diagnostics for determining the degree of smoltification using a set of characteristics that is well-established in the scientific literature. Implementation of a standardized protocol to assign individual fish to one of several life-stage categories (yolk-sac fry, fry, parr, silvery parr, or smolt) will yield valuable information regarding when and where naturally-produced steelhead smolts occur and the disposition of juvenile steelhead through time and space. This will be an important tool in determining current distribution of steelhead throughout the Central Valley.

ACTION - More comprehensive monitoring is needed to determine system-wide distribution. In addition to existing monitoring, new projects should be initiated in the mainstem San Joaquin and Cosumnes rivers and Stony, Thomes, Antelope, and Putah creeks. For the Stanislaus, Tuolumne, Merced, and Yuba rivers and Mill and Deer creeks, the existing chinook salmon monitoring projects should be augmented so that steelhead information can be obtained. Index reaches could be established and monitored by electrofishing, beach seining, hook and line, or some other method to document occurrence, assess smolt production, and provide indices of abundance. The adult fish trap in the Daguerre Point Dam fish ladder, which is operated to monitor adult spring run chinook salmon, should be utilized to monitor adult steelhead escapement as well.

Another method of generating run-size estimates for the upper Sacramento River system, or perhaps an index, needs to be developed.

Capture of non-clipped juvenile steelhead in tributary monitoring projects will help elucidate the location of naturally spawning populations. Some existing anadromous fish monitoring projects have begun recording the life stage and the presence or absence of adipose fins on all rainbow trout observed or captured. All monitoring projects should adopt these protocols into their data collection regimen.

GENETIC AND POPULATION STRUCTURE

NMFS recently completed a genetic analysis on Central Valley steelhead as part of the west coast steelhead Endangered Species Act status review. This study provided useful information for purposes of delineation of Evolutionarily Significant Units (ESU's), but did not have the resolution necessary to provide meaningful information within ESU's, such as the Central Valley ESU. There is a need to augment this analysis to provide comprehensive information on the relationship of Central Valley steelhead populations to each other and to other populations of coastal rainbow trout. A genetic evaluation of Central Valley steelhead populations is necessary to determine phylogenetic relationships among putative native rainbow trout, naturally spawning steelhead, and hatchery steelhead that were founded from non-native broodstock. This information will be useful in estimating the structure and genetic diversity within and among Central Valley steelhead populations.

A generalized population structure can be inferred from existing knowledge of rainbow trout/steelhead life histories and behaviors, and from more specific studies on other anadromous trout population (e.g., brown and cutthroat trout). However more research into this topic is necessary to elucidate fully the interrelationship of the various life history forms, especially the non-anadromous and anadromous forms. Population ecology theory suggests that the non-anadromous forms are important for population persistence through periods of adverse climatic conditions (e.g., drought) and the anadromous forms are important for recolonizing new and restored habitat after catastrophic events (e.g., wildfires) cause the extirpation of the non-anadromous forms of a local population. This would suggest that all life-history forms of a population may be necessary for long-term persistence of the population.

ACTION - A comprehensive, basin-wide evaluation using analysis of mtDNA and microsatellite DNA structure and allele frequencies could provide information that is essential for designing recovery actions and will provide the context for successful interpretation of genetic relationships of steelhead populations in specific streams. Specific objectives of the evaluation would be:

- Evaluate and describe genetic and population structures and genetic diversity of Central Valley steelhead populations.
- Compare genetic profiles and describe phylogenetic relationship of Central Valley naturally-spawning and hatchery steelhead populations.
- Analyze genotypes of self-sustaining, putative native Central Valley rainbow trout populations that are presently isolated above artificial barriers to determine their phylogenetic relationship to anadromous and stream-dwelling rainbow trout populations and strains.
- Provide genetic information on steelhead populations of specific stream systems.

Determining maturation status of rainbow trout captured in the various monitoring projects will assist in elucidating the population structure of Central Valley steelhead and will provide much-needed information on the extent of the contribution of mature parr to the breeding population. Parr maturation, especially in males, is common in steelhead and other polymorphic salmonid populations. Sexually mature non-anadromous parr can be easily detected when working up samples of juvenile steelhead and can be easily incorporated into the steelhead life-stage assessment protocol (IEP Steelhead Project Work Team 1999). When collected systematically throughout the system in conjunction with life stage and condition, these data will provide information about the relationship of anadromous and non-anadromous forms and developmental variation in steelhead, all of which has direct bearing on population growth and dynamics.

INSTREAM FLOW NEEDS AND TEMPERATURE CONTROL

Flow needs for chinook salmon and steelhead often differ in timing; the most important flow needs for steelhead are for cold water during the summer and early fall, while increased flows for chinook typically are scheduled for the spring and mid-fall migration periods. In some cases, such as the temperature criterion for winter-run chinook from Keswick to Red Bluff, flow related actions for chinook provide appropriately timed temperature modulation for steelhead. However, this situation is a rarity. Differences in the timing and amount of flow needed by each species have the potential to lead to difficult management dilemmas in the event of extended drought.

ACTION - Workshops and research designed to contribute to developing flow-assessment protocols should pay equal attention to both steelhead and chinook salmon, and should also specifically address differences in life history between these species that require tradeoffs in flow conditions. This potential conflict should be made explicit for locations where it is most problematic (e.g., Stanislaus, American, Feather, Mokelumne, and Yuba rivers, and Cottonwood Creek). Effects of different flow regimes on habitat attributes important for each species should be evaluated for all water-year types. This information could be used to develop flow-allocation priorities where conflicts exist between the needs of both species.

A set of biological criteria including population abundance, productivity, and location should be established to guide the decision-making process. The objective should be to achieve drought protection for a well distributed set of natural populations that could serve as the source of colonists for populations that may be depleted or extirpated during a prolonged drought. Establishing priorities before a crisis exists should yield a more thoroughly considered and readily implementable course of action.

Locations where a conflict over flow allocation is less likely should also be highlighted (e.g., mainstem Sacramento from Keswick to Red Bluff, Mill, Deer, Antelope, and Butte creeks). Battle, Cow, and Clear creeks

ROLE OF INSTREAM HABITAT IN STEELHEAD PROTECTION AND RESTORATION

Temperature regulation below mainstem dams has replaced a host of other ecological and physical functions of flow as the focal point of setting flow criteria. However, maintenance of an adequate temperature regime does not provide other ecological characteristics associated with cold temperatures in upstream habitats, especially the type and availability of food resources and cover, and refugia from predatory fish. Restoration of connectivity among habitats will permit more natural movement patterns and habitat selection by steelhead juveniles and adults.

Steelhead and resident rainbow trout have been shown to utilize seasonal habitats of intermittent streams for spawning and rearing. Also, there is evidence that steelhead populations exist in some small, low elevation Sacramento River tributaries (e.g., Dry and Auburn Ravine creeks) that do not contain suitable habitat year-round, or are limiting in one or more suitable habitat characteristics. Habitat characteristics, the extent of use of these streams by steelhead, and life-history characteristics (spawning and emigration timing, size/age at emigration, etc.) is unknown.

ACTION - Given the intractability of re-creating headwaters ecology below a mainstem dam, restoration priority should be placed on both protection of intact habitats and improving access to these habitats. The second tier of priority should be degraded habitats that have the greatest potential for restoration to the combination of temperature regime and ecological function that approximate conditions in historic headwaters habitats (Pacific Rivers Council 1996).

The extent of steelhead use of intermittent and low elevation streams, habitat characteristics of these streams, and life-history characteristics (spawning and emigration timing, size/age at emigration, etc.) needs to be assessed.

RESTORATION OF ACCESS TO HISTORICAL HABITAT PRESENTLY BLOCKED BY DAMS

Because of the large-scale loss of spawning and rearing habitat that has occurred in the Central Valley, restoring access to historical habitats above impassable dams needs to be considered on some streams. This would not only increase the amount of available habitat for steelhead, but if spawning and rearing is allowed to take place in the upper reaches of a stream where it occurred historically, this may reduce the reliance on the downstream areas below the dam for spawning and rearing, and this could reduce the need to provide adequate flow and temperature conditions in the lower reach. This could have a positive impact on water storage and power generation.

ACTION - The Yuba River, and Battle and Clear creeks are locations at which evaluating opportunities to provide passage above existing barriers is most needed. Evaluation of habitat capacity above barriers is an essential first step, followed by a engineering feasibility study (Meral and Moyle 1998). In addition to the drainages named above, steelhead restoration above barriers should be pursued in at least one tributary of the San Joaquin.

Removal of barriers provides the highest probability of restoration success. However, the limited number of locations in which barrier removal is feasible, and the limited amount of habitat access provided, may be inadequate to achieve steelhead recovery. Trap, haul, and release approaches to reintroduction should not be dismissed, especially because these approaches will probably be instrumental to effective steelhead restoration in the San Joaquin and American River basins. Furthermore, over the 25 to 30 year course of the ERP, new technologies may enable implementation of trap, haul, and release approaches in locations where they are not currently considered feasible.

ASSESSMENT OF FRESHWATER PREDATION RATES

One of the ultimate factors often associated with the evolution of anadromy is escape from high predation rates on egg and juvenile life stages in the ocean environment. The relatively large egg size and low fecundity of steelhead are life-history adaptations that correspond with reduced juvenile mortality. Low freshwater predation rates are associated with headwaters habitats. Large predatory fish are more abundant and more diverse in mainstem rivers than in headwaters streams. Largemouth and smallmouth bass have been identified as important predators on juvenile chinook salmon in the Tuolumne River (EA Engineering 1992). The effect of predation by introduced striped bass is uncertain.

Paired release experiments with chinook salmon have provided information about conditions affecting freshwater survival for this species. Inferring the causative mechanisms responsible for survival patterns is an important research topic for both steelhead and chinook salmon.

ACTION - Paired release or other types of experiments conducted with steelhead smolts at different sites throughout the Central Valley could provide information on survival rates of migrating juvenile steelhead. These experiments could be incorporated into the ERP adaptive management program. The potential for protecting wild populations by manipulation of the timing and distribution of hatchery releases is one strategy that should be evaluated in these experiments. Red Bluff Diversion Dam, the Hamilton City Pumping Plant, flood bypasses, San Joaquin tributaries and mainstem, and the Delta are locations where predation rates may be high and experiments would be useful (see Gregory and Levings 1998).

Steelhead runs in the American and Feather rivers which are highly supported by hatchery production provide opportunities for using uniquely-marked parr to evaluate survival rates of rearing fish.

MAGNITUDE OF INLAND RECREATIONAL FISHERY

Large experiments with Coleman fish in 1972-73, estimated that 2.7% of the steelhead released were caught before they reached the Delta (Menchen 1980, cited in McEwan and Jackson 1996). Staley

(1976, cited in McEwan and Jackson 1996) found that 51.2% of Nimbus Hatchery yearlings released in the American River were caught. Much lower harvest rates occurred on Nimbus Hatchery fish released in the Sacramento River. Several anecdotal reports suggest that harvest rates on hatchery-stocked fish can be high.

ACTION - Considerable efforts have been made to protect steelhead by modifying recreational fishery regulations and marking all hatchery steelhead. Central Valley steelhead are now listed as threatened under the ESA, and further provisions that minimize incidental take may be necessary. These provisions include:

- Rigorous estimates, with associated error estimates, of the level of potential incidental take,
- Continued marking of hatchery-produced steelhead and retention of only marked fish,
- Specification of time periods and locations of fishing seasons to minimize incidental take,
- Availability of sanctuary areas,
- Availability of effective monitoring efforts,
- Availability of effective enforcement mechanisms and public education programs, and
- Availability of effective implementation agreements.

Given that many anglers target hatchery releases, stocking practices should be designed to avoid overlap with outmigration of wild fish.

INFLUENCE OF HATCHERY PRACTICES ON RECOVERY

Natural production of steelhead is emphasized by both State policy and the ESA. Artificial production will be limited to areas where it already occurs, where it is necessary to prevent the extinction of a native run, or where the native population has already become extirpated and the habitat is irrevocably altered (McEwan and Jackson 1996).

The hatchery percentage of total production is currently estimated at 70 to 90 % (F. Fisher, pers. comm., cited in McEwan and Jackson 1996), and this level is considered to be as high as it should get (McEwan and Jackson 1996). From 1953-54 to 1958-59 the estimated average hatchery contribution to total steelhead production was 12% (Hallock et al. 1961).

Nimbus Hatchery broodstock, and naturally spawning fish in the American River exhibit genetic affinity to populations from the Eel River (NMFS 1997), reflecting the origin of this broodstock from the Van Arsdale Fisheries Station (Busby et al. 1996). This broodstock has also been introduced to the Mokelumne River via the Mokelumne River Fish Installation (Cramer et al. 1995).

Recommendations for hatchery operations (Hard et al. 1992, NRC 1996) provide an appropriate framework for evaluation. One important issue for the Central Valley is to link recovery of native populations with decreasing production objectives for the hatchery program.

ACTION - The objective of complete marking of hatchery fish should continue without exception throughout the duration of the CALFED program.

A plan should be developed by which restoration of natural production is matched by decreases in hatchery production. Hatchery production should not attempt to compensate for poor natural production, but should instead continue or more closely serve in the role of mitigating for the loss of upstream habitat and the loss of resultant fish and not serve to increase the number of naturally spawning fish.

For example, out-of-basin broodstock should be phased out. Replacement broodstock should be developed from wild spawning anadromous steelhead or native non-anadromous rainbow trout that became isolated when the dams were constructed, if sufficient numbers are available to permit take for broodstock. Replacement with another hatchery stock that exhibits genetic association with Central Valley steelhead is preferable to continued propagation of the out of basin stock. The replacement of broodstock by native non-anadromous rainbow trout has much merit, but is premature until certain evaluations are completed. These include identifying native populations isolated above dams (one of the objectives of the comprehensive genetic evaluation is to identify these populations), and demonstrating that anadromous forms can be recreated from these populations.

FECUNDITY OF MAIDEN (FIRST-TIME) AND REPEAT SPAWNERS

Fecundity for steelhead in their initial spawning is about half the fecundity of chinook salmon (Hutchings and Morris 1985). Fecundity is positively related to body weight, and the average fecundity of repeat spawners can approximate that of chinook salmon. In addition to increased fecundity, the larger body size of repeat spawners may enable them to make a disproportionate contribution to population productivity due to: 1) ability to dig deeper, more superimposition- and scour-resistant redds, and 2) a propensity to spawn in deeper water, reducing the potential for redd dewatering.

ACTION - Fish passage facilities should be constructed to pass adult steelhead efficiently in both directions. Recreational fisheries for adults should be governed by retention of only marked fish. Success of restoration should include an evaluation of trends in proportion of repeat spawners; an appropriate target would be at least 17% reported by Hallock (1989) for upper Sacramento River samples.

ROLE OF REARING HABITAT IMMEDIATELY BELOW LARGE DAMS

Maintaining the longest possible profile of riverine habitat capable of supporting all steelhead life stages is the most desirable objective for restoration. However, numerous constraints and competing interests limit attainment of this objective, especially for juvenile steelhead. Where constraints are severe, habitat enhancement near dams may provide opportunities to improve rearing habitat capacity. Most substrate supplementation that currently occurs in the Central Valley is in the form of spawning gravel for chinook salmon. This gravel can also be used by steelhead for spawning, but it does not contribute to enhancement of steelhead rearing habitat. Juvenile steelhead prefer substrates > 4 inches in diameter (Everest and Chapman 1972, Barnhart 1986). Steelhead parr also favor microhabitat sites adjacent to relatively swift currents that have overhead cover (Fausch 1993). Overhead cover is naturally provided by undercut banks and boulders or large woody debris, but artificial structures can also provide this habitat feature. Sedimentation reduces habitat quality by reducing food production, pool depth, and cover (Barnhart 1986).

ACTION - Adding cobble substrate to areas near dams, and providing shaded riparian aquatic habitat, could increase the suitability of tailwater areas as rearing habitat for steelhead. Because maintenance of adequately cool temperatures for steelhead rearing can be accomplished with less water in the immediate vicinity of dams, this habitat enhancement could permit a reduction in the volume of cold water released by encouraging more complete use of the cool water plume.

DROUGHT PERIOD CONTINGENCY PLAN

Recent history has demonstrated the impact prolonged drought can have on fish populations, and the potential for recurring extended droughts has been documented from tree-ring data (Hunrichs 1991, cited in Mount 1995; USFWS 1995).

ACTION - An essential function of a long-term restoration plan for Central Valley steelhead is to avert population bottlenecks resulting from drought. Development of a drought contingency plan should begin with an assessment of which basins afford the greatest potential for successful use of economic incentives to maintain ample instream flows during a protracted drought. Other measures should include establishment of a drought fund that is designated for purchase of water from willing sellers and economic compensation for reduced demand in watersheds identified in the assessment phase.

ADEQUACY OF MONITORING PROGRAM

The recovery criteria found in the Proposed Recovery Plan for the Sacramento River Winter-run Chinook Salmon (NMFS 1997, Botsford and Brittnacher 1998), and the Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes (1995) can be viewed as models for recovery planning. Existing recovery plans require a means for measuring natural spawner abundance (fish or redd counts) with an estimated uncertainty level, and consistent application of this monitoring procedure for an extended period. Duration of monitoring is either specified by a function of both uncertainty associated with estimation techniques and consistent attainment of abundance levels that correspond to an acceptably low probability of extinction, or attainment of specified abundance targets for a length of time often calculated as five times generation time. No recovery plan has been developed for steelhead at this time.

The widespread distribution of steelhead in the Central Valley, the relatively small size of populations in each tributary, and fundamental differences in life history and metapopulation dynamics compared to other listed species all suggest that steelhead monitoring will need to be broader in scope, and longer in duration than for other species.

ACTION - CMARP, in coordination with the IEP Steelhead Project Work Team, has developed a monitoring program for steelhead. Because of the anticipated broad scope and prolonged duration of this program, it should serve as the foundation upon which other monitoring components are built.

The monitoring program (IEP Steelhead Project Work Team 1999), in its base-level application, is designed to keep a pulse on the primary attributes of both existing and potentially-restorable steelhead habitat and associated steelhead populations. The plan is intended for application in tributary streams, mainstem rivers, and the delta and is suitable for addressing the identified specific knowledge gaps concerning Central Valley steelhead populations, collecting baseline information, and gauging the effects of CALFED actions.

The monitoring program has two primary components: habitat monitoring and steelhead population monitoring. The habitat component begins with habitat typing and mapping streams and rivers per the method of Snider et al. (1992). The resultant information on the distribution and abundance of mesohabitats in the stream (e.g., riffles, runs, glides, pools) provides the basis for identifying stream reaches based on stream channel attributes, and a template for allocating study effort (such as the study of juvenile steelhead rearing) per a random-stratified study design.

The steelhead population monitoring component of the plan essentially follows the basic life history of steelhead. The three main life-history compartments are spawning, rearing, and emigration. Within each of these compartments, questions are posed that provide the basis for what will be measured in the monitoring program. Each question is examined, either directly or indirectly, relative to basic habitat conditions being monitored. Thus, the plan is designed to observe population-level responses (in terms of population size and the extent to which a certain activity occurs) to variation in monitored habitat, including variation resulting from management actions implemented under CALFED. In addition, basic biological information will be collected on individual fish to monitor potential responses in the composition and structure of the population to actions taken.

Although monitoring of steelhead spawning will occur on a stream-specific basis, rearing and emigration monitoring will occur not only at that level but also on a linked, system-wide basis. Rearing and emigration monitoring will allow tracking of juvenile steelhead through the system, to the extent possible. This activity will be coupled with marking or tagging of wild fish - in addition to the hatchery marking program - as they are sampled through the system to obtain more specific information about how steelhead use the system as they move toward the ocean, including addressing questions about rearing requirements in downstream areas.

Classifying, prioritizing, and allocating monitoring effort in tributaries can at least be partially guided by considering options for steelhead enhancement and restoration. Monitoring effort and restoration actions should be allocated across a cross-section of these enhancement options so as to maintain the biodiversity of Central Valley steelhead and their associated habitats.

More detailed monitoring of steelhead harvest in Central Valley streams is needed. Continued complete marking of hatchery releases will be essential to the success of this monitoring program.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve steelhead trout habitat or population targets.

- Coordinate protection, enhancement, and restoration of occupied and historic Central Valley steelhead ESU habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, the Anadromous Fish Restoration Program, the U.S. Fish and Wildlife Service recovery plans, the SB 1986 program, and the

Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.

- Implement applicable management measures identified in the restoration plan for the Anadromous Fish Restoration Program and the recovery plan for the native fishes of the Sacramento/San Joaquin Delta.
- Implement management measures as recommended by DFG that are applicable to CALFED actions and achieving CALFED objectives.
- Minimize flow fluctuations to reduce or avoid stranding of juveniles.

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◆ Tidal Brackish and Freshwater Marsh Special-status Plant Species

Introduction

Tidal brackish and freshwater marshes occur in transitional areas between open-water and upland habitats throughout the Bay and Delta and are important habitats for many plant, fish and wildlife of the Bay-Delta. Substantial loss of tidal brackish and freshwater marshes has been incurred as a result of reclamation and channel dredging and scouring, leading to the decline of many native fish, wildlife, and plant species. Special-status plants inhabiting Bay-Delta tidal marshes include Mason's lilaeopsis (*Lilaeopsis masonii*), Suisun Marsh aster (*Aster lentus*), bristly sedge (*Carex comosa*), Suisun thistle (*Cirsium hydrophyllum* var. *hydrophyllum*), soft bird's-beak (*Cordylanthus mollis* ssp. *mollis*), rose-mallow (*Hibiscus lasiocarpus*), mad-dog skullcap, soft bird's-beak Delta tule pea (*Lathyrus jepsonii* var. *jepsonii*), Delta mudwort (*Limosella subulata*), Delta coyote-thistle (*Eryngium racemosum*), and Point Reyes bird's-beak (*Cordylanthus maritimus* ssp. *palustris*).

Species Descriptions

Designated for Recovery

Mason's lilaeopsis. Mason's lilaeopsis is a minute, turf-forming perennial plant in the carrot family (Apiaceae). It spreads by rhizomes and produces long, narrow, jointed leaves. Mason's lilaeopsis is state-listed as rare and is considered rare, threatened, or endangered by the California Native Plant Society (List 1B). Mason's lilaeopsis is semiaquatic and is usually found on saturated clay soils which are regularly inundated by waves and tidal action. Its known distribution extends from the margins of the Napa River in Napa County, east to the channels and sloughs of the Sacramento-San Joaquin Delta in Contra Costa, Solano, Sacramento, Yolo, and San Joaquin Counties. Approximately 50 occurrences of Mason's lilaeopsis were known in 1991 (DFG 1991). Populations of this species are small and fractured and few large contiguous sites exist on non-leveed sloughs or on eroding in-channel islands.

Mason's lilaeopsis has lost a large amount of its habitat through direct loss from flood control structures and rip-rap and through erosion of remnant in-channel islands. Widening of Delta channels for water transport, dredging and dumping of spoils, recreational development, and changes in water quality resulting from decreased flows in the Delta also threaten Mason's lilaeopsis. Although much of the habitat for Mason's lilaeopsis is privately owned, several State and Federal agencies have jurisdiction over the Delta waterways. One site is protected in Solano County on a DFG Ecological Reserve. DFG has been active in coordinating research on and trying to transplant the species. The trend for Mason's lilaeopsis is one of decline (DFG 1991).

Suisun Marsh aster. Suisun Marsh aster is a rhizomatous perennial herb in the sunflower family (Asteraceae). Suisun Marsh aster is on CNPS's List 1B. Suisun Marsh aster has habitat requirements and a distribution similar to that of Mason's lilaeopsis, but is not known from Alameda County. Suisun Marsh aster is threatened by marsh habitat alteration and loss. Factors leading to marsh habitat alteration and loss include development, agriculture, recreation, channelization, channel maintenance activities, and marsh drainage.

Suisun thistle. Suisun thistle is a perennial herb in the sunflower family (Asteraceae). It has slender, erect stems that are 3-4.5 feet tall and are well-branched above. The spiny leaves are deeply lobed. The flower heads are pale lavender-rose and the flower head bracts have a distinct green, glutinous ridge on the back. Suisun thistle is proposed for federal listing as endangered and is on CNPS's List 1B. Suisun thistle is known from only 2 locations in the Suisun Marsh in Solano County (CFR 60(112)). It occurs on the edges of salt and brackish marshes that are periodically inundated during high tides. The total number of individuals of Suisun thistle is a few thousand individuals (CFR 60(112)). One occurrence is on DFG lands and a second occurrence is on Solano County Farmland and Open Space Foundation lands.

Suisun thistle was probably more widespread in the past, but reductions in salt marsh habitat that have resulted from drainage or filling, and possibly water pollution, may have contributed to the species' decline (Niehaus 1977). Its present highly restricted distribution increases its susceptibility to catastrophic events such as disease or pest outbreak, severe drought, oil spills, or other natural or human caused disasters. Continued habitat conversion, habitat fragmentation, indirect effects from urban development, increased salinity, projects that alter natural tidal regime, mosquito abatement activities, competition with non-native plants, and inadequate regulatory mechanisms also threaten this taxon (CFR 60(112)).

SOFT BIRD'S-BEAK. Soft bird's-beak is a sparingly-branched, semi-parasitic herbaceous annual plant in the figwort family (Scrophulariaceae). Its stems are covered by soft hairs, and it bears white two-lipped flowers. Soft bird's-beak is proposed for federal listing as endangered and is state-listed as rare. Soft bird's-beak occurs along the northern shores of the San Francisco Bay, in Suisun Marsh, and in the salt marshes south of Suisun Bay. A dozen historical occurrences were known from Marin to Contra Costa Counties, where the counties border San Francisco Bay. In 1991, the species was known to be extant at only three sites: Benicia State Recreation Area, DFG land along the Napa River at Fagan Slough, and Point Pinole Regional Shoreline (California Department of Fish and Game 1992). Recently, several new populations have been discovered at salt marshes near Martinez and at Suisun Marsh (Natural Diversity Data Base 1996). Soft bird's-beak inhabits the upper reaches of salt grass-pickleweed marshes at or near the limits of tidal action. Soft bird's-beak is susceptible to factors similar to those listed above for Suisun thistle (CFR 60(112)).

VISIONS

The vision for Mason's lilaeopsis is to recover this State listed rare plant by protecting and preserving important habitat sites within the Bay-Delta.

The vision for Suisun Marsh aster is to recover this California Native Plant Society List 1B plant species.

The vision for Suisun thistle is to recover this federally listed endangered species by protecting and preserving important habitat sites within the Bay-Delta.

The vision for soft bird's beak is to recover this federally listed endangered species by protecting and preserving important habitat sites within the Bay-Delta.

DESIGNATED CONTRIBUTE TO RECOVERY

BRISTLY SEDGE. Bristly sedge is a rhizomatous perennial herb in the sedge family (Cyperaceae). Bristly sedge is considered rare, threatened, or endangered in California but more common elsewhere by CNPS (List 2). Bristly sedge occurs around lake margins in Contra Costa, Lake, Shasta, San Joaquin, and Sonoma Counties. It is also widespread outside of California, occurring in Idaho, Oregon, and Washington. Bristly sedge is threatened by marsh habitat alteration and loss.

DELTA TULE PEA. Delta tule pea is a herbaceous perennial plant in the legume family (Fabaceae). Delta tule pea is on CNPS's List 1B. Delta tule pea inhabits freshwater and brackish marshes in Alameda, Contra Costa, Fresno, Marin, Napa, Sacramento, San Benito, Santa Clara, San Joaquin, and Solano Counties. Delta tule pea is threatened by marsh habitat alteration and loss. Factors leading to marsh habitat alteration and loss include development, agriculture, recreation, channelization, channel maintenance activities, and marsh drainage.

DELTA MUDWORT. Delta mudwort is a stoloniferous perennial herb in the figwort family (Scrophulariacae). Delta mudwort is considered rare, threatened, or endangered in California but more common elsewhere by CNPS (List 2). Delta mudwort inhabits marshes in Contra Costa, Sacramento, San Joaquin, and Solano Counties. It is also found on the Atlantic Coast. Delta mudwort is threatened by marsh habitat alteration and loss. Factors leading to marsh habitat alteration and loss are similar to those described above for Delta tule pea.

POINT REYES BIRD'S-BEAK. The Point Reyes bird's-beak is a hemiparasitic, annual herb of the figwort family that grows 10-40 centimeters tall. It is listed as a Category 1B plant by the CNPS. The species grows in coastal saltmarshes. Point Reyes bird's-beak is distributed throughout the northern portion of the north coast and the norther portion of California's central coast. Point Reyes bird's-beak occurs or has the potential to occur in the Suisun Marsh/North San Francisco Bay Ecological Management Zone. The current range of this plant has been reduced by development. Other threats include foot traffic and trampling, competition from non-native plants, altered marsh hydrology, pollution, and cattle grazing.

DELTA COYOTE-THISTLE. Delta coyote-thistle, also known as delta button celery, is a herbaceous perennial in the carrot family. Delta coyote-thistle is listed as endangered under CESA and as a Category 1B plant by the CNPS. The historical distribution of this plant includes Calaveras, Merced, Stanislaus, and San Joaquin counties. Of the approximately 20 known occurrences, about one-third have been extirpated, including all occurrences in San Joaquin County and most of Stanislaus County. Most extant occurrences are found in Merced County along the San Joaquin River. Delta coyote-thistle occurs or has the potential to occur in the Eastside Delta, East San Joaquin, San Joaquin River and the West San Joaquin Ecological Zones. This plant grows 10-50 centimeters tall and occurs at elevations of 15-75 feet. Delta Coyote-thistle occurs on clay soils on sparsely vegetated margins of seasonally flooded floodplains and swales, freshwater marshes, and riparian areas.

VISIONS

The vision for bristly sedge is to contribute to the recovery of this California Native Plant Society List 2 plant species.

The vision for Delta tule pea is to contribute to the recovery of this California Native Plant Society List 1B plant species.

The vision for Delta mudwort is to contribute to the recovery of this California Native Plant Society List 2 plant species.

The vision for Point Reyes bird's-beak is to recover this California Native Plant Society List 1B plant species.

The vision for Delta coyote-thistle is to recover this State listed endangered species and California Native Plant Society List 1B plant species.

DESIGNATED FOR MAINTAIN

MAD-DOG SKULLCAP. Mad-dog skullcap is a rhizomatous perennial herb mint family (Lamiaceae). Mad-dog skullcap is considered rare, threatened, or endangered in California but more common elsewhere by CNPS (List 2). Mad-dog skullcap inhabits mesic meadows and marshes and in California is known from only 2 occurrences in Inyo and San Joaquin Counties (Skinner and Pavlik 1994). Mad-dog skullcap also occurs in New Mexico and Oregon. Mad-dog skullcap is threatened by marsh habitat alteration and loss.

ROSE-MALLOW. Rose-mallow is a herbaceous perennial plant in the Mallow family (Malvaceae). Rose-mallow is considered rare, threatened, or endangered in California but more common elsewhere by CNPS (List 2). Rose-mallow is relatively widespread along the lower portions of the Sacramento and San Joaquin Rivers, but most occurrences are very small. the species prefers open, freshwater marsh habitats along slow-moving watercourses, and is often found on peaty substrates in association with bulrush (*Scirpus* sp.). Rose-mallow does not tolerate shade from dense woody vegetation. Rose mallow is threatened by marsh habitat alteration and loss. Factors leading to marsh habitat alteration and loss include development, agriculture, recreation, channelization, channel maintenance activities, and marsh drainage.

VISIONS

The vision for mad-dog skullcap is to maintain populations of this California Native Plant Society List 2 plant species.

The vision for rose-mallow is to maintain populations of this California Native Plant Society List 2 plant species.

The visions for these tidal brackish and freshwater marsh guild of plant species are to provide protections for existing populations and restore habitats to provide sites for expansion of the species. Existing populations should be protected through acquisition or cooperative efforts with landowners, beginning with the highest quality sites. A site-based evaluation of populations would be conducted to all rank sites based on criteria developed to assess habitat and population conditions. Higher ranked sites that are protected would serve as a source of propagules for restored areas.

Higher quality sites will also be evaluated for potential enhancement opportunities through habitat expansion. Moderate or low quality sites will be restored to low elevation intertidal habitats and establishment of species in this guild promoted. Restoration efforts would include protecting eroding sites, such as on in-channel islands, from further erosion.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore habitat for the Delta plant species will involve cooperation with programs being implemented by DFG to promote their occurrences and cooperation from agencies with responsibility or authority for maintaining or restoring tidal perennial habitat, including:

- California Department of Fish and Game,
- U.S. Fish and Wildlife Service,
- U.S. Army Corps of Engineers,
- Delta Protection Commission
- Benicia State Recreation Area,
- Point Pinole Regional Shoreline, and
- Solano County Farmland and Open Space Foundation.

Other programs that could be solicited for collaboration to benefit the Delta species include the Montezuma Wetlands Project and Tidal Wetlands Species Recovery Plan.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

The Delta guild of plant species is integrally linked with the restoration of tidal perennial aquatic habitat. Stressors that could affect the Delta guild include non-native species such as water hyacinth that shades out habitat when occurring in dense patches; levees, bridges, and bank protection; dredging' water management; human disturbance; and contaminants. Tides are an important primary physical process that affects the tidal brackish and freshwater plant species guild.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

> The Strategic Objective is to achieve, first, recovery and then large self-sustaining populations of at-risk native species dependent on the Delta, Suisun Bay, and Suisun Marsh.

SPECIES TARGETS

MASON'S LILAEOPSIS: Expand suitable habitat by 100 linear miles and protect at least 90% of the currently occupied habitat including 90% of high quality habitat occurrences in the North, South, and East Delta and Napa River Ecological Management Units.

SUISUN MARSH ASTER: Expand suitable habitat by 100 linear miles and protect at least 90% of the currently occupied habitat including 90% of high quality habitat occurrences in the North, South, and East Delta and Napa River Ecological Management Units.

SUISUN THISTLE: Maintain the current distribution and existing populations of Suisun thistle, establish 10 new populations, and increase overall population size tenfold.

SOFT BIRD'S-BEAK: Maintain the current distribution and existing populations of soft bird's-beak and reestablish and maintain viable populations throughout its historic range.

> The Strategic Objective is to contribute to the recovery of at-risk species in the Bay-Delta estuary and its watershed.

Species Targets

Bristley Sedge: Research habitat requirements and use knowledge gained to develop and implement specific recovery measures.

Delta Tule Pea: Protect at least 90% of occupied habitat, including 90% of high quality habitat, throughout the range of the species to protect geographic diversity, and expand suitable habitat by 100 linear miles.

Delta Mudwort: Protect at least 90% of occupied habitat, including 90% of high quality habitat, throughout the range of the species to protect geographic diversity, and expand suitable habitat by 100 linear miles.

Point Reyes Bird's-Beak: Maintain, enhance and restore suitable high marsh and high marsh-upland transition habitat around San Pablo Bay.

Delta Coyote Thistle: Survey all extant populations and suitable habitat and update status and ownership information. Bring at least ten of the largest extant, naturally occurring populations found during surveys into permanent protected status and bring at least 50% of all extant populations and individuals under permanent protected status. Manage protected populations for long-term viability. Increase suitable habitat by 50% over existing extent. Increase populations and individuals by 25% over present exiting numbers.

> The Strategic Objective is to maintain abundance and distribution.

Species Targets

Mad-dog Skullcap: An increase in or no discernable adverse effect on the size or distribution of species populations.

Rose-Mallow: An increase in or no discernable adverse effect on the size or distribution of species populations.

Long-Term Objective: Have self-sustaining populations of Mason's lilaeopsis, Suisun Marsh aster, Suisun thistle, soft birds-beak, rose-mallow, Delta mudwort, and Delta tule pea and similar declining endemic species located throughout their original native range in marshes associated with the Bay-Delta system.

Short-Term Objective: Protect existing populations of the species and restore habitat to provide sites for expansion of all rare native species that require tidal or brackish water marshes.

Rationale: The species listed here are examples of plants that are largely endemic to brackish water marshes of Suisun Bay and elsewhere in the estuary. The likelihood of extinction among these species varies from very high for Suisun thistle, known from only four occurrences, to moderate for Mason's lilaeopsis, which is widely distributed throughout the Delta. In combination, these seven species require a range of declining tidal marsh habitats in the Bay-Delta system. Although only two of the species (Suisun thistle and soft bird's beak) are formally listed as endangered, restoration of all these species to the point where they are fairly common would indicate that major marsh restoration projects in the region had succeeded.

Stage 1 Expectations: The status of the seven species listed here will have improved. Surveys of present ranges of the species (and other rare marsh plants), studies of their ecological requirements, and identification of key restoration sites will have been completed. Ongoing marsh restoration projects in the Bay-Delta system will have been evaluated according to their success at restoring rare native plant species and lessons learned applied to new projects.

Restoration Actions

The following actions would contribute to improving the tidal brackish and freshwater marsh special-status plant species populations:

- Conduct a site-based evaluation of populations and rank sites based on criteria developed to assess habitat and populations conditions.
- Acquire lands supporting existing populations or develop cooperative relationships with landowners to protect existing populations, beginning with the highest quality sites.
- Develop appropriate methods to protect and restore habitat and populations of the tidal

brackish and freshwater marsh special-status plant species.

- Manage protected areas occupied by the species to promote conditions favorable for the establishment, growth, and vigor of the species. Include management techniques such as exotic weed control and hydrologic regulation.
- Restore moderate or low quality sites to low elevation intertidal habitats and promote establishment of species in this guild. During the restoration of habitat, promote ecological functions such as sediment deposition and erosion to balance the formation and loss of intertidal habitats.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve habitat or population targets for tidal brackish and freshwater plant species.

MASON'S LILAEOPSIS AND SUISUN MARSH ASTER

- Maintain processes that support the dynamic habitat distributed throughout the species range and associated with existing source populations (species occurs on eroding margins of levees).
- To the extent practicable, design restoration of tidal habitats to create unvegetated, exposed substrate habitat at tidal margins of tidal fresh emergent wetland and riparian habitat.
- To the extent consistent with CALFED objectives, incorporate sufficient edge habitat to support the species in levee set back and channel island habitat restoration designs.
- To the extent practicable, maximize sinuosity of restored and created slough channels to increase water-land edge habitat.
- To the extent consistent with CALFED objectives, maintain and restore habitat and populations throughout the species' geographic ranges and expand habitat and populations to their historical and ecological ranges based on hydrologic, salinity and other habitat requirements of the species.
- Consistent with CALFED objectives, incorporate suitable habitat for these species in band protection designs used in CALFED actions.
- Monitor status and distribution of the species at five-year intervals and document expansion of the species into restored habitat for the duration of the Program.

SUISUN THISTLE

- Identify opportunities for establishing new populations or expanding existing populations and habitat.
- Control and reduce populations of non-native marsh species with potential effects on Suisun thistle and potential Suisun thistle habitat.
- Monitor the population size and vigor of all extant occurrences at a two-year interval for the duration of the Program.
- Modify conservation measures according to the adaptive management process as more understanding is developed of recovery needs.

SOFT BIRD'S-BEAK

- Expand potential habitat by improving tidal circulation to diked wetlands that sustain some existing exchange.
- Identify opportunities for establishing new populations or expanding existing populations and habitat.
- Establish soft bird's-beak populations to existing and restored suitable habitat.
- Control and reduce populations of non-native marsh species with potential effects on soft bird's beak and potential soft bird's-beak habitat.
- Monitor the populations size and vigor of all extant occurrences at two-year interval for the duration of the program and design and implement remediation measures if the recovery goal is not met.
- Modify conservation measures according to the adaptive management process as more understanding is developed of recovery needs.

BRISTLEY SEDGE

- Identify and implement opportunities to restore suitable wetland habitat within ERP nontidal freshwater marsh restoration actions.

DELTA TULE PEA AND DELTA MUDWORT

- Maintain process that support the dynamic habitat of Delta mudwort and Delta tule pea throughout the species range and associated with existing source populations.
- To the extent consistent with CALFED objectives, create unvegetated, exposed substrate at tidal margins of restored and created tidal fresh emergent wetland and riparian habitat.
- Maximize sinuosity of restored and created slough channels to increase water-land edge habitat.
- Monitor existing populations and their habitat at five year intervals.

POINT REYES BIRD'S-BEAK

- Identify and implement restoration of suitable habitat in high marsh and marsh/upland transition areas. Incorporate high marsh and margin suitable habitat in ERP salt marsh restoration programs.
- Maintain and restore Point Reyes bird's-beak around San Pablo Bay in conjunction with restoration of saline emergent wetlands.
- Prepare and implement a management plan to control and reduce non-native weeds near existing and new populations.

DELTA COYOTE-THISTLE

- Survey all extant populations and suitable habitat and update ecological, population, and ownership information.
- Bring at least 10 of the largest, extant, naturally occurring populations found during surveys into permanent protected status.
- Establish and protect new populations in newly created floodplain habitat along the San Joaquin River and associated sloughs in Merced and Stanislaus counties.
- Restore, enhance, and protect suitable habitat near existing populations and avoid impacts on existing populations to the greatest extent practicable during restoration activities.
- Monitor the status and distribution of all (natural and restored) populations at two-year intervals for the duration of CALFED and evaluate the need for active reintroduction into restored and enhanced habitat when natural colonization does not occur. Evaluate appropriate habitat management measures for maintaining suitable habitat.

ROSE MALLOW

- To the extent consistent with ERP objectives, create unvegetated, exposed substrate at tidal margins of restored and created tidal fresh emergent wetland and riparian habitats.
- To the extent consistent with CALFED objectives, incorporate suitable habitat for this species into levee improvement, levee set back, and channel island habitat restoration designs.
- To the extent consistent with ERP objectives, maximize sinuosity of restored and created slough channels to increase water-land edge habitat.

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◆ Inland Dune Special-Status Plant Species

Introduction

Inland dunes are extremely limited to the Delta, occurring only in the vicinity of the Antioch Dunes Ecological Reserve. This habitat supports two plant and one butterfly species listed as endangered under the federal Endangered Species Act. Both plants are State-listed endangered species. Visions are provided here for the two plant species, Antioch Dunes evening-primrose (*Oenothera deltoides* ssp. *howellii*) and Contra Costa wallflower (*Erysimum capitatum* var. *angustatum*).

Species Descriptions

Antioch Dunes evening-primrose. Antioch Dunes evening-primrose is a showy, white-flowered, highly branched perennial herb with grayish toothed or divided leaves. It is a member of the evening primrose family (Onagraceae). Antioch Dunes evening-primrose is both state and federally listed as endangered. Additionally, this species is considered rare, threatened, or endangered in California and elsewhere by the California Native Plant Society (CNPS) (List 1B). Antioch Dunes evening-primrose is endemic to loose sand and stabilized dunes near river margins in the vicinity of Antioch. It is known from only 7 occurrences (Skinner and Pavlik 1994). Most remaining plants occur at the Antioch Dunes National Wildlife Refuge. In 1992, the population size of this species at 2 disjunct sites on the Antioch Dunes was only 1,200 plants (Greene 1994). Attempts have been made to introduce the species to several other locations with remnant dunes, including Brannan Island State Recreation Area in Rio Vista. Antioch dunes evening-primrose evolved from desert flora which occupied the sand dunes of the Sacramento Valley 5,000 to 8,000 years ago (Green 1994). In recent times, dune habitat in the Delta has been lost to conversion to agriculture, sand mining, and industrial development. Present threats include competition for water with ripgut brome (*Bromus diandrus*) and recreational and fire control activities. The recent trend for Antioch Dunes evening-primrose is one of stability, but its total population size and distribution is still very limited (DFG 1991).

Contra Costa wallflower. Contra Costa wallflower, a member of the mustard family (Brassicaceae), is a coarse-stemmed, erect, herbaceous biennial herb with yellowish-orange flowers. Contra Costa wallflower is state and federally listed as endangered and is also on CNPS's List 1B. Contra Costa wallflower co-occurs with Antioch Dunes evening-primrose at the Antioch Dunes NWR, and is known from only 2 occurrences at the Antioch Dunes. It is threatened by factors similar to those affecting Antioch Dunes evening primrose. The wallflower population is surveyed annually and has shown considerable increase since 1978 (DFG 1991).

Visions

The vision for Antioch Dunes evening-primrose is to recover this federally and State-listed endangered species.

The vision for Contra Costa wallflower is to recover this federally and State-listed endangered species.

The overall vision for both species is to protect existing populations and ensure the long-term viability of the species through habitat restoration, enhancement, and appropriate management. Effective management techniques would be developed and employed to protect existing populations. Existing knowledge acquired primarily at the Antioch Dunes Refuge would serve as a basis of establishing effective management techniques. Prescribed burning is an example of a management technique that has been successful in promoting Antioch Dunes evening-primrose colonization. Controlling non-native competitors would also be an element of on-going management for the species. One study showed that removal of ripgut brome near adult Antioch Dunes evening-primrose plants increased seedling germination (Greene 1994).

Establishing additional populations would greatly increase the recovery potential for Antioch Dunes evening-primrose and Contra Costa wallflower. To promote the expansion of the species, historic inland dunes adjacent to existing ecological reserves in the Sacramento-San Joaquin Delta Ecological Zone would be reestablished and species establishment promoted. Sand dune creation techniques developed at the Antioch Dunes would be employed. Protecting and restoring inland dune scrub that serves as habitat for Antioch Dunes evening-primrose and Contra Costa wallflower would be enhanced by identifying areas that are not currently managed for their resource values. Appropriate methods to protect and restore identified areas would be developed. Protected habitat areas would be evaluated to determine effective restoration management practices to increase habitat value. The results of these evaluations would determine how habitat for Antioch Dunes evening-primrose and Contra Costa wallflower would be protected and restored.

Integration with Other Restoration Programs

Efforts to restore habitat for Antioch Dunes evening-primrose and Contra Costa wallflower will involve cooperation with programs managed by the Antioch Dunes National Wildlife Refuge. Cooperation from agencies with responsibility or authority for restoring inland dune habitat will be solicited. These include:

- California Department of Fish and Game,
- U.S. Fish and Wildlife Service,
- U.S. Army Corps of Engineers, and
- the Delta Protection Commission.

Linkage with Other Ecosystem Elements

Antioch Dunes evening-primrose and Contra Costa wallflower are linked with a habitat ecosystem element, inland dune scrub. These species and habitat elements are closely associated with each other and are limited to the area near the Antioch Dunes Ecological Reserve. Non-native plant species are stressors that compete with Antioch Dunes evening-primrose and Contra Costa wallflower for habitat.

Objective, Targets, Actions, and Measures

> The Strategic Objective is to achieve, first, recovery and then large self-sustaining populations of at-risk native species dependent on the Delta, Suisun Bay, and Suisun Marsh.

Species Targets

ANTIOCH DUNES EVENING-PRIMROSE AND CONTRA COSTA WALLFLOWER: Continue protection of and expand the size of these species' Antioch Dunes populations; enhance and restore suitable habitat at and in the vicinity of the Antioch Dunes; and achieve recovery goals identified in the USFWS recovery plan.

LONG-TERM OBJECTIVE: Establish additional self-sustaining populations of Antioch Dunes evening-primrose and Contra Costa wallflower and similar declining endemic species located throughout their original native range in the vicinity of Antioch Dunes.

SHORT-TERM OBJECTIVE: Protect existing populations of the species and restore habitat to provide sites for establishing addition self-sustaining populations.

RATIONALE: The two species listed here are examples of plants that are endemic to Antioch Dunes. Restoration of these species to the point where they were no longer in danger of extinction would indicate that dune restoration and protection projects in the region had succeeded.

STAGE 1 EXPECTATIONS: The status of the two species listed here will have improved. Surveys of present ranges of the species, studies of their ecological requirements, and identification of key restoration sites will have been completed.

Restoration Actions

The general target for the inland dune special-status plant species is to establish and protect a large enough number of populations of each species to maintain genetic diversity, prevent species extinction from localized catastrophic occurrences, and promote the sustainability of each species.

The following actions would contribute to improving the inland dune special-status plant species populations:

- Develop appropriate methods to protect and restore habitat and populations of the inland dune special-status plant species.
- Manage protected areas occupied by the inland dune special-status species to reduce disturbance of dunes and dune vegetation.
- Manage protected areas occupied by the species to promote conditions favorable for the establishment, growth, and vigor of the species. Include management techniques such as prescribed burning and exotic weed control.
- Acquire historic inland dunes adjacent to existing ecological reserves and reestablish dune habitat and inland dune special-status species populations.

MSCS Conservation Measures

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

Antioch Dunes Evening-Primrose and Contra Costa Wallflower

- Coordinate protection and restoration of inland dune scrub habitats with other programs (e.g., U.S. Fish and Wildlife Service recovery plans and management of the Antioch Dunes Preserve) that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Conduct surveys to locate potential habitat restoration sites on Tinnin soils and identify opportunities for and implement permanent protection, restoration, and management of these habitat areas to enhance habitat conditions for these species.
- Enhance and maintain existing populations.
- Annually monitor establishment success and modify establishment and management techniques as needed using adaptive management.

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◆ LANGE'S METALMARK BUTTERFLY

INTRODUCTION

The Lange's metalmark butterfly, a federally listed endangered species are associated with inland dune habitats. The distribution and populations of these species have declined substantially, primarily as a result of the loss or degradation of these habitats within their range. The loss of habitat and declining condition of these species populations have warranted their listing as threatened or endangered under the federal Endangered Species Act.

Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of conversion of native habitats for agricultural, industrial, and urban uses, and land and water management practices that degrade habitats used by these species.

RESOURCE DESCRIPTION

The preferred habitat of Lange's metalmark, a butterfly, is inland dune scrub. The Lange's metalmark is dependent on its host plant, naked buckwheat. The present range of Lange's metalmark has been reduced to about 70 acres of suitable habitat within the Antioch Dunes National Wildlife Refuge and on a few small parcels of privately held land on the eastern flank of the refuge. Over a 9-day sampling period in 1977, biologists estimated that only 400 adult butterflies remain at the Little Corral site. From 1986 to 1991, the population increased exponentially, from approximately 160 butterflies to nearly 2,000. In 1992, the population fell to about one-third of the peak level, but by 1996 had recovered to more that 2,000 butterflies. A wide variety of stressors (e.g., land use, wildfire, non-native plant species, sand mining, fences, and human-related disturbance) that degrade this species' habitat have contributed to the endangered status of Lange's metalmark.

VISION

The vision for the Lange's metalmark butterfly is to recover this federally listed endangered species by increasing the existing Lange's metalmark population distribution and by increasing its abundance.

Protecting existing and restoring additional suitable inland dune scrub habitat will be critical to maintaining and increasing the abundance of the Lange's metalmark population in the Bay-Delta. Habitat restoration in the Sacramento-San Joaquin Delta Ecological Management Zone will help maintain healthy populations by increasing the quality and quantity of this species habitat.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

There are a number of programs that involve these species:

- U.S. Fish and Wildlife Service,
- California Department of Fish and Game (DFG),
- California State Parks and Recreation,
- Riparian Habitat Joint Venture, and
- DFG's Calhoun Cut Reserve.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of these species is integrally linked with restoration of seasonal wetland, riparian, inland dune, perennial aquatic, and grassland habitats in the Central Valley and are adversely influenced by the detrimental effects of invasive plant species.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

The Strategic Objective is to achieve, first, recovery and then large self-sustaining populations of at-risk native species dependent on the Delta, Suisun Bay, and Susiun Marsh.

SPECIES TARGET: Continue protection of and expand the size of the Antioch Dunes population of the Lange's metalmark butterfly; enhance and restore suitable habitat at and in the vicinity of the Antioch

Dunes; and achieve recovery goals identified in the USFWS recovery plan.

LONG-TERM OBJECTIVE: Restore Lange's metalmark butterfly to populations throughout its inland dune scrub habitat, to the point where it can be removed from the federal endangered species list.

SHORT-TERM OBJECTIVE: Create multiple populations of Lange's metalmark butterfly within the Antioch Dunes region.

RATIONALE: Lange's metalmark butterfly is listed as endangered by the federal government because it exists as just one small population in one small protected area, Antioch Dunes Ecological Reserve. The reserve is a remnant of the coastal dune scrub habitat that was once widespread in the Antioch area. This butterfly depends on one host plant species, naked buckwheat, for the survival of its young. Thus protection of this site from disturbance, fires and invasions of exotic plant species is paramount for the survival of the butterfly.

STAGE 1 EXPECTATIONS: The population size and area inhabited by Lange's metalmark butterfly in Antioch Dunes Ecological Reserve will have been increased substantially. Restoration of the native dune scrub plant community and naked buckwheat populations will have continued both in the reserve and in suitable areas outside the reserve.

RESTORATION ACTIONS

The following general targets will assist in meeting the implementation objective:

- Increase the number and distribution of Lange's metalmark.

The following general programmatic actions will assist in meeting the targets:

- Implement control measures to eradicate invasive plant species.
- Increase the amount of inland dune scrub habitat.
- Develop cooperative management strategies with the Antioch Dune Ecological Reserve that protect and manage existing habitat areas.
- Maintain healthy populations of naked buckwheat within inland dune scrub habitats.
- Enhance the formation of active dunes by such means as importing clean sand of appropriate dimensions, reducing stabilizing vegetation, and increasing topographic relief, dune height, and the frequency of steep north/northwest facing erosional slopes with sparse vegetation cover.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Coordinate protection, enhancement, and restoration of inland dune scrub habitat with other federal and state programs (e.g., U.S. Fish and Wildlife Service species recovery plans and management of the Antioch Dunes Preserve) that could affect management of current and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Conduct surveys to locate potential habitat restoration sites on Tinnin soils and identify opportunities for and implement permanent protection, restoration, and management of these habitat areas to enhance habitat conditions for the Lange's metalmark.
- Monitor enhanced and restored habitat areas to determine the success of enhancement and restoration methods, and to determine the response of Lange's metalmark populations and management.

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◆ VALLEY ELDERBERRY LONGHORN BEETLE

INTRODUCTION

The valley elderberry longhorn beetle (VELB) is a federally listed threatened species associated with riparian habitats. The distribution and populations of this species has declined substantially, primarily as a result of the loss or degradation of habitat within its range. The loss of habitat and declining condition of these species populations have warranted their listing as threatened or endangered under the federal Endangered Species Act.

Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of conversion of native habitats for agricultural, industrial, and urban uses, and land and water management practices that degrade habitats used by these species.

RESOURCE DESCRIPTION

VELB has been found only in association with its host plant, elderberry (*Sambucus* spp.). Elderberry is a component of the remaining riparian forests and adjacent grasslands of the Central Valley. Entomologists estimate that the range of this beetle extends from Redding at the northern end of the Central Valley to the Bakersfield area in the south. Important stressors on VELB are fragmentation of riparian habitat; grazing; and excessive collection of the species for commercial, recreational, scientific, or educational purposes. Local populations can also be severely damaged by pesticides inadvertently drifting from nearby agricultural lands into occupied habitat areas.

VISION

The vision for VELB is to assist in the recovery of the VELB by increasing its populations and abundance through habitat restoration.

Protecting existing and restoring additional suitable riparian habitats and establishing new populations will be critical to recovery of the VELB in the Bay-Delta. Restoration of riparian habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will help maintain healthy populations by increasing the quality and quantity of habitats used by these species.

The period required to achieve recovery of the VELB could be reduced by introducing the species into unoccupied or restored habitat areas. Such a strategy could be implemented through cooperative agreements with land management agencies or cooperative agreements with willing landowners. The VELB would also benefit from development and implementation of alternative designs for and maintenance of flood control, bank protection, and other structures that reduce their potential adverse effects on existing riparian habitats.

Restoration of ecosystem processes and habitats in other ecological management zones will also allow riparian vegetation to develop that will provide habitat for these species elsewhere in the Central Valley. The benefit of these restorations for recovery of the VELB would be increased by implementing restoration of riparian habitats in a manner that links isolated areas supporting existing VELB populations.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

There are a number of programs that involve these species:

- U.S. Fish and Wildlife Service,
- California Department of Fish and Game (DFG),
- California State Parks and Recreation,
- Riparian Habitat Joint Venture.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of these species is integrally linked with restoration of seasonal wetland, riparian, inland dune, perennial aquatic, and grassland habitats in the Central Valley and are adversely influenced by the detrimental effects of invasive plant species.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

> The Strategic Objective is to achieve, first, recovery and then large self-sustaining populations of at-risk native species dependent on the Delta, Suisun Bay, and Suisun Marsh.

SPECIES TARGET: Maintain and restore connectivity among riparian habitats occupied by the valley elderberry longhorn beetle and within its historic range along the Sacramento and San Joaquin rivers and their major tributaries.

LONG-TERM OBJECTIVE: Restore riparian habitat throughout the Central Valley that includes components (i.e., elderberry thickets) suitable for populations of valley elderberry beetle throughout its native range.

SHORT-TERM OBJECTIVE: Contribute to recovery of this species as defined in the Valley Elderberry Longhorn Beetle Recovery Plan (U.S. Fish and Wildlife Service 1984) by restoring habitat for the species in riparian restoration projects in its native range where feasible.

RATIONALE: The valley elderberry longhorn beetle is a federally listed threatened species, although its status and factors limiting its populations are poorly understood. These beetles depend on elderberry bushes for breeding and rearing of young and will sometimes occupy bushes growing in degraded habitat (e.g., levees). Presumably, its populations will respond positively to riparian restoration projects in the Central Valley and Delta.

STAGE 1 EXPECTATIONS: A program will have been developed to minimize clearing of levees or additional habitats will have been developed to offset levee maintenance practices and existing habitat will have been maintained. A comprehensive study will have been completed to locate populations of the beetle and assess their population size. A program will have been implemented to maintain existing habitat and plant new elderberry bushes where possible, particulary in conjunction with the restoration or riparian and riverine aquatic habitats.

RESTORATION ACTIONS

The following general targets will assist in meeting the Strategic Objective:

- Increase the numbers and distribution of valley elderberry longhorn beetle.

The following general programmatic actions will assist in meeting the targets:

- Protect and restore wetland, riparian, and grassland habitat.
- Implement control measures to eradicate invasive plant species.
- Reduce land and water management practices that degrade habitats used by these species.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Coordinate protection and restoration of riparian habitats with other federal and state programs (e.g., U.S. Fish and Wildlife Service recovery plans, the SB 1086 program, and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of occupied and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Within the species current range, design ERP riparian habitat enhancements and restorations to include suitable riparian edge habitat, including elderberry savanna.
- Initially direct ERP riparian habitat actions towards enhancement and restoration of habitat areas located near occupied habitat to encourage the natural expansion of the species range.
- Include sufficient buffer habitat around suitable restored and enhanced habitat areas within the species' range to reduce potential adverse effects associated with pesticide drift.

REFERENCES

Multi-Species Conservation Strategy. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

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◆ SUISUN ORNATE SHREW

INTRODUCTION

The Suisun shrew, a subspecies of the ornate shrew, is a federal species of concern and is also listed as a California Department of Fish and Game Species of Concern. Historically, this species inhabited tidal marshes ranging from San Pablo and Suisun Bays to Grizzly Island and as far west as the mouth of Sonoma Creek, Petaluma River, and Tubbs Island. Most of the shrew's range today exists in the tidal marshes of Suisun Bay.

The primary factor affecting the Suisun shrew is habitat degradation. The shrew prefers tidal wetland to diked or managed wetlands and therefore is limited in its range.

RESOURCE DESCRIPTION

The Suisun shrew typically inhabits tidal salt marsh with adjoining upland areas where they can seek shelter during high tides and flooding. They only occur where dense foliage and driftwood can be used for nesting material and foraging. In addition, the shrew prefers areas where the soil moisture is constant. An upland component to their habitat requirements is necessary to avoid inundation during rising tides. The structure of the vegetation that occurs in their habitat may be more important than species composition. When tides are high and the ground is wet the shrew travels above ground, in the vegetation. Therefore, vegetation needs to be thick enough to provide cover for an escape corridor. The Suisun ornate shrew is an insectivore and additional diet items include crustaceans.

With the development of the Suisun Marsh came the construction of dikes and levees for flood control and protection of lands reclaimed for uses such as agriculture. These reclaimed areas supported livestock grazing, and crops such as asparagus and grain. As more and more lands were converted to agriculture, more and more habitat loss occurred which allowed for severe fragmentation of the habitat that remained. Barriers, such as roads also added to fragmentation of the remaining habitat. Development altered the landscape and geomorphology in many of these areas, which contributed to the loss of habitat.

Tidal marshes occur within the Suisun Marsh/North San Francisco Bay Ecological Management Zone of the ERP area. The elimination of much of Suisun shrew's habitat is the primary cause of the species' decline. Other factors that have contributed to the decline or potentially could inhibit the recovery of the species include human activities that disturb the species and predation by non-native species. Grazing; water management practices; land use practices; contaminants; and human-made structures, such as dikes and levees, continue to degrade the quality of remaining habitat areas.

VISION

The vision for the Suisun ornate shrew is to recover this California species of species concern and contribute to the overall species richness and diversity.

Achieving this vision will reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta.

Protecting existing suitable habitat areas from potential activities that could adversely affect the Suisun shrew could be achieved through cooperative agreements with land management agencies, conservation easements, or purchase from willing sellers. Restoration of adjacent upland habitat will help to recover this species by increasing habitat area. Uplands provide the shrew with refuge from flooding.

Reducing the factors that contribute to degradation of marshes would promote natural restoration and maintenance. Increasing the quantity and quality of Suisun shrew habitat and reducing the adverse effects of stressors would establish conditions necessary to maintain existing populations and allow them to recover naturally.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Existing restoration programs that could benefit the Suisun shrew are:

- Suisun Marsh Recovery Plan

- San Francisco Bay Joint Venture
- Bay Area Wetlands Planning Group
- California Costal Conservancy
- Delta Native Fishes Recovery Plan
- California Department of Fish and Game Delta/Bay Enhanced Enforcement Program
- Grizzly Island Wildlife Area
- National Estuarine Reserve Research System
- North Bay Wetlands Protection Program
- San Francisco Bay National Wildlife Refuge
- Tidal Wetlands Species Recovery Plan, and
- San Francisco Bay Area Wetlands Ecosystem Goals Project.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoring tidal habitat to increase populations of the Suisun shrew would benefit the other species found in this habitat. These species include the salt marsh harvest mouse and wading and shorebirds.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

> The Strategic Objective is to achieve, first, recovery and then large self-sustaining populations of at-risk native species dependent on the Delta, Suisun Bay, and Suisun Marsh.

SPECIES TARGET: Maintain the current distribution and existing populations of the Suisun ornate shrew, and reestablish and maintain viable species' populations throughout its historic range in the portion of the Bay Region within the ERP focus area.

LONG-TERM OBJECTIVE: Restore Suisun ornate shrew to tidal wetland habitats throughout its native range.

SHORT-TERM OBJECTIVE: Identify the remaining populations of Suisun ornate shrew and develop a conservation plan to stop the decline of this species.

RATIONALE: The Suisun ornate shrew is a listed as a species of special concern by the California Department of Fish and Game, but its limited habitat and distribution indicate it may qualify as a threatened species. Long-term survival of this subspecies is dependent upon tidal wetland, as opposed to diked wetlands, and has to have adequate physical structures and plant communities for survival. Its tidal marsh habitat has to have adjacent upland habitat for survival of the species during periods when the marsh is inundated. The upland habitat has to have relatively low densities of exotic predators. Restoring habitat would not only benefit the Suisun ornate shrew but other species, such as the salt marsh harvest mouse, that also use tidal marsh and upland marsh habitats.

STAGE 1 EXPECTATIONS: All remaining populations of Suisun ornate shrew will have been identified and protection/restoration plans developed and implemented.

RESTORATION ACTIONS

The following general programmatic actions will assist in the recovery of the Suisun ornate shrew.

- restore saline emergent wetland and transitional habitats in the Suisun Marsh/North San Francisco Bay Ecological Management Zone.
- enhance existing saline emergent wetlands and improve connectivity between wetlands.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve Suisun ornate shrew habitat or population targets.

- The geographic priorities for implementing actions to protect, enhance, and restore saline emergent wetlands and associated habitats for the California clapper rail should be: 1) western Suisun Marsh, 2) Napa Marshes, and eastern

Suisun Marshes, 3) Sonoma Marshes, Petaluma Marshes and Highway 37 marshes west of Sonoma Creek.

- Coordinate protection, enhancement, and restoration of saltmarsh and associated habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, and USFWS species recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Initial species recovery efforts should be directed to locations where there are immediate opportunities for protection, enhancement, or restoration of suitable habitat.
- To the extent practicable, direct ERP salt marsh enhancement efforts towards existing degraded marshes that are of sufficient size and configuration to develop fourth order tidal channels (marshes would likely need to be at least 1,000 acres in size).
- Restore wetland and perennial grassland habitats adjacent to occupied habitats to create a buffer of natural habitat to protect populations from adverse affects that could be associated with future changes in land use on nearby lands and to provide habitat suitable for the natural expansion of populations.
- To the extent practicable, design salt marsh enhancements and restorations to provide low-angle upland slopes at the upper edge of marshes to provide for the establishment of suitable and sufficient wetland to upland transition habitat. Transition habitat zones should be at least 0.25 mile in width.
- Manage enhanced and restored habitat areas to avoid or minimize impacts on the Suisun ornate shrew associated with recreational uses on lands acquired or managed under conservation easements.
- Direct salt marsh habitat enhancements and restorations towards increasing habitat connectivity among existing and restored tidal marshes within the range of the Suisun ornate shrew.
- To the extent practicable, design dikes constructed in enhanced and restored saline emergent wetlands to provide optimal wetland to upland transitional habitat.
- Identify and implement feasible methods for controlling invasive non-native marsh plants.
- Provide interim management of occupied saltmarshes to maintain source populations until restored habitats have developed sufficiently to provide suitable habitat.
- Provide interim management of occupied salt marshes to maintain source populations until restored habitats have developed sufficiently to provide suitable habitat.
- Acquire conservation easements to adjust grazing regimes to enhance wetland to upland transition habitat conditions in occupied habitat areas.
- Conduct research to determine use of restored salt marsh habitats by Suisun ornate shrews and the rate at which restored habitats are colonized.

REFERENCES

Multi-Species Conservation Strategy. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

INTRODUCTION

Suisun song sparrows live only in and around the Suisun Marsh and Bay. The Suisun song sparrow is associated with saline emergent wetlands. The population and distribution of this species have declined substantially primarily as a result of reclamation of tidal saltmarshes. The loss of habitat and declining condition of this species' population have warranted its inclusion as a species of special concern. Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of historical and current loss or degradation of tidal saltmarshes for agricultural, industrial, and urban uses and excessive predation on nests and individuals by non-native predators.

RESOURCE DESCRIPTION

Historically, much of the Suisun Marsh was a brackish tidal marsh. The Suisun song sparrow inhabited areas with suitable brackish marsh vegetation. The total area of historical tidal marsh habitat is estimated to have been about 66,600-73,700 acres. Between 70,000 and 77,000 pairs of Suisun song sparrows are estimated to have used the available marsh habitat annually. Recent estimates indicate that fewer than 6,000 pairs remain in 13 isolated populations, representing 8% of the species' former abundance. The remaining 13 populations number from about 1,300 pairs to about 20 pairs.

Since artificial levees were constructed beginning in the late 1800s, the managed marsh areas on the nontidal side of the levees are flooded seasonally and then drained or allowed to dry. These areas are consistently avoided by Suisun song sparrows. The birds require appropriate vegetation for nesting sites, song perches, and foraging cover. The vegetation must also produce seeds or harbor invertebrates that the birds pick up from the surface of mudflats. Each sparrow's territory must contain permanent water or moisture in the form of tidal ebb and flow. Typically, each territory contains at least one patch of tall, hard-stemmed bulrush that stands above the surrounding vegetation and is used as a singing perch. The birds apparently need these high song perches to establish territory, and the absence of song perches may be a limiting factor in the distribution of pairs.

The Suisun song sparrow is physiologically and behaviorally adapted to this area's naturally occurring brackish tidal conditions. It can drink brackish water and breeds earlier than upland subspecies. Early breeding avoids nest flooding during the highest spring tides. The Suisun song sparrow forages for invertebrates and seeds directly on the surface of mudflats.

The primary threat to the continued existence of the Suisun song sparrow is the continuing loss of habitat and severe fragmentation of brackish tidal marsh habitat in and around Suisun Marsh. The once-vast marsh has been reduced to small areas that are separated by barriers or connected only by narrow strips of vegetation along the banks of tidal sloughs. Interbreeding between populations in these areas is rare. As the southern shore of Suisun Marsh in Contra Costa County becomes increasingly industrialized and developed, habitat will continue to be degraded and, ultimately, the southern population may no longer be viable. Egg and nestling mortality is about 50% in the first 3 weeks after eggs are laid. The primary causes of this mortality are predation on eggs and nestlings by the introduced Norway rat, predation on nestlings by feral house cats, and flooding of nests during periods of high tides. Maintenance of levees, dikes, and other structures during the breeding period may also create sufficient disturbance to cause nesting failure. Levees constructed in the sparrow's habitat are high enough above the surrounding marsh to allow the growth of upland plants that require fresh water. Although Suisun song sparrow territories may include these areas, the species avoids centering its territory in this type of vegetation.

Long-term changes in the salinity gradient of the Bay-Delta may also have an effect on the species' distribution and abundance. The normal brackish condition of Suisun Marsh is directly attributable to the amount of freshwater outflow it receives from the Delta. This fresh water mixes with saltwater transported on incoming tides through Carquinez Strait. The amount of freshwater outflow has been reduced since historical times during water-years that are now considered normal. Suisun song sparrows can withstand short-term alterations in brackish conditions because they can subsist on pure saltwater for several days. The vegetation they occupy in the brackish marsh is similarly adapted. If the water regime changes drastically or for long periods, however, a large-scale change in habitat could result. If salinity decreases, the Suisun song sparrow could face lowered reproductive rates, increased competition, and loss of genetic integrity as a result of breeding with invading upland subspecies that consume fresh water. If the water becomes too salty, saltwater marsh vegetation could displace brackish vegetation; saltwater marsh is not suitable habitat for the species, which is not adapted to consume saltwater for extended periods.

VISION

The vision for the Suisun song sparrow is to recover this California species of special concern in Suisun Marsh and the western Delta and contribute to the overall species richness and diversity. Achieving this vision will reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta.

Protecting and restoring existing and additional suitable tidal saline and fresh emergent wetlands (including brackish marshes) and reducing breeding stressors will be critical to the recovery of the Suisun song sparrow.

Restoration of tidal emergent wetlands in the Suisun Marsh/North San Francisco Bay Ecological Management Zone will help to recover this species by increasing its habitat area. Restoring associated higher elevation uplands would provide escape cover during high tides and flooding. Restoring these habitats would allow the population to increase at existing protected habitat areas and would ensure long-term survival. The restoration of high-quality sparrow habitat would also reduce the adverse effects of predation by non-native species by creating habitat conditions that are more favorable for sparrows and less favorable for predators.

The potential adverse effects of disturbance on breeding success could be reduced by encouraging agencies, organizations, and private landowners, through cooperative agreements and incentive programs, to conduct infrastructure maintenance activities in occupied habitat areas so that tidal brackish marsh vegetation is disturbed as little as possible and adults are not disturbed during the breeding season. The possibility of managing breeding of the species to increase its reproductive success should be investigated (e.g., transferring eggs and/or young between nearby isolated populations to increase genetic interchange between populations). If the species responds favorably to such manipulations, the period for its recovery would be reduced.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Programs and projects designed to protect, restore, and enhance the Suisun Marsh/North San Francisco Bay Ecological Management Zone to provide direct or incidental benefits to the Suisun song sparrow include:

- San Francisco Estuary Project,
- San Francisco Bay Area Wetlands Ecosystem Goals Project.
- Cache Creek Corridor Restoration Plan,
- California Wetland Riparian Geographic Information System Project,
- Governor's California Wetland Conservation Policy,
- Tidal Wetlands Species Recovery Plan,
- Wetlands Reserve Program,
- Inland Wetlands Conservation Program,
- Montezuma Wetlands Project, and
- National Estuarine Reserve Research System.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of the Suisun Song Sparrow is integrally linked with restoring tidal permanent emergent wetlands in Suisun Bay and Marsh and the western Delta. Restoration of adjacent tidal perennial aquatic habitat, particularly mudflats, is also important.

Objective, Target, Actions, and Measures

The Strategic Objective is to achieve, first, recovery and then large self-sustaining populations of at-risk native species dependent on the Delta, Suisun Bay, and Suisun Marsh.

Species Target: Maintain the current distribution and existing populations of the Suisun song sparrow and reestablish and maintain viable species' populations throughout its historic range in the portion of the Delta and Bay Regions within the ERP focus area.

Long-Term Objective: Restore populations of Suisun song sparrow to habitats throughout its native range by creating/restoring enough brackish tidal marsh habitat to support 40,000 nesting pairs.

Short-Term Objective: With existing populations, find ways to connect fragmented brackish and freshwater habitats to increase the gene flow among population segments and reduce the likelihood of extirpation of isolated population segments.

Rationale: The Suisun song sparrow occurs only in and near Suisun Marsh, in about 13 isolated populations. Populations of this unusual subspecies are declining for a variety of reasons but mainly the degradation of their habitat. Reductions in fresh water outflow from the Sacramento-San Joaquin Rivers and diking and channelization of marsh lands have contributed to their decline. Restoration of their populations is likely to be a good indicator of the success of restoration of brackish tidal marshes in the Suisun Marsh area.

Stage 1 Expectations: All Suisun song sparrow populations will have been identified and protected from further development and habitat alterations; plans will have been developed and implemented to connect isolated populations by means of habitat restoration projects.

Restoration Actions

The following general targets will assist in meeting the implementation objective:

- Increase the total number of pairs.
- Increase the number of pairs in each of the 13 isolated populations.
- Increase the number of populations.
- Reduce the extent of isolation among the populations.

The following general programmatic actions will assist in meeting the targets:

- Increase the amount of tidal brackish water marshes in Suisun Bay and Marsh and in the western Delta.
- Decrease the extent of isolation of remaining tidal marshes in Suisun Bay and Marsh and the western Delta.
- Increase the amount of grassland habitat adjacent to tidal marshes in Suisun Bay and Marsh and the western Delta.
- Within existing and restored marshes ensure presence of tall, hard-stemmed bulrush stands.
- Increase the area of tidal mudflats in close proximity to existing and restored marshes.

MSCS Conservation Measures

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve Suisun song sparrow habitat or population targets. The intent of these conservation measures is to reduce the risk of current and imminent threats to maintaining the current distribution and existing populations of the Suisun song sparrow and reestablish and maintain viable species' populations throughout its historic range in the portion of the Bay Region within the ERP focus area and the Delta Region.

- The geographic priorities for implementing ERP actions to protect, enhance, and restore saline emergent wetlands and associated habitats for the Suisun song sparrow should be: 1) western Suisun Marsh, 2) eastern Suisun Marsh, and 3) the Contra Costa County shoreline.

- Coordinate protection, enhancement, and restoration of saltmarsh and associated habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, and USFWS species recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Restore wetland and perennial grassland habitats adjacent to occupied nesting habitats to create a buffer of natural habitat to protect nesting pairs from potential adverse affects that could be associated with future changes in land use on nearby lands and to provide suitable foraging habitat and nesting habitat area suitable for the natural expansion of populations.
- Initial species recovery efforts should be directed to locations where there are immediate opportunities for protection, enhancement, or restoration of suitable habitat.
- To the extent practicable, design dikes constructed in enhanced and restored saline emergent wetlands to provide optimal wetland to upland transitional habitat.
- To the extent practicable, direct ERP salt marsh enhancement efforts towards existing degraded marshes that are of sufficient size and configuration that are large enough to develop fourth order tidal channels (marshes would likely need to be at least 1,000 acres in size).
- Design salt marsh enhancements and restorations to provide low-angle upland slopes at the upper edge of marshes to provide for the establishment of suitable and sufficient wetland to upland transition habitat. To the extent feasible, transition habitat zones should be at least 0.25 mile in width.
- Control non-native plants in existing salt marshes where non-native plants have degraded habitat quality and in salt marshes restored under the ERP.
- Manage enhanced and restored habitat areas to avoid or minimize potential impacts associated with recreational uses on lands acquired or managed under conservation easements on the Suisun song sparrow.
- Direct salt marsh habitat enhancements and restorations towards increasing habitat connectivity among existing occupied and restored tidal marshes.
- To the extent practicable, direct ERP restorations to improve tidal circulation to diked wetlands that currently sustain partial tidal exchange.
- To the extent practicable, control non-native predator populations in occupied habitat areas and salt marshes enhanced and restored under the ERP.
- Identify and implement feasible methods for controlling invasive non-native marsh plants.
- Conduct research to determine use of restored salt marsh habitats by Suisun song sparrows and the rate at which restored habitats are colonized.
- Acquire conservation easements to adjust grazing regimes to enhance wetland to upland transition habitat conditions.

REFERENCES

Multi-Species Conservation Strategy. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

◆ San Pablo Song Sparrow

Introduction

San Pablo song sparrows live only in and around the North San Francisco Bay. The San Pablo song sparrow is associated with saline emergent wetlands. The population and distribution of this species have declined substantially primarily as a result of reclamation of tidal saltmarshes. The loss of habitat and declining condition of this species' population have warranted its inclusion as a species of special concern by the California Department of Fish and Game.

Resource Description

The current range of the San Pablo song sparrow is reduced from its historical rang. It was once wide spread from Richardson Bay to San Rafael Bay; now only occurring in extreme western Richardson Bay, along Madera Creek, and along the souther end of San Rafael Creek. In the norther portion of San Pablo Bay, this sparrow also occurs in the marshes of Petaluma, Sonoma, and Napa rivers. In the southern portion of the bay, the San Pablo song sparrow occurs at Wilson Point and Pinole Point, and at the mouths of San Pablo Creek and Wildcat Creek (Jurek 1974).

The San Pablo song sparrow inhabits the tidal flats of San Pablo Bay. This sparrow is often associated with grindelia bushes, which it utilizes for nesting sites, song posts, and refuge from high tides. Nests are often built in a singular linear row in shrubs high enough to escape high tides (Walton 1975). This sparrow forages for seeds and insects on mudflats, at the water's edge, and under shrubs (Grinnell and Miller 1944).

Vision

The vision for the San Pablo song sparrow is to recover this California species of special concern in the North Bay and contribute to the overall species richness and diversity.

Protecting and restoring existing and additional suitable tidal saline and fresh emergent wetlands (including brackish marshes) and reducing breeding stressors will be critical to the recovery of the San Pablo song sparrow.

Restoration of tidal emergent wetlands in the Suisun Marsh/North San Francisco Bay Ecological Management Zone will help to recover this species by increasing its habitat area. Restoring associated higher elevation uplands would provide escape cover during high tides and flooding. Restoring these habitats would allow the population to increase at existing protected habitat areas and would ensure long-term survival. The restoration of high-quality sparrow habitat would also reduce the adverse effects of predation by non-native species by creating habitat conditions that are more favorable for sparrows and less favorable for predators.

The potential adverse effects of disturbance on breeding success could be reduced by encouraging agencies, organizations, and private landowners, through cooperative agreements and incentive programs, to conduct infrastructure maintenance activities in occupied habitat areas so that tidal brackish marsh vegetation is disturbed as little as possible and adults are not disturbed during the breeding season. The possibility of managing breeding of the species to increase its reproductive success should be investigated (e.g., transferring eggs and/or young between nearby isolated populations to increase genetic interchange between populations). If the species responds favorably to such manipulations, the period for its recovery would be reduced.

Integration with Other Restoration Programs

Programs and projects designed to protect, restore, and enhance the Suisun Marsh/North San Francisco Bay Ecological Management Zone to provide direct or incidental benefits to the San Pablo song sparrow include:

- San Francisco Estuary Project,
- San Francisco Bay Area Wetlands Ecosystem Goals Project.
- California Wetland Riparian Geographic Information System Project,

- Governor's California Wetland Conservation Policy,
- Tidal Wetlands Species Recovery Plan,
- Wetlands Reserve Program,
- Inland Wetlands Conservation Program,
- National Estuarine Reserve Research System.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of the San Pablo Song Sparrow is integrally linked with restoring tidal permanent emergent wetlands in the North Bay. Restoration of adjacent tidal perennial aquatic habitat, particularly mudflats, is also important.

OBJECTIVE, TARGET, ACTIONS, AND MEASURES

The Strategic Objective is to achieve, first, recovery and then large self-sustaining populations of at-risk native species dependent on the Delta, Suisun Bay, and Suisun Marsh.

SPECIES TARGET: Maintain the current distribution and existing populations of the San Pablo song sparrow and reestablish and maintain viable species' populations throughout its historic range in the portion of the Bay Region within the ERP focus area.

LONG-TERM OBJECTIVE: Reduce the risk of current and imminent threats to maintaining the current distribution and existing populations of the San Pablo song sparrow and reestablish and maintain viable species' populations throughout its historic range in the portion of the Bay Region within the ERP focus area.

SHORT-TERM OBJECTIVE: With existing populations, find ways to connect fragmented brackish and freshwater habitats to increase the gene flow among population segments and reduce the likelihood of extirpation of isolated population segments.

RATIONALE: Populations of this unusual subspecies are declining for a variety of reasons but mainly the degradation of their habitat. Reductions in fresh water outflow from the Sacramento-San Joaquin Rivers and diking and channelization of marsh lands have contributed to their decline. Restoration of their populations is likely to be a good indicator of the success of restoration of brackish tidal marshes in the North Bay Region.

STAGE 1 EXPECTATIONS: All San Pablo song sparrow populations will have been identified and protected from further development and habitat alterations; plans will have been developed and implemented to connect isolated populations by means of habitat restoration projects.

RESTORATION ACTIONS

The following general targets will assist in meeting the implementation objective:

- Increase the total number of pairs.
- Increase the number of populations.
- Reduce the extent of isolation among the populations.

The following general programmatic actions will assist in the recovery of the San Pablo song sparrow:

- Increase the amount of tidal brackish water marshes in the North Bay Region.
- Decrease the extent of isolation of remaining tidal marshes in the North Bay Region.
- Increase the amount of grassland habitat adjacent to tidal marshes in the North Bay Region.
- Within existing and restored marshes ensure presence of tall, hard-stemmed bulrush stands.
- Increase the area of tidal mudflats in close proximity to existing and restored marshes.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve San Pablo song sparrow habitat or population targets. The intent of these conservation measures is to reduce the risk of current and imminent threats to maintaining the current distribution and existing populations of the San Pablo song sparrow and reestablish and maintain viable species' populations throughout its historic range in the portion of the Bay Region within the ERP focus area and the Delta Region.

- The geographic priorities for implementing ERP actions to protect, enhance, and restore saline emergent wetlands and associated habitats for the San Pablo song sparrow should be: 1) Gallinas/Ignacio marshes and Napa Marshes, 2) Sonoma Marshes, Petaluma Marshes, and Highway 37 marshes west of Sonoma Creek, 3) Point Pinole Marshes, 4) Highway 37 marshes east of Sonoma Creek,
- Coordinate protection, enhancement, and restoration of saltmarsh and associated habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, and USFWS species recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Restore wetland and perennial grassland habitats adjacent to occupied nesting habitats to create a buffer of natural habitat to protect nesting pairs from adverse affects that could be associated with future changes in land use on nearby lands and to provide suitable foraging habitat and nesting habitat area suitable for the natural expansion of populations.
- Initial species recovery efforts should be directed to locations where there are immediate opportunities for protection, enhancement, or restoration of suitable habitat.
- Design dikes constructed in enhanced and restored saline emergent wetlands to provide optimal wetland to upland transitional habitat.
- To the extent practicable, direct ERP salt marsh enhancement efforts towards existing degraded marshes that are of sufficient size and configuration to develop fourth order tidal channels (marshes would likely need to be at least 1,000 acres in size).
- To the extent practicable design salt marsh enhancements and restorations to provide low-angle upland slopes at the upper edge of marshes to provide for the establishment of suitable and sufficient wetland to upland transition habitat. Transition habitat zones should be at least 0.25 mile in width.
- Manage enhanced and restored habitat areas to avoid or minimize impacts on the San Pablo song sparrow associated with recreational uses on lands acquired or managed under conservation easements.
- To the extent practicable, control non-native predator populations in occupied habitat areas and salt marshes enhanced and restored under the ERP.
- Identify and implement feasible methods for controlling invasive non-native marsh plants.
- Conduct research to determine use of restored salt marsh habitats by San Pablo song sparrows and the rate at which restored habitats are colonized.

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◆ Species Designated for Contribute to Recovery

Introduction

The Strategic Plan for Ecosystem Restoration presents 6 goals to guide the implementation of restoration actions during the 20-30 year program.

The first Strategic Goal focuses on at-risk species:

This section addresses those species designated as "Contribute to Recovery" in the MSCS and ERP.

> *STRATEGIC GOAL 1: Achieve, first, recovery and then large self-sustaining populations of at-risk native species dependent on the Delta and Suisun Bay; support similar recovery of at-risk native species in the Bay-Delta estuary and its watershed; and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed.*

Contribute to Recovery Designation

CONTRIBUTE TO RECOVERY ("r"): For species designated "r," CALFED will make specific contributions toward the recovery of the species. The goal "contribute to recovery" was assigned to species for which CALFED Program actions affect only a limited portion of the species range and/or CALFED Program actions have limited effects on the species.

To achieve the goal of contributing to a species' recovery, CALFED is expected to undertake some of the actions under its control and within its scope that are necessary to recovery the species. When a species has a recovery plan, CALFED may implement some of the measures identified in the plan, that are within the CALFED Problem Area, and some measures that are outside the Problem Area. For species without a recovery plan, CALFED would need to implement specific measures that would benefit the species.

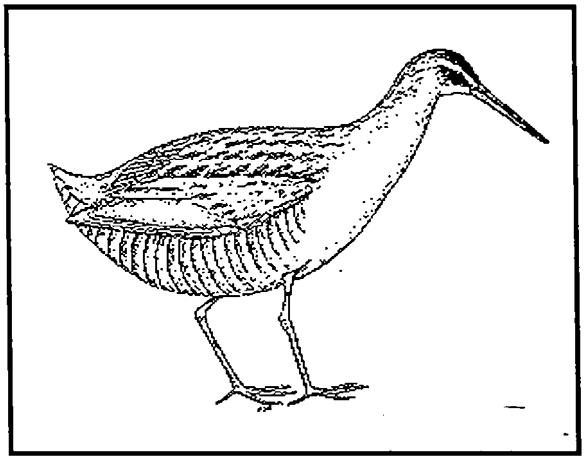
The "contribute to recovery" species addressed in this section include:

- California clapper rail
- California black rail
- Swainson's hawk
- salt marsh harvest mouse
- San Pablo California vole
- riparian brush rabbit
- San Joaquin Valley woodrat
- Sacramento perch
- giant garter snake
- greater sandhill crane
- California yellow warbler
- little willow flycatcher
- western yellow-billed cuckoo
- least Bell's vireo
- saltmarsh common yellowthroat
- bank swallow
- Delta green ground beetle
- bristly sedge*
- delta tule pea*
- delta mudwort*
- alkali milk-vetch*
- Point Reyes bird's-beak*,
- delta coyote thistle*,
- alkali milk-vetch**, and
- Crampton's tuctoria**.

* Denotes species which were described previously in the vision for tidal brackish and freshwater marsh special-status plant species and inland dune special status plants.

** Denotes species which are described in the vision for vernal pools special-status plant species.

> Note: the use of Species Targets in this section is synonymous with the Species Goal Prescriptions provided in the Multi-Species Conservation Strategy.



INTRODUCTION

The clapper rail is a year-long resident in coastal wetlands and brackish areas around San Francisco Bay. Within the Central Valley, this species is found only in the Suisun Marsh/North San Francisco Bay Ecological Management Zone. The California clapper rail is associated with saline emergent wetlands. The population and distribution of this species have declined substantially, primarily as a result of reclamation of its tidal saltmarsh habitats. The loss of habitat and declining condition of the species' population have warranted its listing as endangered under the State and federal Endangered Species Acts. This species characteristically inhabits the more saline marshes of the Bay. Highest population densities are associated with large tidal marsh areas with well-developed channel systems (Goals Project 1999).

Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of historical and current loss or degradation of tidal saltmarshes for agricultural, industrial, and urban uses, and excessive predation on nests and individuals by non-native predators.

RESOURCE DESCRIPTION

Habitat loss is largely a result of reclamation for agricultural, industrial, and urban uses and water management projects. Populations have also been limited due to loss or degradation of tidal saltmarshes for waterfowl hunting and management. The total area of these remaining habitats represents only a small percentage of their historic level. The California clapper rail breeds from February through August. The preferred habitat is saline tidal marshes but are known to use brackish marsh areas with alkali bulrush. It builds a platform nest concealed by a canopy of cordgrasses and pickleweed. It may also use cattails and bulrushes in fresh emergent wetland habitats although these area are not considered suitable foraging and breeding habitat. Adjacent upper wetland or upland habitat with aquatic vegetation are also important because they provide nesting and escape cover during high tides and floodwaters.

Significant loss of saline and brackish emergent wetland habitat and associated upland habitats and high marshes is the primary factor for the decline in this species' populations. These habitat losses have reduced populations sufficiently that predation by non-native species, such as the Norway rat, red fox, and feral cats; swamping of nests by boat wakes; and contaminants, such as selenium, are now also substantial factors affecting the ability of the species to recover.

VISION

The vision for the California clapper rail is to contribute to the recovery of this State- and federally listed endangered species to contribute to overall species richness and diversity.

Achieving this vision will reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.

Protecting existing and restoring additional suitable saline and brackish emergent wetlands and adjacent higher elevation habitats and reducing the effect of other factors that can suppress breeding success will be critical to the recovery of the California clapper rail. The Suisun Marsh and San Francisco Bay areas once comprised a mosaic of large contiguous blocks of tidal saline emergent wetland in association with adjacent upland habitats. Restoration of saline and brackish emergent wetland and associated upland habitats in the Suisun Marsh/North San Francisco Bay Ecological Management Zone will help the recovery of this species by increasing habitat area.

Upland cover could be improved by providing incentives to farmers to allow natural vegetation to reclaim portions of the upland habitat adjacent to tidal wetlands.

Clapper rail habitat utilization in Suisun Marsh and the Napa Marshes suggest that a natural network of small tidal creeks which begin high in the marsh and grade down into large tidal sloughs and bays are essential habitat components for successful breeding populations. Improved habitat would also include water quality levels and other components necessary to support isopods, arthropods, mollusks, and insects on which clapper rails forage. These components could be provided by developing and implementing a program to reduce the level of toxins that adversely affect clapper rail populations in the Bay-Delta. Clapper rail breeding success could be improved by reducing the adverse effects of boat wakes on nests during the February through August breeding period. Restoring high-quality clapper rail habitat would also reduce the adverse effects of predation by non-native species by creating habitat conditions that are more favorable for rails and less favorable for predators.

Improved habitat would also include water quality levels and other components necessary to support isopods, arthropods, mollusks, and insects on which clapper rails forage. These components could be provided by developing and implementing a program to reduce the level of toxins that adversely affect clapper rail populations in the Bay-Delta. Restoring high-quality clapper rail habitat would also reduce the adverse effects of predation by non-native species by creating habitat conditions that are more favorable for rails and less favorable for predators.

Integration with Other Restoration Programs

Wetland restoration and management programs that would improve habitat for the clapper rail include:

- the Agricultural Stabilization and Conservation Service's Wetland Reserve Program,
- the Wildlife Conservation Board's Inland Wetlands Conservation Program,
- implementing recommendations of the Goals Project (1999) regarding restoration of large areas of tidal marsh in all subregions of the Bay,
- protect remaining tidal slough habitats supporting pickleweed, cordgrass, bulrushes, and cattails,
- maintain adjacent higher elevation wetland and upland habitat to provide cover during high tides and floods,
- the Suisun Marsh Protection Plan, and
- ongoing management of State and federal wildlife refuges and private duck clubs.

Restoration efforts will be conducted in cooperation with agencies or organizations with responsibility or authority for restoring wetland and aquatic habitats, including:

- the California Department of Fish and Game,
- California Department of Water Resources,
- U.S. Fish and Wildlife Service (USFWS),
- California Coastal Conservancy,
- San Francisco Bay Conservation and Development Commission,
- San Francisco Bay Joint Venture,
- San Francisco Bay Regional Water Quality Control Board,
- U.S. Army Corps of Engineers, and
- Delta Protection Commission.

Linkage with Other Ecosystem Elements

Improvement of the population of clapper rail in the Bay is integrally linked with wetland and riparian habitat restoration, and water quality (contaminants) improvement.

Objective, Targets, Actions, and Measures

The Strategic Objective is to contribute to the recovery of at-risk native species in the Bay-Delta estuary and its watershed.

Species Target: Maintain the current distribution and existing populations of the California clapper rail, and reestablish and maintain viable species' populations throughout its historic range in the portion of the Bay Region within the ERP focus area.

Long-Term Objective: Have self-sustaining populations of California clapper rail located throughout their original native range in tidal marshes of the Bay-Delta system.

Short-Term Objective: Protect existing populations of the species and restore habitat to provide sites for expansion of present populations.

Rationale: The California clapper rail requires tidal salt marshes for all phases of its life cycle. Its populations have declined as these marshes have been eliminated and fragmented, permitting easier access of non-native predators (e.g., house cats, red fox), people, and other intruders to their nesting and high-tide roosting areas. These birds should recover as tidal salt marshes are allowed to re-expand and as marsh restoration efforts proceed.

Stage 1 Expectations: Substantial progress will have been made in protecting habitat for all existing populations and management plans will be in place to further improve existing habitats for clapper rails. Potential additional restoration sites will have been identified.

Restoration Actions

The general target is to increase the numbers of breeding pairs of clapper rails in the Bay-Delta. The U.S. Fish and Wildlife Service is currently revising the recovery plan for the clapper rail, which will establish population recovery goals.

The following general programmatic actions will contribute to the recovery of the California clapper rail:

- restore saline and brackish wetland habitat in the Bay,
- protect remaining tidal slough habitats supporting pickleweed, cordgrass, bulrushes, and cattails, especially in areas adjacent to high marsh meadows characterized by pickleweed-saltgrass plant associations,
- improve water quality of Bay marshes,
- reduce the adverse effects of boat wakes on nests during the breeding period,
- develop and implement predator control programs,
- maintain adjacent higher elevation wetland and upland habitat to provide cover during high tides and floods, and
- improve upland cover by providing incentives to farmers to allow natural vegetation to reclaim portions of the upland habitat adjacent to tidal wetlands.

MSCS Conservation Measures

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- The geographic priorities for implementing actions to protect, enhance, and restore saline emergent wetlands and associated habitats for the California clapper rail should be: 1) Gallinas/Ignacio marshes and Napa Marshes, 2) Sonoma Marshes, Petaluma Marshes, and Highway 37 marshes west of Sonoma Creek, 3) Point Pinole Marshes, 4) Highway 37 marshes west of Sonoma Creek, and 5) the Contra Costa County shoreline.
- Coordinate protection, enhancement, and restoration of saltmarsh and associated habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, and USFWS species

recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.

- Restore wetland and perennial grassland habitats adjacent to occupied nesting habitats to create a buffer of natural habitat to protect nesting pairs from potential adverse affects that could be associated with future changes in land use on nearby lands and to provide suitable foraging habitat and nesting habitat area suitable for the natural expansion of populations.
- Initial species recovery efforts should be directed to locations where there are immediate opportunities for protection, enhancement, or restoration of suitable habitat.
- To the extent practicable, design dikes constructed in enhanced and restored saline emergent wetlands to provide optimal wetland to upland transition habitat.
- Direct ERP salt marsh enhancement efforts towards existing degraded marshes that are of sufficient size and configuration to develop fourth order tidal channels (marshes would likely need to be at least 1,000 acres in size).
- To the extent practicable, design salt marsh enhancements and restorations to provide low-angle upland slopes at the upper edge of marshes to provide for the establishment of suitable and sufficient wetland to upland transition habitat. Transition habitat zones should be at least 0.25 mile in width.
- Manage enhanced and restored habitat areas to avoid or minimize impacts on the California clapper rail associated with recreational uses on lands acquired or managed under conservation easements.
- Direct ERP restoration actions towards improving tidal circulation to dikes wetlands that currently sustain partial tidal exchange.
- Direct some habitat enhancements and restorations towards increasing habitat connectivity among existing and restored tidal marshes.
- To the extent practicable, control non-native predator populations in occupied habitat areas and salt marshes enhanced and restored under the ERP.
- Identify and implement feasible methods for controlling invasive non-native marsh plants.
- Monitor to determine use of restored salt marsh habitat by California clapper rails and the rate at which restored habitats are colonized.

REFERENCES

Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco and San Francisco Regional Water Quality Control Board, Oakland, California.

Multi-Species Conservation Strategy. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

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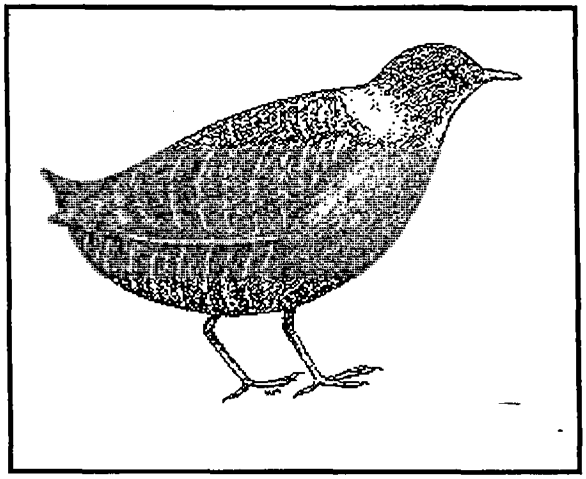
◆ CALIFORNIA BLACK RAIL



INTRODUCTION

The California black rail is a rarely seen, year-round resident of saline, brackish and fresh emergent wetlands and viable populations of the species are found only in the Suisun Marsh, San Francisco Bay, and the Delta. The California black rail is associated with tidal and nontidal emergent wetlands. The population and distribution of this species have declined substantially primarily as a result of reclamation of its wetland habitats. The loss of habitat and declining condition of the species' population have warranted its listing as threatened under the California Endangered Species Act. The major factor that limits this resource's contribution to the health of the Delta is related to the adverse effects of historical and current loss or degradation of salt, brackish, and freshwater marshes.

RESOURCE DESCRIPTION

Historically, the black rail was a resident of coastal wetlands from Santa Barbara County to San Diego County. Much of the California black rail's marshland habitat in California has been destroyed or modified since the mid-1800s. This decline in marshland has reduced population densities of black rail throughout its range.

Important habitats for the species include tidal perennial and nontidal perennial aquatic, dead-end and open-ended sloughs, seasonal wetland and aquatic, saline and fresh emergent wetland, and midchannel islands and shoals. Many tidal habitats, including those that support pickleweed, bulrushes, and saltgrass, are critical types for this species that need to be protected and currently exist as only a small percentage of their historical extent. In addition, upper wetland or upland areas adjacent to these habitat areas provide nesting and escape cover during high tides and floods. Black rails are especially abundant in undiked tidal marshes of Suisun Marsh. They are most often associated with dense stands of American bulrush (*Scripus americanus*) immediately adjacent to high marsh meadows supporting pickleweed-saltgrass associations. They are often associated with soft bird's-beak, an endangered plant of the high tidal marsh.

Black rail habitat is directly influenced by sediment supply from the upstream portion of the Delta and tidal influences from the Bay. As sediment is deposited in a tidal marsh, the elevation of the marsh changes. Eventually, the marsh may no longer be affected by tidal action or support tidal marsh plants which depend on the interaction of compatible tides and sediment supply regimes. Water quality in habitat areas must be sufficiently high to support the invertebrates and vegetation that sustain black rails. Currently, the condition most hazardous to the black rail's existence in salt marshes is the elevated water level associated with the highest tides and high outflow conditions. High water destroys nests and forces rails to leave the marsh temporarily in search of sufficient cover in uplands. Black rails use corridors between wetland and upland habitats to seek cover during high tides. However, these corridors have been fragmented by the extensive system of Delta levees, which are often devoid of vegetation. This lack of sufficient cover subjects black rails to predation, frequently by non-native species. These habitats continue to be threatened by sedimentation, water diversions, recreational activities, and land use practices. Insufficient quantity and quality of emergent wetland habitat is the primary factor limiting recovery of the species' population in the estuary. Other factors that can also adversely affect the black rail include disturbance during its breeding period, contaminants, and excessive predation by non-native species.

VISION

The vision for the California black rail is to contribute to the recovery of this State-listed threatened species and contribute to overall species richness and diversity.

Achieving this vision will reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.

Restoring suitable fresh, brackish, and saline emergent wetlands and tidal sloughs in the Bay-Delta and adjacent higher elevation habitats is critical to the recovery of the species in the estuary. These restored habitats would provide refuge for the California black rail during high-water periods. Although the black rail's range extends into other ecological zones, the primary focus for habitat restoration will be in the Sacramento-San Joaquin Delta Ecological Management Zone and the Suisun Marshland Ecological Management Unit in the Suisun Marsh/North San Francisco Bay Ecological Management Zone. Efforts outside the Delta and Suisun Marsh to restore natural tidal action to aquatic and wetland habitats within the Suisun Marsh/North San Francisco Bay Ecological Management Zone would also benefit the species.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Many programs designed to benefit broader groups of fish and wildlife that use or depend on wetlands, sloughs, or adjacent aquatic systems in the Bay-Delta also benefit the California black rail. Some of these are operated by the following organizations:

- Bay Area Wetlands Planning Group,
- California Coastal Conservancy,
- Delta Native Fishes Recovery Team,
- San Francisco Bay National Wildlife Refuge,
- San Francisco Bay Conservation and Development Commission,
- San Francisco Bay Joint Venture,
- San Francisco Bay Regional Water Quality Control Board,
- U.S. Fish and Wildlife Service San Francisco Bay Program, and
- San Francisco Bay Area Wetlands Ecosystem Goals Project.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration and recovery of the California black rail population of the Bay-Delta is integrally linked with wetland and riparian habitat restoration, and water quality (contaminants) improvement.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

The Strategic Objective is to contribute to the recovery of at-risk native species in the Bay-Delta estuary and its watershed.

SPECIES TARGET: Maintain the current distribution and existing populations of the California black rail, and reestablish and maintain viable species' populations throughout its historic range in the portion of the Bay Region within the ERP focus area.

LONG-TERM OBJECTIVE: Have self-sustaining populations of California black rail located throughout their original native range in tidal marshes of the Bay-Delta estuary.

SHORT-TERM OBJECTIVE: Restore the population of California black rails to levels necessary to have its status down-graded from a threatened species.

RATIONALE: The California black rail is a state-listed threatened species and is considered a species of concern by the federal government. The leading cause of its decline is the degradation and loss of emergent wetland habitat throughout its range. The California black rail builds nest on the ground and is susceptible to predation by terrestrial species. Non-native species such as the red fox and feral domestic animals (cats and dogs) in some areas have raided nests and contributed to their decline. To develop improve the status of this species, it will be necessary to restore and enhance suitable habitat throughout the wetlands of the estuary. It will also be very important to develop methods to control the non-native predators.

STAGE 1 EXPECTATIONS: Plans should be developed and implemented to restore and protect emergent wetlands within the Napa and Suisun marshes and along San Francisco Bay; develop strategies for controlling problem predators.

RESTORATION ACTIONS

The general target is to increase the number of breeding pairs of black rail in the Bay-Delta.

General programmatic actions to achieve the target for the California black rail include:

- restore the natural tidal action of aquatic habitats;
- preserve the remaining populations of black rail, tidal slough habitats that support pickleweed, bulrushes, and saltgrass;
- enhance and restore connectivity between tidal sloughs and adjacent upland refugial habitats;
- improve the connection between wetland and upland habitat areas to reduce predation;
- implement management programs for small water diversions, disturbance, land use changes, and contaminants would improve habitat, reproductive potential, and recruitment for black rails;
- protect tidal sloughs and wetlands from adverse land uses;
- protect nearby unoccupied suitable habitat areas would help ensure natural expansion area is available;
- protect of existing suitable habitats by implementing conservation easement purchasing from willing landowners, or establishing incentive programs to maintain suitable habitat;
- develop and implement alternatives to land management practices on public lands that continue to degrade the quality or inhibit the recovery of black rail habitats; and
- restore, protect, and improve emergent wetlands, tidal sloughs, and adjacent uplands.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve California black rail habitat or population targets.

- The geographic priorities for implementing actions to protect, enhance, and restore saline emergent wetlands and associated habitats for the California black rail should be: 1) western Suisun Marsh, 2) Gallinas/Ignacio marshes, Napa Marshes, and eastern Suisun Marshes, 3) Sonoma Marshes, Petaluma Marshes, and Highway 37 marshes west of Sonoma Creek, 4) Point Pinole Marshes, 4) Highway 37 marshes west of Sonoma Creek, and 6) the Contra Costa County shoreline.
- Coordinate protection, enhancement, and restoration of saltmarsh and associated habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, and USFWS species recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Restore wetland and perennial grassland habitats adjacent to occupied nesting habitats to create a buffer of natural habitat to protect nesting pairs from potential adverse affects that could be associated with future changes in land use on nearby lands and to provide suitable foraging habitat and nesting habitat area suitable for the natural expansion of populations.
- Initial species recovery efforts should be directed to locations where there are immediate opportunities for protection, enhancement, or restoration of suitable habitat.
- To the extent practicable, design dikes constructed in enhanced and restored saline emergent wetlands to provide optimal wetland to upland transition habitat.
- Direct ERP salt marsh enhancement efforts towards existing degraded marshes that are of

sufficient size and configuration to develop fourth order tidal channels (marshes would likely need to be at least 1,000 acres in size).

- To the extent practicable, design salt marsh enhancements and restorations to provide low-angle upland slopes at the upper edge of marshes to provide for the establishment of suitable and sufficient wetland to upland transition habitat. Transition habitat zones should be at least 0.25 mile in width.
- Manage enhanced and restored habitat areas to avoid or minimize impacts on the California black rail associated with recreational uses on lands acquired or managed under conservation easements.
- Direct ERP restoration actions towards improving tidal circulation to dikes wetlands that currently sustain partial tidal exchange.
- Direct some habitat enhancements and restorations towards increasing habitat connectivity among existing and restored tidal marshes.
- To the extent practicable, control non-native predator populations in occupied habitat areas and salt marshes enhanced and restored under the ERP.
- Identify and implement feasible methods for controlling invasive non-native marsh plants.
- Monitor to determine use of restored salt marsh habitat by California clapper rails and the rate at which restored habitats are colonized.
- Acquire conservation easements in occupied habitat areas to adjust grazing regimes to enhance wetland to upland transition habitat conditions.

References

Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco and San Francisco Regional Water Quality Control Board, Oakland, California.

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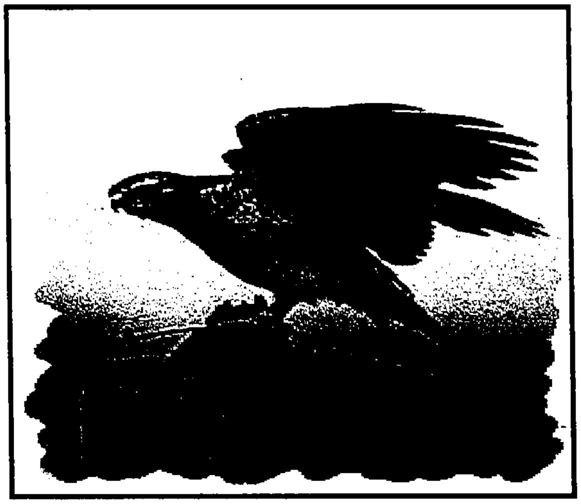
Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

◆ Swainson's Hawk



Introduction

Swainson's hawks occur throughout the Central Valley where riparian forest and oak savanna habitats are present. The nesting population of the Swainson's hawk has declined substantially, primarily as a result of habitat loss and degradation, reduced reproductive success, and high rates of mortality during migration and on South American wintering areas. The loss of habitat and declining condition of the species' population have warranted its listing as threatened under the California Endangered Species Act. Major factors that limit this resource's contribution to the health of the Bay-Delta are related to adverse effects of habitat loss and degradation, toxic pesticides accumulated in the foodweb on reproduction, human-associated disturbances at nest sites, and increased competition with other species for nest sites.

Resource Description

The Swainson's hawk was common in the Central Valley at the end of the 19th century. Historical populations were estimated between 4,000 and 17,000 pairs, but declines were documented as early as the 1940s. In 1979, 110 active pairs were observed in the Central Valley with estimates of 375 pairs present throughout the State. Today, the few remaining concentrations of breeding pairs are supported within the Yolo, Sacramento, San Joaquin, Sutter, and Colusa counties, with steadily decreasing numbers to the north and south.

Possible reasons for the Swainson's hawk's decline include

- loss or degradation of habitat on the breeding grounds,
- disturbance on the breeding grounds,
- thin eggshells from pesticide residues,
- increased competition with other species, and
- mortality during migration and on the wintering grounds in South America.

To a large degree, the decline of the Swainson's hawk can be attributed to the long-term, cumulative effects of riparian and wetland habitat conversion and degradation. A combination of changes to Central Valley area ecosystems has added to the problem. These changes include:

- the conversion of perennial grassland to agricultural uses, eliminating foraging habitat;
- urban development adjacent to waterways and nesting areas;
- incompatible land use that disrupts breeding and nesting;
- levees and bank protection that eliminate nesting habitat;
- disturbance from human activities near nest sites; and
- contaminants from agricultural runoff and pesticide use.

Excessive harvest of Swainson's hawk on South American wintering grounds is also thought to be a major factor affecting the decline of the species.

Agricultural crops, such as alfalfa, and dryland pasture provide habitat that supports a continual prey base for the Swainson's hawk. A large number of hawks may congregate near farming activities such as mowing, discing, and irrigation where prey, including some agricultural pests such as grasshoppers, is abundant. Valley oak and riparian woodlands are essential for Swainson's hawk nesting, and 78% of nest trees are located within riparian systems with adjacent foraging habitat. The Swainson's hawk typically returns to the same nest site; therefore, the preservation of nest sites is important to prevent total loss.

> **VISION**
> The vision for the Swainson's hawk is to contribute to the recovery of this State-listed threatened species and contribute to the overall species richness and diversity.

Achieving this vision will reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta.

Habitat restoration in the Sacramento-San Joaquin Delta Ecological Management Zone will help achieve recovery of the Swainson's hawk by increasing the quality and quantity of its habitats. Limiting land use changes can help to retain foraging and nesting habitat. Because many agricultural practices are compatible with Swainson's hawk foraging, simply improving the timing of farming activities would further improve foraging habitat.

Strategies could be implemented collaboratively with organizations to improve existing preserves that support Swainson's hawk habitat. Cooperative agreements with land management agencies, conservation easements or landowner incentives will improve land management practices for the Swainson's hawk.

Restoration of habitats proposed in other ecological management zones will also allow Swainson's hawk nesting and foraging habitats to develop elsewhere in the Central Valley.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Several organizations have plans that indirectly target the Swainson's hawk for recovery through habitat restoration.

- The Riparian Habitat Joint Venture includes 11 federal, State, and private organizations that signed a cooperative agreement to protect and enhance habitats for native land birds throughout California.
- The Putah Creek - South Fork Preserve, which works to increase fish and wildlife populations dependent on riparian and wetland habitats, including species of special concern, plans to restore 130 acres of riparian habitat.
- The Upper Sacramento River Fisheries and Riparian Habitat Management Plan (SB1086) also targets riparian habitat for restoration that will benefit the Swainson's hawk.
- Restoration and strategies should be coordinated with the Swainson's Hawk Technical Group, a group of agency and non-agency specialists dedicated to restoring the health of this species.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of the Swainson's hawk population is integrally linked with restoration of riparian, grassland, and agricultural habitat in the Central Valley.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

> The Strategic Objective is to contribute to the recovery of at-risk native species in the Bay-Delta estuary and its watershed.

SPECIES TARGET: Protect, enhance, and increase habitat sufficient to support a viable breeding population. The interim prescription is to increase the current estimated population of 1,000 breeding pairs in the Central Valley to 2,000 breeding pairs. This prescription will be modified based on results of a population viability analysis being conducted by the California Department of Fish and Game.

LONG-TERM OBJECTIVE: Have self-sustaining breeding and wintering populations of Swainson's hawk located throughout their original native range in the Delta and the Central Valley and provide habitat needed to support Swainson's hawks that migrate from overwintering in Argentina.

SHORT-TERM OBJECTIVE: Determine the importance to the species of the small numbers that overwinter in the Delta and determine and develop plans to expand the number of overwintering birds.

RATIONALE: Swainson's hawk is listed as a threatened species by the State of California because its numbers have declined to a small (<2%) percentage of its original population. It nests in riparian areas and forages in upland grasslands and crop lands. The decline has been caused by the combined loss of riparian nesting habitat and foraging habitat and by large mortalities in its overwintering habitat in Argentina. A small number of these hawks overwinter in the Delta rather than migrating, for unknown reasons. If restoration of breeding habitat does not significantly reverse the decline of these birds because of mortality during their long migrations, then there may be a need to find ways to encourage more overwintering in the Delta.

STAGE 1 EXPECTATIONS: A recovery plan for Swainson's hawk in the Central Valley and Delta will have been developed and implemented with key habitats identified and initial protective steps taken.

RESTORATION ACTIONS

The general target is to increase the number of breeding pairs of Swainson's hawks in the Central Valley.

General programmatic actions that will contribute to reaching the targets include:

- protect existing and restoring additional suitable valley oak and other riparian habitats and grasslands;
- improve agricultural land management;
- reduce the effect of factors that can suppress breeding success;
- protect known nest sites from loss, degradation, or disturbance during the entire year;
- increase prey populations (e.g., rodents) necessary to support an expanding population;
- establish buffer zones that eliminate human disturbance during nesting; and
- provide habitat to support increased numbers of Swainson's hawks that migrate from overwintering in Argentina.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve Swainson's hawk habitat or population targets.

- Proposed ERP actions designed to restore valley/foothill riparian habitat should initially be implemented in the Delta.
- To the extent practicable, design restored seasonal wetlands in occupied habitat areas to provide overwinter refuge for rodents to provide source prey populations during spring and summer.
- To the extent consistent with CALFED objectives, enhance at least 10% of agricultural lands to be enhanced under the ERP in the Delta, Sacramento River, and San Joaquin River Regions to increase forage abundance and availability within 10 miles of occupied habitat areas.
- To the extent consistent with CALFED objectives, manage lands purchased or acquired under conservation easements that are occupied by the species to maintain or increase their current population levels.
- To the extent practicable, manage restored or enhanced habitats under the ERP to maintain desirable rodent populations and minimize potential impacts associated with rodent control.

REFERENCES

Multi-Species Conservation Strategy. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

◆ Salt Marsh Harvest Mouse

Salt Marsh Harvest Mouse
Endangered (Federal)
Endangered (State)

Introduction

The salt marsh harvest mouse is associated with saline emergent wetlands. The population and distribution of this species have declined substantially, primarily as a result of reclamation of tidal salt marshes for agriculture, salt production, and urban development. The loss of habitat and declining condition of this species' population have warranted its listing as endangered under the State and federal Endangered Species Acts. The major factors that limit this resource's contribution to the health of the Delta are related to the adverse effects of historical and current loss or degradation of saline tidal wetlands that support the dense stands of pickleweed on which the salt marsh harvest mouse is dependent.

Resource Description

The salt marsh harvest mouse occurs only in saline emergent wetlands associated with San Francisco Bay and its tributaries. Historically, these areas supported extensive tidal wetlands, which sustained dense stands of pickleweed. These plants, in turn, supported the salt marsh harvest mouse.

With the gradual development of the Suisun Marsh and San Francisco Bay areas came the construction of dikes and levees for flood control and protection of lands reclaimed for uses such as for salt ponds and agriculture. These reclaimed areas supported livestock grazing and, in the Suisun Marsh, small grain crops and asparagus. The vegetation growing beyond the limits of high tide supported grazing, and settlers found that if they diked those areas, wetland plants would eventually recede and give way to upland plants favored by livestock. As more and more settlers arrived, development resulted in the loss of large areas of habitat and severe fragmentation of the habitat that remained. Barriers, such as a road or path no more than 10 feet across, isolated the mouse in fragmented habitats because it would not use or travel across areas lacking vegetation. Upland areas consisting of grasslands or salt-tolerant plants that offered refuge during extreme high tides and high outflow periods were adjacent to the saline emergent wetlands. Development altered the landscape and geomorphology in many of these areas, which contributed to the loss of habitat.

Saline emergent wetlands with pickleweed occur only within the Suisun Marsh/North San Francisco Bay Ecological Management Zone of the Ecosystem Restoration Program Plan (ERPP) area. The elimination of much of the salt marsh harvest mouse's habitat is the primary cause of the species' decline. Other factors or "stressors" that have contributed to the decline or potentially could inhibit the recovery of the species include human activities that disturb the species and predation by non-native species. Grazing; water management practices; land use practices; contaminants; and human-made structures, such as dikes and levees, continue to degrade the quality of remaining habitat areas.

Vision

The vision for the salt marsh harvest mouse is to contribute to the recovery of this State- and federally listed endangered species through restoring salt marsh habitat in San Pablo and Suisun bays and adjacent marshes.

Existing occupied and unoccupied suitable habitat areas will be protected. Saline emergent wetlands will be restored. Stressors to the population and habitat will be reduced. New populations will be introduced into unoccupied habitat areas.

Protecting existing suitable habitat areas from potential activities that could adversely affect the harvest mouse could be achieved through cooperative agreements with land management agencies, conservation easements, or purchase from willing sellers. Restoration of adjacent upland habitat will help to recover this species by increasing habitat area. Uplands provide the mouse with refuge from flooding.

Reducing factors that contribute to degradation of saline emergent wetland communities would promote natural restoration and maintenance. Increasing the quantity and quality of salt marsh harvest mouse habitat and reducing the adverse effects of stressors would establish conditions necessary to maintain existing populations and allow them to recover naturally. However, introducing the mouse into unoccupied habitat areas within its historic range would speed the recovery of the species by establishing new populations before the species would be expected naturally to expand into these or restored habitat areas.

Many programs are underway to restore the Bay-Delta salt marshes. Successful restoration program implementation will increase the chances of salt marsh harvest mouse recovery. Current land management practices need to be examined and redefined to restore, enhance, and promote salt marsh harvest mouse habitat. Salt marsh harvest mouse management strategies should focus on:

- managing known critical mouse habitat areas;
- providing additional research to identify other factors limiting the population and determine corrective measures; and
- addressing the needs of waterfowl and other migratory birds that also use saline emergent wetlands.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Existing restoration programs that would benefit the salt marsh harvest mouse include:

- Suisun Marsh Recovery Plan,
- San Francisco Bay Joint Venture,
- San Francisco Bay Area Wetlands Ecosystem Goals Project,
- California Coastal Conservancy,
- Delta Native Fishes Recovery Plan,
- California Department of Fish and Game Delta/Bay Enhanced Enforcement Program,
- Grizzly Island Wildlife Area,
- National Estuarine Reserve Research System,
- North Bay Wetlands Protection Program,
- San Francisco Bay National Wildlife Refuge, and
- Tidal Wetlands Species Recovery Plan.

Targets and actions will be coordinated through these programs.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of salt marsh harvest mouse is integrally linked with restoration of saline emergent wetlands and adjacent grasslands adjacent to San Pablo and Suisun Bays.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

> The Strategic Objective is to contribute to the recovery of at-risk native species in the Bay-Delta estuary and its watershed.

SPECIES TARGET: Maintain the current distribution and existing populations of salt marsh harvest mouse and establish and maintain viable species' populations throughout its historic range in the portion of the Bay Region within the ERP focus area.

LONG-TERM OBJECTIVE: Restore salt marsh harvest mouse to tidal marsh throughout their historical range.

SHORT-TERM OBJECTIVES: Reestablish populations in newly created or restored marshland and protect existing populations as outlined in the salt marsh harvest mouse recovery plan.

RATIONALE: This species is listed as endangered by both state and federal governments and exists in small isolated populations in Bay salt marshes. Historically, about 107,000 acres of habitat suitable for the salt marsh harvest mouse existed. Degradation of habitat due to agricultural practices, diking, and human disturbance has limited greatly what is available today. It is important that this degradation and loss of any more habitat be stopped. Existing habitat is susceptible to flooding and silting in, as well as new building projects. New wetlands have to be created to outweigh disappearing marsh in other areas if the small isolated populations are to be enhanced. Created habitat would also benefit other species that use tidal marsh environments.

STAGE 1 EXPECTATIONS: Key items in the salt marsh harvest mouse recovery plan will have been identified, followed by implementation of those that would have immediate benefits to the species, including stopping population decline and increasing genetic flow between isolated populations. The existing populations will have been studied to determine their size and their habitat requirements. Limit the activities that would further increase erosion of Bay marshes and therefore reduce existing population sizes.

RESTORATION ACTIONS

The following general targets will assist in meeting the implementation objective:

- Increase the number of salt marsh harvest mice in San Pablo and Suisun Bay marshes.
- Reduce the extent of isolation among the mouse populations.

The following general programmatic actions will assist in meeting the targets:

- Increase the area of salt marsh adjacent to San Pablo and Suisun Bays.
- Decrease the extent of isolation among remaining salt marshes.
- Increase the amount of adjacent grasslands to the marshes.
- Reduce the degree of stressors including water management and land use practices on existing and restored marshes and adjoining upland habitats.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve salt marsh harvest mouse habitat or population targets.

- The geographic priorities for implementing actions to protect, enhance, and restore saline emergent wetlands and associated habitats for the California clapper rail should be: 1) western Suisun Marsh, 2) Gallinas/Ignacio marshes, Napa Marshes, and eastern Suisun Marshes, 3) Sonoma Marshes, Petaluma Marshes, and Highway 37 marshes west of Sonoma Creek, 4) Point Pinole Marshes, 5) Highway 37 marshes west of Sonoma Creek, and 6) the Contra Costa County shoreline.

- Coordinate protection, enhancement, and restoration of saltmarsh and associated habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, and USFWS species recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.

- Restore wetland and perennial grassland habitats adjacent to occupied nesting habitats to create a buffer of natural habitat to protect nesting pairs from adverse affects that could be associated with future changes in land use on nearby lands and to provide suitable foraging habitat and nesting habitat area suitable for the natural expansion of populations.

- Initial species recovery efforts should be directed to locations where there are immediate opportunities for protection, enhancement, or restoration of suitable habitat.

- To the extent practicable, design dikes constructed in enhanced and restored saline emergent wetlands to provide optimal wetland to upland transition habitat.

- To the extent practicable, direct ERP salt marsh enhancement efforts towards existing degraded marshes that are of sufficient size and configuration to develop fourth order tidal channels (marshes would likely need to be at least 1,000 acres in size).
- To the extent practicable, design salt marsh enhancements and restorations to provide low-angle upland slopes at the upper edge of marshes to provide for the establishment of suitable and sufficient wetland to upland transition habitat. Transition habitat zones should be at least 0.25 mile in width.
- Manage enhanced and restored habitat areas to avoid or minimize potential impacts on the salt marsh harvest mouse associated with recreational uses on lands acquired or managed under conservation easements.
- Direct restoration efforts towards restoration of lands adjacent to occupied habitat areas.
- Direct restoration efforts towards improving tidal circulation to diked wetlands that currently sustain partial tidal exchange.
- Direct some habitat enhancements and restorations towards increasing habitat connectivity among existing and restored tidal marshes.
- To the extent practicable, control non-native predator populations in occupied habitat areas and salt marshes enhanced and restored under the ERP.
- Control non-native invasive plants in existing salt marshes where non-native plants have degraded habitat quality and in salt marshes restored under the ERP.
- Monitor the use of restored salt marsh habitats by salt marsh harvest mice and the rate at which restored habitats are colonized.
- Acquire conservation easements to adjust grazing regimes to enhance wetland to upland transition habitat conditions.
- To the extent consistent with CALFED objectives, manage lands purchased or acquired under conservation easements that are occupied by the species to maintain or increase their current population levels.

REFERENCES

Multi-Species Conservation Strategy. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

◆ SAN PABLO CALIFORNIA VOLE

INTRODUCTION

The San Pablo California vole is known to inhabit the salt marshes of San Pablo Bay. This species has declined, primarily as a result of the loss or degradation of its habitat. The loss of habitat has warranted its listing as a California Special Concern Species. The major factor that limits this resource's contribution to the health of the Bay-Delta are related to adverse effects of habitat loss.

RESOURCE DESCRIPTION

The San Pablo California vole is known exclusively from the salt marshes of San Pablo Creek, Contra Costa County, on the south shore of San Pablo Bay.

To a large degree, the decline of the San Pablo California vole can be attributed to the long-term cumulative effects of salt marsh habitat conversion and degradation. A combination of changes to salt marsh ecosystems has added to the problem. These changes include:

- loss of salt marsh habitat,
- agricultural activities such as discing and poisoning, and
- nonnative predators such as the red fox.

VISION

The vision for the San Pablo California vole is to contribute to the recovery of this California species of special concern and contribute to the overall species richness and diversity.

Achieving this vision will reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Existing restoration programs that would benefit the San Pablo California Vole include:

- San Francisco Bay Joint Venture,
- Bay Area Wetlands Planning Group,
- California Coastal Conservancy,
- California Department of Fish and Game Delta/Bay Enhanced Enforcement Program,
- National Estuarine Reserve Research System,
- North Bay Wetlands Protection Program,
- San Francisco Bay National Wildlife Refuge,
- Tidal Wetlands Species Recovery Plan, and
- San Francisco Bay Area Wetlands Ecosystem Goals Project.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of the San Pablo California Vole is integrally linked with restoration of salt marsh habitat of San Pablo Bay.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

The Strategic Objective is to contribute to the recovery of at-risk native species in the Bay-Delta estuary and its watershed.

SPECIES TARGET: Maintain the current distribution and existing populations of San Pablo California vole and establish and maintain viable species' populations throughout its historic range in the portion of the Delta and Bay Region within the ERP focus area.

LONG-TERM OBJECTIVE: Restore San Pablo vole to tidal marsh throughout their historical range.

SHORT-TERM OBJECTIVE: Determine the distribution and taxonomic status of the vole while maintaining existing salt marsh habitat know to contain populations. Undertake wetland restoration projects in and adjacent know populations to increase available habitat.

RATIONALE: The San Pablo vole is a California Department of Fish and Game Special Concern species. Although little is known about its distribution, biology, or taxonomy, it appears to be a distinct form that is confined to salt marshes and adjoining grasslands in Contra Costa County. To limit the decline of the populations even further, salt marsh and adjoining grassland habitats in Contra Cosa County need to be protected and further degradation and loss of habitat halted. Because present populations appear to be isolated from one another, there is a need to expand salt marsh habitats to maintain populations sizes and increase gene flow between the isolated populations.

RESTORATION ACTIONS

The following general programmatic actions will contribute to the recovery of the San Pablo California vole.

- Increase the area of salt marsh adjacent to San Pablo Bay.
- Decrease the extent of isolation among the remaining salt marshes in the San Pablo Bay region.
- Establish control measures for non-native predators within the habitat areas for the San Pablo California vole.

STAGE 1 EXPECTATIONS: All known localities for this species will have been protected and a thorough search made for other populations. A restoration plan will have been developed and implemented that includes genetic studies to determine its relationship to the widely distributed California vole.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve San Pablo California vole habitat or population targets.

- Coordinate protection, enhancement, and restoration of saltmarsh and associated habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, and USFWS species recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Restore wetland and perennial grassland habitats adjacent to occupied habitats to create a buffer of natural habitat to protect populations from potential adverse affects that could be associated with future changes in land use on nearby lands and to provide habitat suitable for the natural expansion of populations.
- Manage enhanced and restored habitat areas to avoid or minimize potential impacts easements on the San Pablo California vole that could be associated with recreational uses on lands acquired or managed under conservation.
- To the extent practicable, acquire, restore and manage historic tidal salt marshes and surrounding lands occupied by the San Pablo California vole along the west side of Point Pinole to tidal marsh with sufficient wetland to upland transition and adjacent upland habitat to improve habitat conditions for the San Pablo California vole.
- To the extent practicable, control non-native predator populations in occupied habitat areas and salt marshes enhanced and restored under the ERP.
- Identify and implement feasible methods for controlling invasive non-native marsh plants.
- To the extent consistent with CALFED objectives, manage land purchases or acquired under conservation easement that are occupied by the species to maintain or increase their current population levels.

REFERENCES

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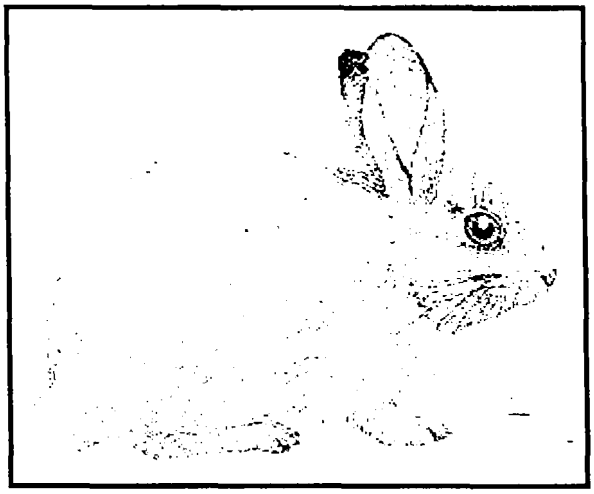

INTRODUCTION

The riparian brush rabbit is associated with riparian habitats of the Central Valley floodplain. It has been eliminated from the Delta from loss of riparian habitat. Elsewhere, the population and distribution of this species have declined substantially, primarily as a result of the loss or degradation of its habitat. The loss of habitat and declining populations have warranted its listing as endangered under the California Endangered Species Act and the federal Endangered Species Act.

The major factor that limits this resource's contribution to the health of the Delta is related to adverse effects of the historical loss and degradation of the mature riparian forests, on which the riparian brush rabbit depends, in the Delta and San Joaquin River floodplain.

RESOURCE DESCRIPTION

The remaining population of riparian brush rabbit is restricted to remnant San Joaquin Valley riparian forests with dense brushy understory. Unlike other rabbits, the riparian brush rabbit occupies riparian forests that have an ample brushy understory within natural floodplains. These floodplain riparian forests must be attached to suitable upland areas for cover and retreat from annual floods. Historically, this species' habitat was throughout the floodplain on the valley floor in northern San Joaquin Valley, including the Delta, but the original forest and floodplain have been reclaimed, cleared, altered, and degraded.

The remnant population of riparian brush rabbit is now restricted to 198 acres of remaining native riparian forest along the Stanislaus River in Caswell Memorial State Park in southern San Joaquin County in the East San Joaquin Basin Ecological Management Zone. It is considered the most sensitive mammal in California because of its susceptibility to floods, fire, disease, predation, disturbance, and flood control activities. The large-scale loss of riparian forest has resulted in over a 99% decline in the riparian brush rabbit population from historical levels. A population census conducted during January 1993, found that the population size ranged from about 210 to 310 individuals. Subsequent surveys following the January 1997 flood indicate that this species may be close to extinction. No brush rabbits were trapped in 22 nights of trapping between April 21 and May 30, 1997. In 1998, only one riparian brush rabbit was trapped (Federal Register 2000).

Overall, the decline of the riparian brush rabbit was caused by the destruction, fragmentation, and degradation of the San Joaquin Valley native riparian forest habitat. Less than 6% of the original habitat remains. Remaining suitable habitat is so severely fragmented that the rabbit has no means of naturally dispersing to other areas and establishing additional populations. Because the remaining riparian brush rabbit population occurs within one small area, any of the following events threaten the remaining population:

- Caswell Memorial State Park is subject to periodic flooding that often inundates the entire area. Without adequate cover on adjacent upland areas, the rabbits become easy targets for both native and non-native predators.
- The normal buildup of downed logs, dried vegetation, and ground litter in the riparian forest increases the potential severity of wildfires. Although this type of habitat is preferred and typically occupied by the riparian brush rabbit, any wildfire occurring within the remaining habitat could cause direct mortality as well as massive habitat destruction.
- Human activities have modified the habitat. The modified habitat has "selected" against the

riparian brush rabbit and for the desert cottontail. The desert cottontail presents two threats: one from competition and the other from diseases common to rabbits and carried by the species. These diseases are typically contagious and fatal; any disease becomes epidemic in this small and restricted population of rabbits.

VISION

The vision for the riparian brush rabbit is to contribute to the recovery of this federally and State-listed endangered species in the Bay-Delta through improvements in riparian habitat and reintroduction to its former habitat.

Restoring suitable mature riparian forest, protecting and expanding the existing population, and establishing new populations will be critical to the recovery of the riparian brush rabbit. Restoration of riparian habitats in the South Delta Ecological Management Unit of the Sacramento-San Joaquin Delta Ecological Management Zone and the East San Joaquin Basin Ecological Management Zone and adjacent upland plant communities will help the recovery of this species by increasing habitat area and providing refuge from flooding. Mature riparian forests with a brushy understory and adjacent upland habitat with sufficient cover during flooding would be suitable restored habitat. A healthy, brushy understory would contain:

- wild rose,
- blackberries,
- elderberries,
- wild grape,
- a buildup of downed logs,
- dried vegetation, and
- ground litter.

Restoring riparian habitat in the East San Joaquin Basin Ecological Management Zone to expand the area of suitable riparian brush rabbit habitat adjacent to occupied habitat along the Stanislaus River will help to protect and allow the existing population of brush rabbits to expand. Establishing additional populations within the riparian brush rabbit's historical range in the Sacramento-San Joaquin Delta Ecological Management Zone would help to avoid potential species extinction. To ensure the survival of introduced populations, newly occupied habitat areas should be suitable only for the riparian brush rabbit. That would reduce the likelihood of disease transmission from the desert cottontail. Hunting regulations should be modified to preclude hunting of rabbits and hares in and near reintroduction sites to limit the harvest of riparian brush rabbits until the species has recovered.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

A Recovery Plan for Upland Species of the San Joaquin Valley, California has been developed which contains specific measures for the riparian brush rabbit (U.S. Fish and Wildlife Service 1998). Resources agencies have identified Christman Island, part of the San Joaquin River National Wildlife Refuge, as possessing the greatest potential for providing habitat needed by the riparian brush rabbit. The agencies also agreed to continue work to identify one or more other sites on public property along the San Joaquin River in Merced County for restoration and reestablishment of a third population of the riparian brush rabbit. The California Department of Fish and Game and the U. S. Fish and Wildlife Service should continue the interagency coordination and commitment necessary to halt the further loss and deterioration of habitat and begin restoration and preservation of suitable habitat deemed essential to maintaining the subspecies in perpetuity.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration and protection of riparian brush rabbit is integrally linked with restoration of riparian forests and adjacent grasslands and reduction in wildfires and human disturbance in the northern San Joaquin Valley and the Delta.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

The Strategic Objective is to contribute to the recovery of at-risk native species in the Bay-Delta estuary and its watershed.

SPECIES TARGET: Protect the Caswell Memorial State Park population; protect, enhance, and expand the species' Caswell Memorial Park population; and restore four additional self-sustaining populations in the Delta and along the San Joaquin River by 2020.

LONG-TERM OBJECTIVE: Recover brush rabbit populations to the point where the species can removed from the state and federal endangered species list.

SHORT-TERM OBJECTIVE: Establish five additional self-sustaining populations of riparian brush rabbits along the San Joaquin River and in the Delta.

RATIONALE: The riparian brush rabbit a distinct subspecies of cottontail rabbit that historically lived in riparian areas along the San Joaquin River and Delta. It is listed as endangered under both the State and federal ESAs. It currently exists as one tiny remnant population in Caswell State Park that is in continuous threat of extinction. It has declined because of the loss of riparian habitats and the conversion of adjacent upland habitats to cropland. This species requires high ground, with extensive cover that it can move to when its primary riparian habitat floods. Due to the possibility of being extirpated by floods and wildfires it is important to develop other self-sustaining populations and restore riparian areas. Develop more brush habitat within the park to allow for good coverage and areas of minimal disturbance.

STAGE 1 EXPECTATIONS: The existing population will have been protected from further decline by protecting the species from seasonal flooding. More brushy riparian habitat within Caswell State Park will have been developed to provide good cover and areas of minimal disturbance. An inventory of potential restoration sites will have been completed and work begun on making them suitable for brush rabbit reintroduction. Due to low population numbers, the benefits and detriments of a captive breeding program will have been evaluated and implemented if the resource agencies find that captive breeding will prevent extinction of the species during the period that habitat is being restored.

RESTORATION ACTIONS

The following general targets will assist in meeting the implementation objective:

- Increase abundance in remaining population.
- Increase the number of rabbit populations
- Investigate the health of riparian brush rabbits in the existing population to determine the effect of non-native rabbit populations, if any, and take measures to improve their health if necessary.

The following general programmatic actions will contribute to the recovery of the riparian brush rabbit:

- Expand the amount of riparian forest in the northern San Joaquin Valley and the Delta.
- Increase the amounts of specific habitat features needed by rabbits in riparian forests where the existing population occurs or where introduced.
- Expand the amount of upland habitat adjacent to riparian habitat where the existing populations occurs or to where new populations will be introduced.
- Manage existing and new habitats to reduce potential threat of wildfire and human disturbance including hunting.
- Control predators and non-native competitors where populations exist or will be introduced.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve riparian brush rabbit habitat or population targets.

- Coordinate protection and restoration of riparian brush rabbit populations and its habitats with other federal and state programs (e.g., U.S. Fish and Wildlife Service species recovery plans) that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Conduct surveys to identify suitable habitat areas for establishment of additional populations in the Delta and along the San Joaquin River and implement introductions to establish four additional populations in these areas by 2020.

- Direct ERP actions proposed for the Stanislaus River towards protecting, enhancing, and restoring suitable riparian and associated flood refuge habitats in and adjacent to occupied habitat at Caswell Memorial State Park.

- Develop and implement a monitoring plan to assess populations status and trends.

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◆ San Joaquin Valley Woodrat

Introduction

The San Joaquin Valley woodrat is associated with riparian habitats of the Central Valley floodplain. It has been eliminated from the Delta due to loss of riparian habitat. Elsewhere, the population and distribution of this species has declined substantially, primarily as a result of the loss or degradation of its habitat. The loss of habitat and declining populations have warranted its listing as a California Special Concern species and as an endangered species under the Endangered Species Act. (Federal Register 2000).

The major factor that limits this resource's contribution to the health of the Delta is related to adverse effects of the historical loss and degradation of the mature riparian forests, on which the San Joaquin Valley woodrat depends, in the Delta and San Joaquin River floodplain.

Resource Description

The remaining population of San Joaquin Valley woodrat is restricted to remnant San Joaquin Valley riparian forests with dense brushy understory. Unlike other woodrats, the San Joaquin Valley woodrat occupies riparian forests that have an ample brushy understory within natural floodplains. These floodplain riparian forests must be attached to suitable upland areas for cover and retreat from annual floods. Historically, this species' habitat was throughout the floodplain on the valley floor in northern San Joaquin Valley, including the Delta, but the original forest and floodplain have been reclaimed, cleared, altered, and degraded.

The remnant population of San Joaquin Valley woodrat is now restricted to 198 acres of remaining native riparian forest along the Stanislaus River in Caswell Memorial State Park and possibly on private property directly across from the Park in southern San Joaquin County in the east San Joaquin Basin Ecological Management Zone. It is considered a sensitive mammal because of its susceptibility to floods, fire, disease, predation, disturbance, and flood control activities. The large-scale loss of riparian forest has resulted in a substantial decline in the woodrats' population from historical levels.

Overall, the decline of the San Joaquin Valley woodrat was caused by the destruction, fragmentation, and degradation of the San Joaquin Valley native riparian forest habitat. Less than 6% of the original habitat remains. Remaining suitable habitat is so severely fragmented that the woodrat has no means of naturally dispersing to other areas and establishing additional populations. Because the remaining San Joaquin Valley woodrat population is known to occur within one small area, any of the following events threaten the remaining populations:

- Caswell Memorial State Park is subject to periodic flooding that often inundates the entire area. Without adequate cover on adjacent upland areas, the woodrats become easy targets for both native and non-native predators.
- The normal buildup of downed logs, dried vegetation, and ground litter is the riparian forest increases the potential severity of wildfires. Although this type of habitat is preferred and typically occupied by the San Joaquin Valley woodrat, any wildfire occurring within the remaining habitat could cause direct mortality as well as massive habitat destruction.
- Human activities have modified the habitat. The modified habitat has "selected" against the San Joaquin Valley woodrat.

VISION

The vision for the San Joaquin Valley woodrat is to contribute to the recovery of this federally listed endangered species through improvement in its habitat to contribute to the overall species richness and diversity.

Achieving this vision will reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta.

Restoring suitable mature riparian forest, protecting and expanding the existing population, and establishing new populations will be critical to the recovery of the San Joaquin Valley woodrat. Restoration of riparian habitats in the South Delta Ecological Management Unit of the Sacramento-San Joaquin Delta Ecological Management Zone and the East San Joaquin Basin Ecological Management Zone and adjacent upland plant communities will help the recovery of this species by increasing habitat area and providing refuge from flooding. Mature riparian forests with a brushy understory and adjacent upland habitat with sufficient cover during flooding would be suitable restored habitat. A healthy, brushy understory would contain: wild rose, blackberries, elderberries, wild grape, a buildup of downed logs, dried vegetation, and ground litter.

Restoring riparian habitat in the East San Joaquin Basin Ecological Management Zone to expand the area of suitable San Joaquin Valley woodrat habitat adjacent to occupied habitat along the Stanislaus River will help protect and allow the existing population of woodrats to expand. Establishing additional populations within the San Joaquin Valley woodrat's historical range in the Sacramento-San Joaquin Delta Ecological Management Zone would help to avoid potential species extinction. To ensure the survival of introduced populations, newly occupied habitat areas should be suitable only for the San Joaquin Valley woodrat and the riparian brush rabbit.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

A Recovery Plan for Upland Species of the San Joaquin Valley, California has been developed which contains specific measures for the San Joaquin Valley woodrat (U.S. Fish and Wildlife Service 1998). The California Department of Fish and Game and the U.S. Fish and Wildlife Service should continue the interagency coordination and commitment necessary to halt the further loss and deterioration of habitat and begin restoration and preservation of suitable habitat deemed essential to maintaining the subspecies in perpetuity.

There are a number of programs that involve these species:

- U.S. Fish and Wildlife Service,
- California Department of Fish and Game (DFG),
- California State Parks and Recreation,
- Riparian Habitat Joint Venture.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration and protection of the San Joaquin Valley woodrat is integrally linked with restoration of riparian forests reduction in wildfires and human disturbance in the northern San Joaquin Valley and the Delta.

The San Joaquin Valley woodrat is associated with the riparian brush rabbit in the riparian forests of the upper San Joaquin Valley. The historic range of this subspecies is nearly identical to that of the riparian brush rabbit. Presumably, suitable habitat restoration, expansion, and preservation for the San Joaquin Valley woodrat will also benefit the riparian brush rabbit.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

The Strategic Objective is to contribute to the recovery of at-risk native species in the Bay-Delta estuary and its watershed.

SPECIES TARGET: Protect the Caswell Memorial State Park Population; protect, enhance, and expand the species' Caswell Memorial Park population; and improve habitat connectivity and genetic interchange among isolated populations.

LONG-TERM OBJECTIVE: Establish San Joaquin Valley woodrat populations in riparian areas throughout its former range along the San Joaquin River.

SHORT-TERM OBJECTIVE: Increase the population sizes along the San Joaquin River in Stanislaus, Merced, and San Joaquin counties to the point where the woodrat will no longer be regarded as endangered.

RATIONALE: The San Joaquin Valley woodrat is a riparian-dwelling species whose distribution and ecology is poorly understood, but it apparently is confined to riparian areas in the San Joaquin Valley. It has been listed as endangered under the ESA and is a state Species of Special Concern. Because this population is known to exist in such a limited area in which most riparian habitat has been degraded, its long-term survival is likely to depend upon creation of more riparian habitat along the San Joaquin River, especially in Stanislaus, Merced, and San Joaquin counties. Any additional loss of habitat would have a significant negative impact on this species.

STAGE 1 EXPECTATIONS: A thorough survey of all riparian areas in the San Joaquin Valley will have been undertaken, both to identify the extent of existing populations and to identify habitats that would be good restoration sites for the woodrat and other riparian species. All precautions will have been taken to protect the existing populations from further decline.

RESTORATION ACTIONS

The following general targets will assist in meeting the implementation objective:

- Increase abundance in remaining population.
- Increase the number of woodrat populations.
- Increase the health of woodrats in the populations.

The following general programmatic actions will contribute to the recovery of the San Joaquin Valley woodrat:

- Expand the amount of riparian forest in the northern San Joaquin Valley and the Delta.
- Survey and map all riparian area along the San Joaquin River in it major tributaries.
- Increase the amounts of specific habitat features needed by woodrats in riparian forests where the existing population occurs or where introduced.
- Expand the amount of upland habitat adjacent to riparian habitat where the existing populations occur or to where new populations will be introduced.
- Develop in collaboration with owners of riparian land and local levee-maintenance districts incentive programs to preserve cover and riparian vegetation.
- Manage existing and new habitats to reduce potential threat of wildfire and human disturbance including hunting.
- Control predators where populations exist or will be introduced.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve San Joaquin Valley woodrat habitat or population targets.

- Coordinate protection and restoration of San Joaquin Valley woodrat populations and its habitats with other federal and state programs (e.g., U.S. Fish and Wildlife Service species recovery plans and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Direct ERP actions proposed for the Stanislaus River towards protecting, enhancing, and restoring suitable riparian and associated flood refuge habitats in and adjacent to occupied habitat at Caswell Memorial State Park.
- Direct ERP actions proposed for the San Joaquin River and its major tributaries within the current range of the species towards protecting and

enhancing existing occupied habitat areas; restoring suitable habitat adjacent to occupied habitat areas; and restoring suitable riparian habitat to create habitat corridors linking isolated populations.

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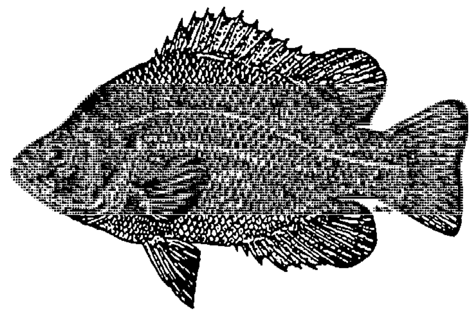
◆ Sacramento Perch



Sacramento Perch

Introduction

The Sacramento perch evolved in the Central Valley and is the only native sunfish in California and the only sunfish to evolve west of the Rocky Mountains (Moyle 1976). As a result of its isolation and lack of competition from other related species, it has retained many primitive structural and behavioral features. Given its historical lack of competition, it is not surprising that Sacramento perch have virtually disappeared from its native habitat following the introduction of a variety of sunfishes from the eastern United States.

Between 1888 and 1899, 40,000 to 432,000 pounds of Sacramento perch were sold annually in San Francisco. Sacramento perch are very rare today in the Delta. The decline, however, is probably not linked to harvest, but to three major stressors: habitat alteration or destruction, interspecific competition, and egg predation.

Sacramento perch are listed as a California species of special concern.

Resource Description

Prior to development, Sacramento perch inhabited much of the Central Valley with sloughs, sluggish rivers, and lakes in the valley floor as their primary habitats. Sacramento perch evolved with the ability to withstand high turbidities, high temperatures, and high salinities and alkalinities, all relatively common in the waters of the Central Valley (Moyle 1976).

Like many other aquatic species, Sacramento perch were likely affected by the construction of levees, the draining of overflow "swamp lands", and general loss of historic habitat. During this period, sunfishes from the eastern United States were introduced in to the Central Valley as well as catfish and carp. All of these introduced species were more aggressive than the native Sacramento perch and the resulting interspecific competition for food and space contributed to the population decline. In addition, these introduced species were able to consume Sacramento perch eggs as the eggs were undefended by adult perch.

Vision

The vision for the Sacramento perch is to contribute to the recovery of this California species of special concern and contribute to the overall species richness and diversity.

Achieving this vision will reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta.

Integration with Other Restoration Programs

There are a number of programs that could potentially involve this species and restoration efforts will be coordinated with agencies that have responsibility for implementing programs to restore certain types of wetlands:

- U.S. Fish and Wildlife Service,
- California Department of Fish and Game (DFG),
- Delta Protection Commission,
- Wildlife Conservation Board.

Efforts to restore and maintain Sacramento perch would involve cooperation and support from other established programs that protect and improve conditions for the delta smelt, striped bass, and other species.

- The Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes.

- Central Valley Project Improvement Act will implement actions that will benefit the Sacramento perch.

Linkage with Other Ecosystem Elements

The reintroduction of Sacramento perch into selected habitats in the Central Valley is closely linked to restoration of non-tidal perennial aquatic habitats, Delta sloughs, and elimination of interspecific competitor or predator species. It may be feasible to link the reintroduction of Sacramento perch with efforts to reverse subsidence in certain Delta islands. One approach to reversing subsidence may be to flood sections of subsided land for the purpose of promoting the growth of aquatic vegetation such as cattails and tules, plants which can contribute organic matter for rebuilding peat. These shallow water, heavily vegetated experimental plots may provide ideal habitat to design an experiment that addresses the reintroduction of Sacramento perch.

Objective, Targets, Actions, and Measures

> The Strategic Objective is to contribute to the recovery of at-risk native species in the Bay-Delta estuary and its watershed.

Species Target: Establish multiple self-sustaining populations of Sacramento perch within the Central Valley.

Long-Term Objective: Establish multiple, self-sustaining populations of Sacramento perch within the Central Valley region.

Short-Term Objective: Evaluate the status and biology of Sacramento perch to determine if restoration of wild populations within its native range is feasible.

Rationale: The Sacramento perch was once one of the most abundant fish in lowland habitats of the Central Valley. With the exception of a small population in Clear Lake, it has been extirpated from natural habitats within its native range, apparently because of competition and predation from introduced centrarchid fishes, such as black bass. It would be certainly be formally listed as an endangered species except that it has been widely introduced into reservoirs, lakes, and ponds outside its native habitats in California and other western states. Although some of these introduced populations are probably secure, most are in artificial waters subject to dewatering and other perturbations and a number have disappeared in recent years. There is thus a need to establish populations in places within their native range that can be closely monitored to be sure this species persists in the future. It is quite likely that many, if not all, of these places will be artificial habitats (e.g., ponds, reservoirs).

Stage 1 Expectations: A thorough status review of the Sacramento perch will have been completed and a plan for its long-term preservation in the Central Valley developed. At least one experimental population will have been established in the Delta.

Restoration Actions

Sacramento perch would benefit from the following actions and restoration activities:

- adding and modification of aquatic habitat,
- creation of tidally influenced wetlands,
- creation of set-back levees to increase shallow water habitat along existing channels,
- eliminating water hyacinth and other noxious aquatic plants from Delta channels,
- updating existing fish protection facilities at South Delta pumping plants,
- installing screens on unscreened diversions,
- removing competitors for similar habitats and food sources, and
- preventing further introductions of non-native aquatic organisms

MSCS Conservation Measures

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve Sacramento perch habitat or population targets.

- Coordinate protection and restoration of Sacramento perch and its habitats with other federal and state programs (e.g., U.S. Fish and Wildlife Service species recovery plans) that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Implement reintroductions into suitable habitat areas and manage habitat areas to maintain introduced populations.

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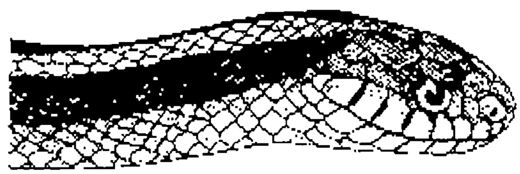

INTRODUCTION

The giant garter snake is a species that lives in the Central Valley of California. It inhabits sloughs, low-gradient streams, marshes, ponds, small lakes, agricultural wetlands, and other waterways, where it feeds on small fish and frogs during the active season. Populations of giant garter snake are found throughout much of the ERP study area including: the Feather River/Sutter Basin, Colusa Basin, Butte Basin, Yolo Basin, East Side Delta Tributaries, American River Basin, and portions of the Sacramento-San Joaquin Delta Ecological Management Zones. The status of giant garter snake in the San Joaquin Valley is unknown. The distribution and population of these species has declined substantially, primarily as a result of the loss or degradation of wetlands and nearby uplands. The loss of habitat and declining condition of these species' populations has warranted the listing of the giant garter snake as threatened under the State and federal Endangered Species Acts.

Major factors that limit these resources' contribution to the health of the Delta are related to adverse effects of conversion of aquatic, wetland, riparian, and adjacent upland habitats to other land uses and land use practices that degrade the value of otherwise suitable habitat areas.

RESOURCE DESCRIPTION

Historic habitat areas used by these species have been substantially reduced as a result of converting land for agriculture, urban, or industrial uses or degraded as a result of ongoing land-use practices. Remaining habitat areas, such as ponds, rivers, streams, lakes, marshes, and irrigation ditches, are largely fragmented. Associated uplands, used for reproduction and hibernation, are largely unavailable. Upland habitats adjacent to aquatic habitats are now mostly isolated in small riparian bands along the tributaries that supply water to the Sacramento and San Joaquin Rivers and along canals with small levees.

Because much of the original habitat used by these species has been lost, irrigation canals and ditches (especially canals with nearby vegetation) now provide important replacement habitat for these species. Rice farming makes up a significant portion of the agricultural activity in the Sacramento Valley, and drainage ditches associated with rice farming practices provide much of this surrogate habitat. Adjacent breeding and hibernating cover, however, is often limiting for these species.

Other factors that limit these species populations include:

- some agricultural practices (e.g., discing, mowing, burning, and applying herbicides and rodenticides) that degrade habitat or cause mortality;
- introduced large predatory fish that prey on juveniles and injure adults; and
- mortality caused by flooding of hibernation sites during heavy rains, floods, or for waterfowl.

VISION

The vision for the giant garter snake is to contribute to the recovery of this State- and federally listed threatened species in order to contribute to the overall species richness and diversity.

Achieving this vision will reduce the conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta.

Protecting existing and restoring additional suitable wetland and upland habitats will be critical to achieving recovery of the giant garter snake. The ERPP's proposed restoration of aquatic, wetland, riparian, and upland habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will help in the recovery of these species by increasing habitat quality and area.

Integration with Other Restoration Programs

Restoration projects to improve upland and wetland agriculture and seasonal wetland and riparian habitats would be closely linked to the restoration of these species. The American River Basin is ecologically important because it contains the most stable populations of giant garter snakes. The Biological Resources Division of the USGS is presently studying stable populations of giant garter snakes that occur outside the American River Basin. These include populations in the Colusa–Basin (Sacramento and Colusa National Wildlife Areas), the Badger Creed areas of the Cosumnes River Preserve, and the Gilsizer Slough area of the Sutter Basin. Restoration and agricultural improvements will be developed for implementation both north and south of the Delta.

Efforts to recover giant garter snake populations will involve cooperation and support from other established programs aimed at restoring habitat and populations.

Wetland restoration and management programs that would improve habitat for these species include the Agricultural Stabilization and Conservation Service's Wetland Reserve Program, the Wildlife Conservation Board's Inland Wetlands Conservation Program, restoration programs administered by Ducks Unlimited and the California Waterfowl Association, and ongoing management of State and federal wildlife refuges and private duck clubs. Restoration efforts will be conducted in cooperation with agencies or organizations with responsibility or authority for restoring wetland and aquatic habitats, including DFG, California Department of Water Resources, USFWS, U.S. Army Corps of Engineers, and the Delta Protection Commission. USFWS is also preparing a recovery plan for the giant garter snake that will establish population recovery goals.

Linkage with Other Ecosystem Elements

Restoration of ecosystem processes and habitats proposed by ERPP in other ecological management zones will also allow natural floodplains, stream meanders, and seasonal pools to develop that assist in the recovery of their populations elsewhere in their historic ranges.

Objective, Targets, Actions, and Measures

> The Strategic Objective is to contribute to the recovery of at-risk native species in the Bay-Delta estuary and its watershed.

Species Target: Protect the existing population and habitat within the Delta Region, and restore, enhance, and manage suitable habitat areas adjacent to known populations to encourage the natural expansion of the species.

Long-Term Objective: Establish or restore populations of giant garter snake in restored marshlands through out its original range.

Short-Term Objective: Maintain present populations with no further declines in size by ensuring that waterways known to being used by giant garter snakes have water in them year round.

Rationale: The giant garter snake is listed by both state and federal governments as a threatened species. Most of the original giant garter snake habitat, freshwater marshes, has been lost to agriculture. This snake resides in marsh habitat where there are pools and sloughs that exist year round to provide the frogs and invertebrates on which they feed. This snake survives today because small numbers live in rice fields and along irrigation ditches. Survival of the species, however, is likely to depend upon increasing its natural habitat through marsh restoration combined with special protection measures on the agricultural land it currently inhabits.

Stage 1 Expectations: Existing natural habitats that have available water all year will have been maintained, and key habitats in agricultural areas identified for special management. Sites for freshwater marsh restoration will have been identified and a restoration program established.

RESTORATION ACTIONS

The general target is to increase the population size of giant garter snakes.

General programmatic actions to protect occupied habitat areas include the following:

- Implement a preservation plan to protect these areas from adverse effects associated with human encroachment and recreation,
- Create canals, side channels, and backflow pools containing emergent vegetation within the South, East, and North Delta Ecological Units of the Sacramento-San Joaquin Delta Ecological Management Zone to provide forage habitat and escape cover, and create dispersal corridors by linking habitat areas.
- Restore suitable adjacent upland habitat or modify land use practices to render existing uplands as suitable habitat and reestablish connectivity between wetland and upland habitat areas, provide nest and hibernation sites, and provide refuge habitat during floods.
- Create buffer zones where none currently exist to improve habitat value.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve giant garter snake habitat or population targets.

- A substantial portion of tidal wetlands to be restored under the ERP should be restored in the North Delta (the Yolo Basin and Bypass)
- To the extent consistent with CALFED objectives, protect existing and restore additional habitat in the east Delta to create a corridor of suitable habitat linking Stone Lakes, the Cosumnes River, and White Slough.
- To the extent practicable, design setback levees in the restored Stone Lakes/Cosumnes River/White Slough habitat corridor to include a mosaic of habitats.
- Identify opportunities for implementing levee maintenance practices in the Delta that will maintain suitable levee habitat or minimize the impacts of necessary maintenance on the species and its habitat.
- Incorporate restoration of permanent or seasonal flooded (April-October) suitable habitat areas as part of a mosaic of the seasonal wetland and agricultural land enhancements to be implemented under the ERP.
- To the extent consistent with CALFED objectives, locate ERP nontidal marsh restorations near existing occupied habitat areas and design restorations to include suitable upland habitat areas at least 200 feet around restored wetlands.
- Include improvements to and maintenance of suitable agricultural infrastructure habitat (i.e., ditches, drains, canals, and levees) as part of ERP actions to improve wildlife habitat values associated with agricultural lands.
- To the extent consistent with CALFED objectives, manage lands purchased or acquired under conservation easements that are occupied by the species to maintain or increase their current population levels.
- Monitor suitable wetlands restored in the Delta Region adjacent to or near occupied habitats to assess if and when (relative to habitat maturity) giant garter snake occupy restored habitat or to identify reasons they are not using restored and apparently suitable habitat.

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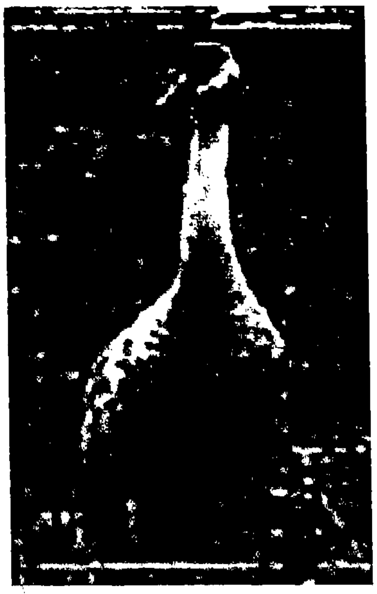
◆ GREATER SANDHILL CRANE



INTRODUCTION

This subspecies of the sandhill crane primarily winters in the Delta and forages and roosts in agricultural fields and pastures. Because the winter range of the greater sandhill crane overlaps the winter range of other sandhill crane subspecies, all subspecies are considered important resources. The greater sandhill crane population has declined primarily as a result of loss of suitable wetland nesting habitats. The loss of habitat and declining condition of the subspecies' population have warranted its listing as threatened under the California Endangered Species Act. Major factors that limit this resource's contribution to the health of the Bay-Delta are related to adverse effects of conversion of grassland and wetland habitats for agricultural, industrial, and urban uses.

RESOURCE DESCRIPTION

The greater sandhill crane is an important part of the biological integrity and health of the Bay-Delta and Sacramento-San Joaquin Valley ecosystems. The greater sandhill crane is found throughout most of the Central Valley in winter and nests in northeastern California and Oregon.

Habitats used by the sandhill crane include seasonal and fresh emergent wetlands, grasslands, and agricultural lands. Large wintering populations of greater and lesser sandhill cranes congregate in the Sacramento and San Joaquin Valleys. Generally, crane wintering habitat consists of shallowly flooded grasslands that are used as loafing and roosting sites and nearby agricultural areas that provide food sources include rice, sorghum, barley, and corn. In the Delta, in adequate roost sites, relatively free from disturbance and quality and quantity of forage, are potential limiting factors on the wintering population.

The State-listed greater sandhill crane is a fully protected species because the small remaining population depends on habitat that is threatened with loss or degradation. The conversion of grasslands, wetlands, and agricultural land to urban development is an ongoing process that is not likely to be reversed. The sandhill crane now depends primarily on artificially created areas where natural wetland and grassland habitats have been eliminated. Disturbance associated with human activities, illegal harvest, and predation have also affected the overall health of the crane population, although less severely than the loss and degradation of its habitats.

VISION

The vision for the greater sandhill crane is to contribute to the recovery of this State-listed threatened species in the Bay-Delta.

Recovery of the greater sandhill cane would contribute to overall species richness and diversity. Achieving this vision will reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.

Maintenance of healthy populations of other sandhill crane subspecies will also improve by providing sufficient wintering habitat in the Bay-Delta. Habitat restoration these in the Sacramento-San Joaquin Delta Ecological Management Zone will help maintain healthy populations.

The greater sandhill crane will benefit from restoration of shallowly flooded wetlands. Implementing existing crane recovery and waterfowl management plans will also help achieve this vision. Such strategies could be implemented through collaborative work with organizations to maintain and improve existing preserves, cooperative agreements with land management agencies, or conservation easements or purchase from willing sellers.

Restoration of ecosystem processes and habitats in other ecological management zones will also allow seasonal and fresh emergent wetlands and grasslands to develop that will provide habitat for wintering sandhill cranes elsewhere in the Central Valley.

Integration with Other Restoration Programs

Restoration of sandhill cranes in the Central Valley is conducted by the following programs:

- A Pacific Flyway Management Plan for the Central Valley population of greater sandhill cranes to recover the population has been developed and is being implemented by the U.S. Fish and Wildlife Service and the California and Oregon Departments of Fish and Game.
- The Central Valley Habitat Joint Venture Implementation Plan contains goals to protect and restore Central Valley aquatic and upland habitats that are needed for waterfowl. This plan provides indirect benefits for the greater sandhill crane and other species that use these wetland and upland habitats.
- California Department of Fish and Game and The Nature Conservancy are working to protect and restore crane habitat in the area of the Woodbridge Ecological Reserve and the Cosumnes River Preserve.

Linkage with Other Ecosystem Elements

Restoration and recovery of the greater sandhill crane population of the Central Valley is integrally linked with wetland and riparian habitat restoration, and agricultural habitat improvement.

Objective, Targets, Actions, and Measures

> The Strategic Objective is to contribute to the recovery of at-risk native species in the Bay-Delta estuary and its watershed.

Species Target: Achieve recovery objectives identified in the Pacific Flyway Management Plan for the Central Valley population of greater sandhill cranes and Assembly Bill (AB) 1280 legislation that applicable to CALFED problem area, the Butte Sink, and other species' use areas.

Long-Term Objective: Restore roosting, foraging, and loafing habitat for the greater sandhill crane in the Central Valley.

Short-Term Objective: Restore populations to the point where the crane can be removed from the state threatened species list.

Rationale: The greater sandhill crane is a spectacular bird that listed as threatened in California and fully protected under the Fish and Game Code. It is a year around resident, nesting in grasslands and wetlands. Much of their nesting habitat has been lost to agricultural conversion and intensive cattle grazing. They will forage in moist cropland and as well as in emergent wetlands, newly planted and sprouting crops, harvested crops, fallow fields, uncultivated areas, canals and irrigation ditch banks. Greater sandhill cranes prefer open areas with shallow fresh water for drinking and bathing. Most winter in the Delta region and require protected roosting habitat near dormant agricultural fields in which they forage.

Stage 1 Expectations: A program will have been implemented to protect wintering (foraging, roosting, and loafing habitats) habitat that already exists and maintain population size. Current populations within the Central Valley will have been monitored.

Restoration Actions

General targets for greater sandhill crane are to:

- Increase the number of greater sandhill cranes in the Central Valley population,

- Increase the distribution of greater sandhill crane in the Central Valley,
- Decrease disturbance at roosting sites due to waterfowl, pheasant, and rabbit hunters, and
- Increase the number and sizes of "closed areas" on wildlife areas to provide undisturbed areas for the crane.

General programmatic actions to contribute to the recovery of greater sandhill crane include:

- Protect existing habitats and restore additional suitable seasonal and fresh emergent wetlands grasslands, riparian woodlands, fallow fields, and harvested fields,
- Increase the number of duck clubs that retain water after the waterfowl season ends, and
- Improve agricultural land management to reduce disturbance caused by human activities.

MSCS Conservation Measures

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve greater sandhill crane habitat or population targets.

- To the extent consistent with Program objectives, implement ERP actions in concert with the species recovery strategies identified in AB 1280 and the Pacific Flyway Plan.
- Implementation of proposed ERP actions to enhance agricultural habitats should give priority to improving the abundance and availability of upland agricultural forage (e.g., corn and winter wheat) in the core use area centered around Bract Tract.
- Implementation of proposed ERP actions to restore wetlands should give priority to restoring and managing wetland habitat area within the core use area centered on Bract Tract that would provide suitable roosting habitat.
- Avoid or minimize recreational uses in the core area centered on Bract Tract that could disrupt crane habitat use patterns from October-March.
- To the extent consistent with Program objectives, at least 10% of agricultural lands to be enhanced under the ERP in the Delta and the Butte Sink should be managed to increase forage abundance and availability for cranes. Priority should be given to implementing these habitat improvements within 10 miles of core habitat area centered on Bract Tract.
- Monitor to determine use of protected, restored, and enhanced habitats by sandhill cranes in core wintering areas.

References

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◆ California Yellow Warbler

Introduction

As a neotropical migrant, the California yellow warbler is present in California from April to October. During these months the California yellow warbler primarily utilizes underbrush of open deciduous riparian woodlands for home territories, foraging areas and nesting sites. Recently, breeding populations in valley areas have been declining due to destruction of riparian habitats as well as nest parasitism by the brown-headed cowbirds. Due to a consistent, gradual decline of breeding populations in California, the California yellow warbler has been listed as a California Species of Special Concern.

Resource Description

California yellow warblers summer throughout northern California and in the coastal regions of southern California. In recent decades there has been a marked decline in the breeding population of California yellow warblers in the San Joaquin and Sacramento valleys. Once common in these areas, the California yellow warbler has been displaced due to loss of riparian habitat caused by agricultural and urban development.

Another cause of breeding population decline is brood parasitism by brown-headed cowbirds. Brood parasitism by cowbirds has been documented to lower the reproductive success of warblers. In areas where cowbird populations are high the population numbers of California yellow warblers are very low despite the quality of habitat, therefore, decline of warbler populations due to parasitism can be attributed to loss of the birds' common habitat. As habitat decreases both birds must use more common habitat for foraging and territory creating a situation where California yellow warblers are more accessible and therefore more easily parasitized by brown-headed cowbirds.

Vision

The vision for the California yellow warbler is to contribute to the recovery of this California species of special concern.

This will be accomplished by increasing the size and quality of riparian habitats in California, especially in those areas with high populations of brown-headed cowbirds. By increasing the area of riparian habitats, the California yellow warbler and the brown-headed cowbird populations will not be as compacted. Greater areas of riparian habitat and lowering population densities of yellow warblers and cowbirds will allow for higher population numbers of passerine species that the cowbird can also parasitize. With more habitat and greater numbers of those species that the cowbird can parasitize, the rate at which California yellow warblers are being parasitized should decrease. Furthermore, by creating more riparian habitat and improving the quality of existing habitat, a more diverse and sustainable riparian community will be created.

Integration with Other Restoration Programs

Related restoration programs include:

- Central Valley Project Improvement Act,
- Cache Creek Corridor Restoration Plan,
- Cosumnes River Preserve,
- Riparian Habitat Joint Venture,
- Upper Sacramento River Advisory Council's Riparian Habitat Committee (SB 1086 program),
- San Joaquin River Management Program, and
- U.S. Fish and Wildlife Service's Anadromous Fish Restoration Plan.

Linkage with Other Ecosystem Elements

Restoration of the California yellow warbler and its riparian habitat is linked to restoring healthy and diverse riparian communities throughout California.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

> The Strategic Objective is to contribute to the recovery of at-risk native species in the Bay-Delta estuary and its watershed.

SPECIES TARGET: Maintain and enhance suitable riparian corridor migration habitats and restore suitable breeding habitat within the historic breeding range of these species in the Central Valley.

LONG-TERM OBJECTIVES: Substantially improve breeding and migration habitats for all neotropical migrant birds to increase their rates of reproduction and survival.

SHORT-TERM OBJECTIVES: Maintain breeding populations at present levels and develop restoration projects that will benefit migrating individuals.

RATIONALE: Neotropical migratory birds constitute a diverse group of largely passerine songbirds that overwinter in the tropics but breed in or migrate through the Central Valley and Bay-Delta region. As a group, they are in decline because of loss of habitat on their breeding grounds, in their migratory corridors, and in their wintering grounds. The species within this group are good indicators of habitat quality and diversity and their popularity with birders means that populations are tracked and have high public interest. They can also be good indicators of contaminant levels, by monitoring reproductive success and survival in areas near sources of contamination. Riparian forests are particularly important to this group because they are major migration corridors and breeding habitat for many species. By providing improved nesting and migratory habitat, it may be possible to partially compensate for increased mortality rates in the wintering grounds. Improved habitat for songbirds also provides habitat for many other species of animals and plants.

STAGE 1 EXPECTATIONS: A "master plan" will have been developed for the conservation of neotropical migrants in the Bay-Delta watershed that includes status reports and habitat requirements for all species. This information will have been used to integrate neotropical migrant conservation into various restoration projects or to develop restoration projects specifically aimed at improving migration and breeding habitat for selected members of this group.

RESTORATION ACTIONS

The following targets will aid in achieving the implementation objective:

- Increase breeding numbers of California yellow warblers throughout California.
- Reduce the amount of brood parasitism by brown-headed cowbirds on California yellow warblers.

The following programmatic actions will contribute to the recovery of the California yellow warbler:

- Increase the amount of riparian habitat throughout California
- Improve the quality of disturbed riparian habitat

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve California yellow warbler habitat or population targets.

- Coordinate protection and restoration of riparian habitat areas with other federal and state programs (e.g., the Riparian Habitat Joint Venture, the SB 1086 Program, and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- To the extent consistent with CALFED objectives, protect existing suitable riparian habitat corridors from potential future changes in land use or other activities that could result in the loss or degradation of habitat

- A portion of restored riparian habitat area should be designed to include riparian scrub communities.
- To the extent practicable, restore riparian habitat in patch sizes sufficient to discourage nest parasitism by brown-headed cowbirds..

REFERENCES

Multi-Species Conservation Strategy. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

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◆ LITTLE WILLOW FLYCATCHER

INTRODUCTION

The little willow flycatcher is one of many neotropical migrants which is a relatively widespread summer resident in wooded settings near water and open areas. It prefers dense shrub cover to timber, especially willow thickets. It is dependent upon the flora of California to forage and reproduce, typically from about May until September. The rest of the year is normally spent in Central America and South America.

Efforts to protect and restore the habitat needed to attain a healthy state for this species will not only require the restoration of a number of ecological process and functions, but will also require the combined efforts of federal, state, private organizations, and landowners to provide sufficient restored and improved habitat for the survival of this species.

RESOURCE DESCRIPTION

Habitats used by this species include forested woodland, riparian, unforested lowlands, grasslands, montane riparian habitats, and shrub habitats near open areas or water. These habitats have been and continue to be lost due to the alteration of habitat by agricultural conversions and urban land development.

VISION

The vision for the little willow flycatcher is to contribute to the recovery of this State-listed endangered species.

Recovery of the little willow flycatcher would contribute to overall species richness and diversity. Achieving this vision will reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta. The vision will be attained by improving nesting and foraging habitat in the Central Valley and foothills of the State through the restoration of natural processes and functions which will help lead to sustained healthy populations. Restoring broad bands of dense willow-cottonwood riparian and riparian scrub habitat will contribute to sustaining improved ecosystem processes and functions to restore the health of aquatic and terrestrial resources in and dependent on the riverine and riparian systems. While attaining this vision, habitat improvements will support an increased level of production of insects and other macro invertebrates which are important elements of the food web for fish and wildlife including rearing chinook salmon.

The restored riparian habitat and natural processes in the relevant ecological management zones will improve river and channel water temperatures, and support stream meander and flood processes that will all contribute to improving the ecological health of the aquatic resources in and dependent on the Bay-Delta. This vision is congruent with CALFED's vision to restore the Bay-Delta ecosystem to a healthy state for listed fish and wildlife.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Examples of related restoration programs include the following:

- Central Valley Project Improvement Act;
- Cache Creek Corridor Restoration Plan;
- Cosumnes River Preserve;
- Riparian Habitat Joint Venture;
- Upper Sacramento River Advisory Council's Riparian Habitat Committee (SB 1086 Program);
- San Joaquin River Management Program; and,
- U.S. Fish and Wildlife Service's Anadromous Fish Restoration Plan.

All these programs will play important and integral roles, coordinated through CALFED, to achieve the vision for the little willow flycatcher.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Efforts to protect and restore the habitat needed to attain a healthy state for this species will not only require the restoration of a number of ecological process and functions, but will also require the combined efforts of federal, state, private organizations, and landowners to provide sufficient restored and improved habitat for the survival of this species.

ECOSYSTEM PROCESSES. The primary ecological processes that help recruit neotropical migrants include nutrient inputs and vegetation succession. These two processes supply the food and cover components required such as the invertebrates which invariably become prey items. These processes are currently influenced by land uses and other human disturbances and their restoration is vital to improve ecological health of the Bay-Delta. Through the restoration of several ecological process including stream meander belts, vegetation succession, overbank flooding, floodplain inundation, and secondary production the essential elements needed by this species will be restored to improve the food web as well as provide optimum breeding and roosting habitat.

HABITAT. The primary threat to neotropical migratory birds has been, and continues to be, loss and alteration of habitat by agricultural conversion (plowing and leveling of land), river channelization, dam construction, drainage and pipeline construction. The little willow flycatcher and other species' nests are parasitized by brown-headed cowbirds when adequate vegetative cover is not available. Species that are deep forest nesters have been the most adversely affected by habitat fragmentation.

Restoration of habitats used by neotropical birds such as riparian, perennial grasslands, and oak woodlands, in conjunction with restoring related ecosystem functions and processes, will be the primary approach used to achieve CALFED's vision. Large scale restoration of nesting habitat will help reduce nest parasitism and predation.

STRESSORS. Stressors at one time or another contribute to reduced reproductive success of neotropical avian species. Land use, human disturbance, elevated levels of competition and predation by exotic species, wildfire, and contaminants are all stressors that affect the ecological health of this species. For instance, insect populations that form the base of the food web can be severely impacted by pesticide drift from nearby agricultural lands.

Reducing the effects of stressors will be a major factor in preventing further loss of existing nesting and foraging habitat. Where consistent with flood control needs, modification of levees and bank protection measures which would otherwise inhibit the natural establishment of vegetation succession will allow areas to naturally change over time. By controlling human disturbance in nesting areas and improving water management a number of species will benefit. The implementation of fire breaks and other types of buffers would be useful in preventing the adverse impacts of wildfires.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

> The Strategic Objective is to contribute to the recovery of at-risk native species in the Bay-Delta estuary and its watershed.

SPECIES TARGET: Maintain and enhance suitable riparian corridor migration habitats and restore suitable breeding habitat within the historic breeding range of this species in the Central Valley.

LONG-TERM OBJECTIVE: Restore little willow flycatcher to abundance throughout its native range by protecting and restoring contiguous expanses of montane riparian habitats in the Sierra Nevada and Cascade ranges.

SHORT-TERM OBJECTIVE: Have enough self-sustaining populations of little willow flycatcher so that the species can be removed from the state list of endangered species.

RATIONALE: The little willow flycatcher is a neotropical migrant bird that is listed by the state as endangered and by federal government as a species of concern. Little willow flycatchers nest and roost in montane riparian habitats in the Sierra Nevada and Cascade ranges consisting of dense willow thickets. Lower exposed perches provide singing and hunting platforms. In areas that are heavily grazed by cattle little willow flycatchers are absent from areas that appear to provide suitable habitat. Restoration of this bird will presumably require restoring large expanses of riparian thickets within the habitat ranges of the little willow flycatcher, in part by excluding cattle grazing.

STAGE 1 EXPECTATIONS: The range within California of the little willow flycatcher will have been determined and measures to protect and enhance remaining habitat areas will have been implemented.

RESTORATION ACTIONS

The target for restoring the neotropical migratory birds including the little willow flycatcher is to restore riparian habitat in the Delta Ecological Management Zone, the Sacramento River Ecological Management Zone, and the San Joaquin Ecological Management Zone. The actions proposed to achieve this target will be implemented in conjunction with actions taken by CALFED members and cooperating agencies to restore aquatic resources in and dependent on the Bay-Delta

The following are potential actions that if implemented by themselves or in combination would help achieve the short and long-term targets:

- Set back levees to create hydrologic conditions necessary for seasonal flooding and vegetation succession.
- Establish programs for landowners that provide incentives for the establishment and maintenance of shaded riverine aquatic and oak woodland habitat.
- Modify, where consistent with flood control objectives, vegetation management practices along levees to allow for the natural reestablishment of shaded riverine aquatic vegetation.
- Develop and implement alternatives to land management practices on public lands that now continue to degrade woodland and shaded riverine aquatic habitat quality or inhibit recovery and provide incentives to landowners for implementing more desirable land use practices.
- Protect 50 percent of existing habitat areas from potential future degradation through acquisition of conservation easements or in-fee title.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve little willow flycatcher habitat or population targets.

- Coordinate protection and restoration of riparian habitat areas with other federal and state programs (e.g., the Riparian Habitat Joint Venture, the SB 1086 Program, and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- To the extent consistent with CALFED objectives, protect existing suitable riparian habitat corridors from potential future changes in land use or other activities that could result in the loss or degradation of habitat
- A portion of restored riparian habitat area should be designed to include riparian scrub communities.
- To the extent practicable, restore riparian habitat in patch sizes sufficient to discourage nest parasitism by brown-headed cowbirds..

REFERENCES

Multi-Species Conservation Strategy. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

◆ Western Yellow-Billed Cuckoo

Introduction

The western yellow-billed cuckoo is associated with mixed riparian and cottonwood forests. This species has been eliminated from the Bay-Delta. Elsewhere, the population and range of this species have declined primarily as a result of the loss or degradation of extensive, mature and successional riparian cottonwood forests. The loss of habitat and declining condition of the species' population have warranted its listing as endangered under the California Endangered Species Act.

Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of flood control and bank protection projects, which resulted in the direct loss of riparian forests and reduced or eliminated the processes that create and maintain floodplains that support riparian forests, and reclamation of riparian forests for agricultural, industrial, and urban uses.

Resource Description

Historically, the yellow-billed cuckoo commonly occurred from the Mexican border along the coast belt through the San Francisco Bay region as far as Sebastopol, Sonoma County, and through the Sacramento and San Joaquin Valleys. Yellow-billed cuckoos inhabit extensive deciduous riparian thickets or forests with dense, low-level or understory foliage that abut rivers, backwaters, or seeps. The cuckoo, is limited to some reaches of the Sacramento River, Sanborn Slough in the Butte Sink, and the Feather River. The population of this species is critically low. Dense, large patches of willow-cottonwood riparian habitat are the preferred nesting habitat for this neotropical migrant. This habitat was once much more common, particularly along the Sacramento and San Joaquin rivers; however, conversion of land to agriculture, urbanization, and flood control projects have caused the loss of habitat. Other stressors that continue to adversely affect the species are loss of habitat as a result of bank protection projects, mortality associated with non-native nest parasites and predators, and inadvertent drift of some types of herbicides and pesticides into habitat areas.

Vision

The vision for the western yellow-billed cuckoo is to contribute to the recovery of this State-listed endangered species.

Recovery of this species would contribute to overall species richness and diversity. Achieving this vision will reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.

Protection and restoration of existing and suitable mature riparian forest will be critical to the recovery of the yellow-billed cuckoo. Restoration of riparian habitats in the Sacramento-San Joaquin Delta, Sacramento River, Cottonwood Creek, Colusa Basin, Feather River/Sutter Basin, and American River Basin Ecological Management Zones will help to recover this species by increasing the quality and quantity of its habitat.

Integration with Other Restoration Programs

No program is specifically charged with restoring yellow-billed cuckoo populations. Restoration efforts sponsored by the Upper Sacramento Fish and Riparian Habitat Advisory Council (SB1086) have the potential for benefitting the species. The purpose of riparian habitat planning through the SB1086 program is to preserve remaining riparian habitat and reestablish a continuous riparian ecosystem along the Sacramento River.

Linkage with Other Ecosystem Elements

Restoration and recovery of the yellow-billed cuckoo population of the Central Valley is integrally linked with wetland and riparian habitat restoration, and agricultural habitat improvement.

Objective, Targets, Actions, and Measures

> The Strategic Objective is to contribute to the recovery of at-risk native species in the Bay-Delta estuary and its watershed.

Species Target: Protect existing suitable riparian forest habitat areas within the species' historic range, and increase the areas of suitable riparian forest habitat sufficiently to allow the natural expansion of the Sacramento Valley population.

Long-Term Objective: Establish breeding populations of western yellow-billed cuckoo in riparian areas throughout the Central Valley.

Short-Term Objective: Restore enough populations to western yellow-billed cuckoo so it can be removed from the list of endangered species.

Rationale: The yellow-billed cuckoo is listed as an endangered species in California because it has disappeared from most of the riparian areas it once inhabited. The cause of their decline seems too have been loss and alteration of riparian forests, combined with heavy pesticide use in adjacent farmland. Yellow-billed cuckoos have strict habitat requirements for successful breeding, including humid conditions and dense strands of willows and cottonwoods along riverbeds. Yellow-billed cuckoos do not just inhabit old growth trees so reforested areas can be used as successful breeding areas. Limiting pesticide use in the area is needed so there is an ample food supply of insects to feed the young.

Stage 1 Expectations: Existing populations will have been stabilized and any further loss of feeding and nesting habitat will have been prevented. Riparian areas suitable for yellow-billed cuckoo will have been identified and prioritized for restoration and, if necessary, reintroduction of cuckoos.

Restoration Actions

The general target is to increase the population of yellow-billed cuckoo in the Central Valley.

The general programmatic action which will assist in reaching the target is to improve and restore riparian forest habitat suitable for the yellow-billed cuckoo in the Central and Sacramento valleys.

MSCS Conservation Measures

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve yellow-billed cuckoo habitat or population targets.

- Coordinate protection and restoration of riparian habitat areas with other federal and state programs (e.g., the Riparian Habitat Joint Venture, the SB 1086 Program, and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Initially direct ERP actions to restore suitable valley/foothill riparian forest and woodland along at least 10 contiguous miles of channels in the Delta to create a riparian forest corridor at least 200 meters in width.
- Restore large contiguous blocks of suitable valley/foothill riparian forest and woodland at least 200 meters in width and 500 acres in size along reaches of the Sacramento River adjacent to occupied habitat areas (Red Bluff to Chico).

References

Multi-Species Conservation Strategy. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

INTRODUCTION

The least Bell's vireo is listed as both a federal and state endangered species. It is a rare summer resident in parts of southern California and northern Baja. It is most likely seen in San Benito and Monterey counties in the canyons and willows and other dense valley-foothill riparian habitat.

The major factors affecting the least bell vireo's population is cowbird parasitism and habitat destruction and degradation.

RESOURCE DESCRIPTION

The least Bell's vireo population in California has declined drastically over the past few decades in both numbers and expanse of the breeding range. The northern range of the population once extended to Chico, California, currently however it is limited to Santa Barbara county. It is estimated that the current population of least Bell's vireo in California is limited to 450 nesting pairs. The decline of the least Bell's vireo can be attributed to two different events that directly affect the population. Nest parasitism by brown-headed cowbirds and the degradation and loss of riparian habitat to support breeding populations through out California.

Nesting occurs from mid-April to July at the edge of riparian thickets or open fields with nesting pairs building at least two nests per territory. The eggs hatch in 14 days and the young fledge from the nest in 11 to 12 days.

VISION

The vision for the Least Bell's vireo is to contribute to the recovery of this State and federally listed endangered species to contribute to the overall species richness and diversity.

Achieving this vision will reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. This will be accomplished by increasing the existing breeding range in California to historic levels in the early 1900s. It is believed that increasing the amount of nesting habitat will spread out current breeding pairs and reduce the level of brown-headed cowbird nest parasitism and reduce nesting failures.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Related restoration programs include:

- Central Valley Project Improvement Act,
- Cache Creek Corridor Restoration Plan,
- Cosumnes River Preserve,
- Riparian Habitat Joint Venture,
- Upper Sacramento River Advisory Council's Riparian Habitat Committee (SB 1086 program),
- San Joaquin River Management Program, and
- U.S. Fish and Wildlife Service's Anadromous Fish Restoration Plan.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of the least Bell's vireo and its riparian habitat is linked to restoring healthy and diverse riparian communities throughout California.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

The Strategic Objective is to contribute to the recovery of at-risk native species in the Bay-Delta estuary and its watershed.

SPECIES TARGET: Achieve recovery objectives identified in the least Bell's vireo recovery plan applicable to the ERP focus study area.

LONG-TERM OBJECTIVE: Restore populations of least Bell's vireo to riparian areas throughout California.

SHORT-TERM OBJECTIVE: Recover least Bell's vireo populations to the point where it can be removed from state and federal endangered species lists.

RATIONALE: The least Bell's vireo was once quite common throughout the coastal and Sacramento and San Joaquin Valleys. The current distribution of least Bell's vireo in California is in isolated pockets in Southern California and along the Colorado River. Currently, the least Bell's vireo is listed as an endangered species by both the state and federal governments due to its rapid decline in population and distribution. The least Bell's vireo's decline has been attributed to degradation and destruction of nesting habitat among riparian thickets. Nest parasitism by cowbirds, a side effect of the narrowing and isolation of riparian habitats, has also contributed to the decline of least Bell's vireo.

STAGE 1 EXPECTATIONS: The current distribution and population of least Bell's vireo within California will have been determined and strategies for reintroducing it into central California will have been completed. Riparian restoration programs will have included the idea of recreating habitat for this bird.

RESTORATION ACTIONS

The target would be to increase the number of nesting pairs and their distribution within historic ranges.

Least Bell's vireo will benefit from the following actions and restoration activities:

- Reduce the amount of brood parasitism by brown-headed cowbirds on California yellow warblers.
- Increase the amount of riparian habitat throughout California.
- Improve the quality of existing degraded riparian habitat.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve least Bell's vireo habitat or population targets.

- Coordinate protection and restoration of riparian habitat areas with other federal and state programs (e.g., the least Bell's vireo recovery plan team, Riparian Habitat Joint Venture, and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- To the extent consistent with CALFED objectives, protect existing riparian habitat areas from potential future changes in land use or other activities that could result in the loss or degradation of habitat areas that would be suitable for reintroductions or natural colonization of the species.
- A portion of restore riparian habitat area should be designated to include riparian scrub communities.
- To the extent practicable, restore riparian habitats in patch sizes sufficient to discourage nest parasitism by brown-headed cowbirds.

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◆ SALTMARSH COMMON YELLOWTHROAT

INTRODUCTION

The saltmarsh common yellowthroat is designated as a species of special concern by the California Department of Fish and Game.

RESOURCE DESCRIPTION

The historical distribution of the saltmarsh common yellowthroat included the San Francisco Bay Area from Tomales Bay and Napa Sloughs south to San Jose during the breeding season, and San Francisco Bay south along the coast to San Diego County during winter (Grinnell and Miller 1944). Although the range for the yellowthroat has remained relatively stable, the total population of the subspecies has decreased.

The saltmarsh common yellowthroat occurs year round in the Suisun Marsh/North San Francisco Bay Ecological Management Zone.

During the breeding season, April to July, the saltmarsh common yellowthroat build nest among dense vegetation in fresh- or brackish water marshes. Associated plant species include cattails, tules, and other sedges, young willow trees, and blackberry vines. The species if found near saltwater marshes more often during the fall and winter months (Grinnell and Miller 1944).

Loss of suitable habitat around the San Francisco Bay and along the coast is the main reason for the decline of the species. Brood parasitism by brown-headed cowbirds has also negatively affected numbers in some localities.

> **VISION**
>
> The vision for saltmarsh common yellowthroat is to maintain self-sustaining populations and their habitat in order to contribute to the overall species richness and diversity.

A major focus of efforts to maintain saltmarsh common yellowthroat will be to assure that marsh restoration programs in the Suisun Marsh/North San Francisco Bay Ecological Management Zone consider and integrate habitat need for the species.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Programs and projects designed to protect, restore, and enhance the Suisun Marsh/North San Francisco Bay Ecological Management Zone to provide direct or incidental benefits to the saltmarsh common yellowthroat include:

- San Francisco Estuary Project,
- San Francisco Bay Area Wetlands Ecosystem Goals Project.
- California Wetland Riparian Geographic Information System Project,
- Governor's California Wetland Conservation Policy,
- Tidal Wetlands Species Recovery Plan,
- Wetlands Reserve Program,
- Inland Wetlands Conservation Program,
- Montezuma Wetlands Project, and
- National Estuarine Reserve Research System.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of the saltmarsh common yellowthroat is integrally linked with restoring tidal permanent emergent wetlands in Suisun Bay and Marsh and the western Delta. Restoration of adjacent riparian and riverine aquatic habitat, particularly willow, is also important.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

> The Strategic Objective is to contribute to the recovery of at-risk native species in the Bay-Delta estuary and its watershed.

SPECIES TARGET: Maintain the current distribution and existing populations of the saltmarsh common yellowthroat, and reestablish and maintain viable species' populations throughout its historic range in the portion of the Bay Region within the ERP focus area.

LONG-TERM OBJECTIVE: Reduce the risk of current and imminent threats to maintaining the current distribution and existing populations of the saltmarsh common yellowthroat and reestablish and maintain viable species' populations throughout its historic range in the portion of the Bay Region within the ERP focus area..

SHORT-TERM OBJECTIVE: With existing populations, find ways to connect fragmented brackish, freshwater, and riparian habitats to increase the likelihood of stabilizing the population.

RATIONALE: The saltmarsh common yellowthroat only in and near Suisun Marsh and other areas of the north bay. Populations of this unusual subspecies are declining for a variety of reasons but mainly the degradation of their habitat. Restoration of their populations is likely to be a good indicator of the success of restoration of brackish tidal marshes in the Suisun Marsh area.

STAGE 1 EXPECTATIONS: Habitat for the saltmarsh common yellowthroat will have been identified and protected from further development and habitat alterations; plans will have been developed and implemented to connect isolated habitat by means of habitat restoration projects.

RESTORATION ACTIONS

The following general targets will assist in meeting the strategic objective:

- Increase the total number of pairs.
- Increase the total population.

The following general programmatic actions will contribute to the recovery of the saltmarsh common yellowthroat:

- Increase the amount of tidal brackish water marshes in Suisun Bay and Marsh and in the North Bay.
- Decrease the extent of isolation of remaining tidal marshes in Suisun Bay and Marsh and the North Bay.
- Within existing and restored marshes ensure presence of tule and cattail stands.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve saltmarsh common yellowthroat habitat or population targets.

- The geographic priorities for implementing ERP actions to protect, enhance, and restore saline emergent wetlands and associated habitats for the saltmarsh common yellowthroat should be: 1) Gallinas/Ignacio marshes and Napa Marshes, 2) Sonoma Marshes, Petaluma Marshes, and Highway 37 marshes west of Sonoma Creek, 3) Point Pinole Marshes, 4) Highway 37 marshes east of Sonoma Creek, and 5) the Contra Costa County
- Coordinate protection, enhancement, and restoration of saltmarsh and associated habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, and USFWS species recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Restore wetland and perennial grassland habitats adjacent to occupied nesting habitats to create a buffer of natural habitat to protect nesting pairs from potential adverse affects that could be associated with future changes in land use on nearby lands and to provide suitable foraging habitat and nesting habitat area suitable for the natural expansion of populations.
- Initial species recovery efforts should be directed to locations where there are immediate opportunities for protection, enhancement, or restoration of suitable habitat.
- To the extent practicable, design dikes constructed in enhanced and restored saline emergent wetlands to provide optimal wetland to upland transitional habitat.
- Direct ERP salt marsh enhancement efforts towards existing degraded marshes that are of

sufficient size and configuration to develop fourth order tidal channels (marshes would likely need to be at least 1,000 acres in size).

- To the extent practicable, design salt marsh enhancements and restorations to provide low-angle upland slopes at the upper edge of marshes to provide for the establishment of suitable and sufficient wetland to upland transition habitat. Transition habitat zones should be at least 0.25 mile in width.
- Manage enhanced and restored habitat areas to avoid or minimize impacts on the saltmarsh common yellowthroat associated with recreational uses on lands acquired or managed under conservation easements.
- Direct ERP restorations towards improving tidal circulation to diked wetlands that currently sustain partial tidal exchange.
- Direct some salt marsh habitat enhancements and restorations towards increasing habitat connectivity among existing and restored tidal marshes.
- To the extent practicable, control non-native predator populations in occupied habitat areas and salt marshes enhanced and restored under the ERP.
- Identify and implement feasible methods for controlling invasive non-native marsh plants.
- Monitor to determine use of restored salt marsh habitats by saltmarsh common yellowthroat and the rate at which restored habitats are colonized.

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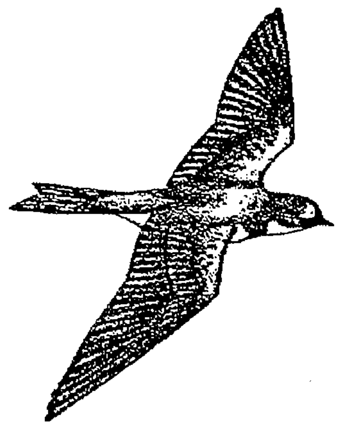

Bank Swallow
Threatened (State)

INTRODUCTION

The bank swallow is associated with riparian and riverine habitats and nests in vertical cliff and bank faces eroded by rivers. The population and range of this species have declined primarily as a result of the loss or degradation of ecosystem processes that maintain suitable nesting substrates along streams and rivers. The loss of habitat and declining condition of the species' population have warranted its listing as threatened under the California Endangered Species Act. The major factor that limits this resource's contribution to the health of the Delta is related to the adverse effects of levees and bank-protection structures on river and stream channel migration. These structures inhibit or prevent the channels' ability to erode its banks and form the nesting cliffs and banks required by the species.

RESOURCE DESCRIPTION

Once an abundant lowland species in California, the bank swallow is now limited to breeding in a small part of its former range. The bank swallow is found in only a small number of ecological units within the Central Valley's ecological management zones that are adjacent to major rivers and their tributaries. The species is not known to occur in the Sacramento-San Joaquin Delta or the Suisun Marsh/North San Francisco Bay Ecological Management Zones. Nesting colonies are found along the Sacramento River from mile 143 to 243, with 40-60 colonies remaining along the upper Sacramento River and approximately 10-20 colonies on the Feather River. A total of 5-10 colonies are located above and below miles 143 on the Sacramento River. Other small colonies are found along other waterways, including: the American River, Thomes Creek, Cache Creek, and the Cosumnes River.

Bank swallows breed in vertical banks or cliffs that are created when streams and rivers erode their banks. Friable soils are an important habitat requirement. Their population is estimated to have been reduced by 50% since 1900. Only a few colonies remain within the State as a result of stream channelization, bank protection, and flood control projects, which have reduced the availability of breeding sites (i.e., cliffs) by constraining rivers from eroding their banks. As much as 75% of the current breeding population in California concentrates along the banks of the Central Valley's streams; 70-80% of remaining breeding habitat is found along a small stretch of the Sacramento River.

The decline of the bank swallow can be attributed primarily to human activities that have changed the ecosystem processes that create and sustain its bank and bluff nesting habitat. Stream meander migration is necessary to maintain, enhance, and create the fine-textured or sandy-type vertical banks or cliffs in which bank swallows dig their nesting holes. Levees and riprapped banks along streams and rivers have impeded the creation of nesting cliffs by preventing channels from following the natural process of erosion, deposition, and meandering. Currently proposed projects for confining channels within the species' nesting range represent the largest threat to maintaining existing bank swallow colonies. The general deterioration or loss of adjacent floodplain habitats (e.g., shaded riverine aquatic, riparian corridors and forests, and open grasslands) has also, although to a lesser degree, contributed to the species' decline.

VISION

The vision for the bank swallow is to contribute to the recovery of this State-listed threatened species.

Recovery of the bank swallow would contribute to overall species richness and diversity. Achieving this vision will reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.

Protecting existing nesting colonies from activities that could result in their loss or degradation and restoring ecological process of confined channel migration will be critical to the recovery of the bank swallow. The Ecosystem Restoration Program Plan's proposed restoration of stream meander and riparian habitat in the Sacramento River and Butte Basin Ecological Management Zones will help to protect the remaining nesting colonies along the Sacramento and Feather rivers. Protecting the remaining nesting colonies is an essential requirement to preventing the bank swallow population from declining to a point where restoration efforts may offer little help to the species.

Recent studies have shown that most nesting colonies are adjacent to open grasslands. Other colonies live in agricultural lands and riparian and oak forests. Restoring these habitats while protecting and restoring streamside banks and levees would also help maintain or increase existing bank swallow populations.

Restoring Sacramento River meander belts and other confined streams and rivers is an approach that would restore, on a large scale, the processes that create nesting banks. Partially restoring the processes that create nesting sites would be feasible in some areas by modifying flood control and bank stabilization practices to allow channels to migrate and cut banks.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Other programs linked to restoring riparian systems and bank swallow habitat include:

- the Upper Sacramento River Fisheries and Riparian Habitat Advisory Council (SB 1086),
- the Central Valley Improvement Act,
- Anadromous Fish Restoration Program,
- Cosumnes River Preserve,
- Delta Native Fishes Recovery Team,
- Department of Fish and Game Central Valley Salmon and Steelhead Management and Restoration Program,
- Riparian Habitat Joint Venture, and
- California Department of Fish and Game's recovery plan for the bank swallow.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of the bank swallow population and its habitat will be integrally linked to restoration of natural stream meander corridors in the rivers of the Central Valley.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

The Strategic Objective is to contribute to the recovery of at-risk native species in the Bay-Delta estuary and its watershed.

SPECIES TARGET: Allow reaches of the Sacramento River and its tributaries that are unconfined by flood control structures (i.e., bank revetment and levees) to continue to meander freely, thereby creating suitable bank nesting substrates through the process of bank erosion.

LONG-TERM OBJECTIVE: Create the conditions that will allow nesting colonies of bank swallows to thrive along the Sacramento and San Joaquin rivers, as well as their major tributaries, especially the Feather River.

SHORT-TERM OBJECTIVE: Recover sufficient populations so that the bank swallow can be removed from the state list of threatened species.

RATIONALE: The bank swallow is listed as a state threatened species. It has declined because of the progressive loss of its prime nesting habitat: freshly exposed steep riverbanks, in which it digs burrows. Stabilization of river channels, placement of rip-rap on eroding banks , and other factors which decrease the availability of fresh-cut banks have reduced potential spawning areas throughout the Central Valley. This is a species that will benefit from the creation of "meander zones" in large rivers and other actions that increase the ability of rivers to find their natural channels.

STAGE 1 EXPECTATIONS: An inventory will have been completed of areas of dynamic river bank which meet requirements for bank swallow nesting habitat. Methods will have been developed by which to maintain the creation of fresh-cut banks in these regions to keep the creation of new nesting habitat at least even with the natural deterioration of old habitat.

RESTORATION ACTIONS

The general target is to increase the number of bank swallow pair in the Central Valley.

General programmatic actions which will contribute to reaching the target include:

- protect existing nesting colonies along the Sacramento River, Feather River and their tributaries,
- restore natural river meander process, and
- increase and link potential nesting habitat.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve bank swallow habitat or population targets.

- Coordinate protection and restoration of channel meander belts and existing bank swallow colonies with other federal and state programs (e.g., the SB 1086 Program and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Proposed ERP actions designed to protect or restore stream meander belts should initially be implemented along reaches of the Sacramento River and its tributaries that support nesting colonies or potential nesting habitat.
- Monitor to determine the response of bank swallows to restoration of stream meander belts and riparian habitat.
- Coordinate with the U.S. Bureau of Reclamation and the Department of Water Resources to phase spring-summer reservoir releases in a manner that would reduce the potential for adverse effects on nesting colonies that could result from large, pulsed, releases.
- To the extent consistent with CALFED objectives, protect all known nesting colonies from potential future changes in land use or activities that could adversely affect colonies.

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Multi-Species Conservation Strategy. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

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◆ DELTA GREEN GROUND BEETLE

INTRODUCTION

The Delta green ground beetle, a federally listed threatened species, is associated with vernal pool habitats. The distribution and populations of this species has declined substantially, primarily as a result of the loss or degradation of habitats within its range. The loss of habitat and declining condition of these species populations have warranted their listing as threatened or endangered under the federal Endangered Species Act.

Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of conversion of native habitats for agricultural, industrial, and urban uses, and land and water management practices that degrade habitats used by these species.

RESOURCE DESCRIPTION

The Delta green ground beetle is found at the Jepson Prairie Preserve in Solano County, which is in the Yolo Basin Ecological Management Zone. The Delta green ground beetle and its soft-bodied prey species are most often observed on moist environments such as those provided by Olcott Lake and vernal pools within the Jepson Prairie Preserve. Vernal pools and aquatic seasonal habitats supply the critical needs of the Delta green ground beetle. Entomologists believe that appropriate conditions for the species are found in open, moist habitats with limited vegetative cover.

Since 1974, entomologists have seen or collected only 75 adult Delta green ground beetles in the preserve area. Although the historical distribution of the Delta green ground beetle is unknown, the widespread disruption of wetland and grassland habitats in the Central Valley over the last 150 years strongly suggests that the range of the beetle has been reduced and fragmented. Today, the beetle predominately inhabits the borders of vernal pools and Olcott Lake at the Jepson Prairie Preserve. The primary threats to the survival of the Delta green ground beetle have been, and continue to be, loss and alteration of its wetland habitat primarily because of agricultural conversion (i.e., the plowing and leveling of land); grazing; river channelization; and construction of dams, drainage ways, and pipelines.

VISION

The vision for the Delta green ground beetle is to contribute to the recovery of this federally listed threatened species by increasing their populations and abundance through habitat restoration.

Protecting existing and restoring additional suitable seasonal wetlands, including vernal pools, and associated grasslands will be critical to recovery of the Delta green ground beetle in the Bay-Delta. Restoration of these habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will help maintain healthy populations by increasing the quality and quantity of habitats used by this species.

The Delta green ground beetle would also benefit from cooperative management strategies with The Nature Conservancy's Jepson Prairie Preserve.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

There are a number of programs that involve these species:

- U.S. Fish and Wildlife Service,
- California Department of Fish and Game (DFG),
- California State Parks and Recreation,
- Riparian Habitat Joint Venture,
- DFG's Calhoun Cut Reserve, and
- TNC's Jepson Prairie Preserve.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of these species is integrally linked with restoration of seasonal wetland, riparian, inland dune, perennial aquatic, and grassland habitats in the Central Valley and are adversely influenced by the detrimental effects of invasive plant species.

Objective, Targets, Actions, and Measures

> The Strategic Objective is to contribute to the recovery of at-risk native species in the Bay-Delta estuary and its watershed.

Species Target: Protect all known occupied habitat areas from potential adverse affects associated with current and potential future land uses, and establish three additional populations of the delta green ground beetle within its current and/or historic range.

Long-Term Objective: Expand the existing population of Delta green ground beetle and establish at least three additional populations to remove it from the federal threatened species list.

Short-Term Objective: Expand the existing population levels of Delta green ground beetle by increasing and improving its habitat.

Rationale: The Delta green ground beetle is federally listed as a threatened species that is currently known only from Jepson Prairie Preserve (Solano County). Habitat requirements for this species are not clearly understood but the beetles seem to require open places near vernal pools. A better knowledge would help restoration efforts. Limiting pesticide use in adjacent areas and increasing habitat are two ways to increase population size but until we know what the ideal habitat is, a mixture of habitats that could be used by this species is essential.

Stage 1 Expectations: The existing population of Delta green ground beetle will have been studied in order to develop a clearer idea of what its habitat requirements are. Additional areas of vernal pool habitat in Solano County will have been acquired and managed for the beetle and other native species.

Restoration Actions

The following general target will assist in meeting the implementation objective:

- Increase the numbers and distribution of Delta green ground beetle.

The following general programmatic actions will assist in meeting the targets:

- Protect and restore wetland, riparian, and grassland habitat.
- Implement control measures to eradicate invasive plant species.
- Design and manage restored seasonal wetlands and grasslands near Delta green ground beetle populations to improve habitat quality for the species.
- Introduce species into unoccupied or restored habitat areas.
- Reduce land and water management practices that degrade habitats used by these species.

MSCS Conservation Measures

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve Delta green ground beetle habitat or population targets.

- Coordinate protection, enhancement, and restoration of delta green ground beetle populations and its habitat with other federal and state programs (e.g., U.S. Fish and Wildlife Service species recovery plans and management of the Jepson Prairie Preserve) that could affect management of current and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Direct ERP actions towards protecting, enhancing, and restoring suitable vernal pool and associated grassland habitat within the species historic range, including expansion of Jepson Prairie Preserve westward to Travis Air Force Base.
- To the extent consistent with ERP objectives, direct ERP actions towards protection of the Davis Antenna Site population.

- Conduct surveys to identify suitable habitat areas, including enhanced and restored habitats, for establishment of additional populations in the Delta and Bay Regions and implement species introductions to establish three additional populations.
- To the extent consistent with CALFED objectives, manage lands purchased or acquired under conservation easements that are occupied by the species to maintain or increase current population levels and enhance occupied habitat areas.

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◆ SPECIES DESIGNATED AS MAINTAIN

INTRODUCTION

The Strategic Plan for Ecosystem Restoration presents 6 goals to guide the implementation of restoration actions during the 20-30 year program.

The first Strategic Goal focuses on at-risk species:

This section addresses those species designated as "Maintain" in the MSCS and ERP.

> STRATEGIC GOAL 1: *Achieve, first, recovery and then large self-sustaining populations of at-risk native species dependent on the Delta and Suisun Bay; support similar recovery of at-risk native species in the Bay-Delta estuary and its watershed; and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed.*

MAINTAIN DESIGNATION

MAINTAIN ("M"): For species designated "m," the CALFED Program will undertake actions to maintain the species. This category is less rigorous than "contribute to recovery." For this category, CALFED will avoid, minimize, and compensate for any adverse effects to the species commensurate with the level of effect on the species. Actions may not actually contribute to the recovery of the species; however, at a minimum, they will be expected to not contribute to the need to list an unlisted species or degrade the status of an already listed species. CALFED will also, to the extent practicable, improve habitat conditions for these species.

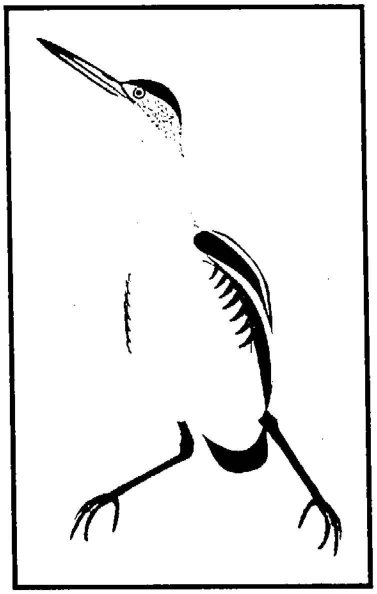
The "maintain" species addressed in this section include:

- western least bittern
- hardhead
- California red-legged frog
- California tiger salamander
- western pond turtle
- western spadefoot toad
- California freshwater shrimp
- mad-dog skullcap *
- rose-mallow *
- eel-grass pondweed
- Colusa grass
- Boggs Lake hedge-hyssop
- Contra Costa goldfields
- Greene's legenere
- heartscale
- recurved larkspur.

* Denotes species which were described previously in the vision for tidal brackish and freshwater marsh special-status plant species and inland dune special status plants.

> Note: the use of Species Targets in this section is synonymous with the Species Goal Prescriptions provided in the Multi-species Conservation Strategy.

◆ Western Least Bittern



Introduction

This species is considered part of the heron family and is its smallest member. The Western least bittern utilizes freshwater tidal and nontidal marshes and wetlands for foraging and nesting habitat. The population and distribution of this species have declined substantially primarily as a result of reclamation of its wetland habitats and because of its decline is a Department of Fish and Game California "Special Concern Species," is on Audubon's Blue List, and is a U.S. Fish and Wildlife Service "Migratory Nongame Bird of Management Concern." The major factor that limits this resource's contribution to the health of the Delta is related to the adverse effects of historical and current loss or degradation of freshwater wetlands.

Resource Description

The Western least bittern inhabits stands of emergent vegetation within freshwater marshes and wetlands. Shallow water, emergent cover, and substrate with high invertebrate abundance are the most important features of Western least bittern habitat. The bittern is also known to feed on amphibians, fish, crayfish, and small mammals.

Much of the Western least bittern's wetland habitats have been destroyed or modified since the mid-180's. This decline in wetlands has reduced population densities of the bitterns throughout their range.

Habitat loss is largely a result of reclamation for agricultural, industrial, and urban uses and water management projects. The total area of those remaining habitats represents only a small percentage of their history level. These habitats continue to be threatened by sedimentation, water diversions, recreational activities, water quality, and land use practices. Insufficient quantity and quality of wetland habitat is the primary factor limiting recovery of the species' population in the estuary. Other factors that can also adversely affect the Western least bittern include disturbance during its breeding period, contaminants, and excessive predation by non-native species.

Vision

The vision for the Western least bittern is to contribute to the recovery of this species to contribute to overall species richness and diversity.

Achieving this vision will reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.

Restoring suitable tidal and nontidal freshwater wetlands in the Bay-Delta is critical to the recovery of the species in the estuary. These restored habitats would provide nesting and foraging habitat for the Western least bittern. Although the Western least bittern's range extends into other ecological management zones, the primary focus for habitat restoration will be in the Sacramento-San Joaquin Delta Ecological Management Zone. Efforts outside the Delta to restore freshwater habitats would also benefit the species.

Integration with Other Restoration Programs

Many programs designed to benefit broader groups of fish and wildlife that use or depend on wetlands, sloughs, or adjacent aquatic systems in the Bay-Delta also benefit the Western least bittern. some of these are operated by the following organizations:

- San Francisco Bay Area Wetlands Ecosystem Goals Project,
- California Coastal Conservancy,
- Delta Native Fisheries Recovery Team,
- San Francisco Bay National Wildlife Refuge,
- U.S. Fish and Wildlife Service San Francisco Bay Program, and
- Tidal Wetlands Recovery Plan Ecosystem Wetland Goals Project.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration and recovery of the Western least bittern population of the Bay-Delta is integrally linked with wetland restoration, and water quality (contaminants) improvement.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

The Strategic Objective is to maintain abundance and distribution.

SPECIES TARGET: An increase in or no discernable adverse effect on the size or distribution of species populations..

LONG-TERM OBJECTIVE: Restore the western least bittern to the status as a common overwintering marsh bird in the Central Valley and Delta.

SHORT-TERM OBJECTIVE: Develop wintering habitat for least bitterns by creating "no disturbance" refuges along the central corridor of the Central Valley and Delta for all shore and wading birds.

RATIONALE: The western least bittern, a California Department of Fish and Game Species of Special Concern nests in emergent wetlands of cattails and tules in the upper and lower reaches of the Central Valley but winters in marshlands along the main rivers and in the Delta. Least bitterns were apparently once a common wintering bird in the Central Valley but are now scarce. The loss of wintering habitat as a result of channelization and reclamation of marsh lands along the major rivers and Delta has been a major factor in their decline. Therefore, to increase their overwintering survival, there needs to be an increase in contiguous areas of emergent marsh along both the Sacramento and San Joaquin rivers. Important, but less critical, is the need protect breeding habitats not only in the Central Valley but along the Colorado River and Salton Sea.

STAGE 1 EXPECTATIONS: A thorough review of the status and habitat requirements of western least bittern will have been conducted. Areas within the Central Valley will have been set aside as "no disturbance" refuges to protect wintering habitat of bitterns and other wading and shore birds from human disturbance.

RESTORATION ACTIONS

The general target is to increase the number of breeding pairs of Western least bittern in the Bay-Delta.

General programmatic actions to achieve the target for the Western least bittern include:

- restore the natural tidal action of aquatic habitats;
- preserve the remaining populations of Western least bittern, tidal and nontidal freshwater marsh habitats;
- implementation of management programs for small water diversions, disturbance, land use changes, and contaminants would improve habitat, reproductive potential, and recruitment for Western least bitterns;
- protect tidal and nontidal freshwater marshes and wetlands from adverse land uses;
- protect nearby unoccupied suitable habitats areas would help ensure natural expansion area is available;
- protect existing suitable habitats by implementing conservation easement purchasing from willing landowners, or establishing incentive programs to maintain suitable habitat;

- develop and implement alternatives to land management practices on public lands that continue to degrade the quality or inhibit the recovery of Western least bittern habitats; and
- restore, protect, and improve tidal and nontidal wetlands.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve western least bittern habitat or population targets.

- To the extent consistent with ERP objectives, design and manage wetland habitat restorations and enhancements to provide suitable nesting and foraging habitat conditions.
- To the extent consistent with ERP objectives, restore wetland habitats adjacent to occupied nesting habitats to create a buffer zone of natural habitat to protect nesting pairs from potential adverse effects that could be associated with future changes in land use on nearby lands and to provide foraging and nesting habitat areas suitable for the natural expansion of populations.

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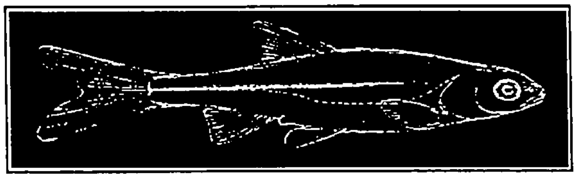


INTRODUCTION

Hardhead are one of many species of minnow, native to the Sacramento-San Joaquin watershed. Hardhead are also found in the Napa River watershed.

Hardhead are listed as a species of special concern by the California Department of Fish and Game. The Multi-Species Conservation Strategy includes hardhead as an evaluated species with a species goal of "maintain" (MSCS 1999a).

Possible factors contributing to the decline of hardhead include predation and competition by non-native species, loss and degradation of habitat, poor foodweb productivity, losses to water diversions, and reduced survival from exposure to toxins in the water.

RESOURCE DESCRIPTION

Native minnows such as hardhead, hitch, and California roach are important species occupying important and diverse ecological niches in Central Valley low to mid-elevation streams.

The habitat attributes of the low to mid-elevation streams are characterized by deep, bedrock pools, clear water, and cool temperatures. Within higher quality habitats, hardhead are typically found in association with other native fishes including Sacramento pikeminnow and Sacramento sucker (Moyle 1996). Moyle et al. (1996) pointed out that hardhead are one of the most specialized species in the Sacramento-San Joaquin watershed and their long-term survival is dependent on clear, cool water and deep pools. These habitats are the locations that have been most impacted or lost by the construction of large mid-elevation reservoirs.

Hardhead populations are also susceptible to declines resulting from predation by non-native species. This has been observed in the South Yuba River and the Kings River as a result of the introduction of smallmouth bass. Introduced species were identified as the most significant cause of population declines, and included, to lesser degrees, the construction and operation of dam and diversions, changes in aquatic habitat, watershed disturbance, and a variety of other factors (Moyle et al. 1996).

Hardhead typically mature and reproduce during their second year. Their spawing occurs in the spring following extensive upstream migration. Young hardhead feed mainly on planktonic organisms then prey on increasingly larger organisms. Mature hardhead are bottom browsers and feed on aquatic plants such as filamentous algae and small invertebrates. In some areas, larvae of mayflies and caddisflies provide the primary prey items. Adult hardhead occupy the lower portion of the water column and juveniles utilize the shallow water areas close to the stream margins (MSCS 1999b).

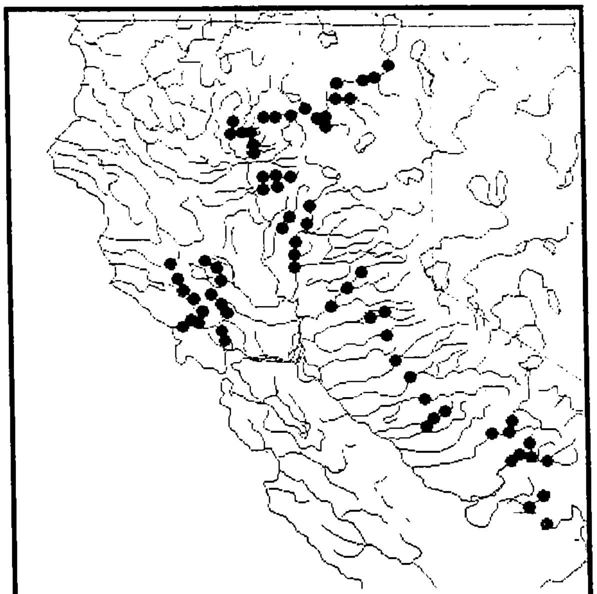
Hardhead are found within the following Ecological Management Zones:

- Sacramento River
- North Sacramento Valley
- Cottonwood Creek
- Colusa Basin
- Feather River/Sutter Basin
- American River Basin
- Yolo Basin
- Eastside Delta Tributaries
- East San Joaquin
- West San Joaquin, and
- Suisun Marsh/North San Francisco Bay (Napa River Ecological Management Zone).

VISION

The vision to maintain and restore the distribution and abundance of hardhead to contribute to the overall species richness and diversity.

Achieving this vision will reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta.



Distribution of Hardhead.

Ecosystem processes are closely tied to habitat restoration needs and actions. Resident species would benefit from conditions to maintain productivity and suitability of spawning and rearing habitat (including production of food). Actions to rehabilitate ecosystem processes include: providing adequate flow and temperatures. Flows need to be provided to support channel maintenance such as scour and sediment transport.

Stressor reduction is a major component of restoration and maintenance of resident species populations. A primary concern with regard to vulnerable species is the reduction of losses to diversions. Actions to reduce losses installing fish screens on currently unscreened facilities, removing predators associated with diversions and fish protection facilities, relocating and consolidating existing diversions, changing seasonal timing of diversions, and reducing the number of diversions. Resident species would also benefit from actions to reduce pollutant input to streams and rivers in the Sacramento-San Joaquin River basin and may benefit from actions to prevent introduction of non-native species that would prey upon or compete with native species for habitat and food supply.

Integration with Other Restoration Programs

Efforts to restore and maintain resident species would involve cooperation and support from other established programs that protect and improve conditions for delta smelt, striped bass, and other species.

- The Recovery Plan for the Sacramento/San Joaquin Delta native fishes will be considered in the development of actions.
- Central Valley Project Improvement Act will implement actions that will benefit resident species, including changing the timing of diversions and restoring habitat.
- The State Water Resources Control Board will implement the Water Quality Control Plan for the San Francisco/Sacramento-San Joaquin Delta estuary that will include provisions to limit entrainment in diversions and protect habitat conditions for Sacramento splittail, chinook salmon, striped bass, and other species.

Linkage with Other Ecosystem Elements

Restoration efforts relating to resident fish will be linked to efforts to maintain and restore health stream corridors, fish passage flows or structures, and water quality.

Objective, Targets, Actions, and Measures

The Strategic Objective is to maintain abundance and distribution.

Species Target: An increase in or no discernable adverse effect on the size or distribution of species populations.

Long-Term Objective: Within 25 years, all hardhead will have stable or increasing populations, in multiple localities, with localities interconnected as much as feasible.

Short-Term Objective: Determine the distribution, status, and habitat requirements of hardhead in the Bay-Delta watershed to see if species-specific strategies are needed to reverse declines or if habitat-oriented restoration strategies will be adequate.

RATIONALE: The Central Valley has a native resident fish fauna that is largely endemic to the region. Some species are extinct (thicktail chub) or nearly extinct (Sacramento perch) in the wild. While some native species (e.g., Sacramento pikeminnow [squawfish], Sacramento sucker) are clearly thriving under altered conditions, others are not (e.g., hitch, Sacramento blackfish, hardhead). Although most of these species may benefit from actions listed under goal 2, there is a need to determine if some have unique problems or requirements that will prevent them from responding to general habitat improvements.

STAGE 1 EXPECTATIONS: A distribution and status survey of native stream fishes will have been completed. Sites with high species richness or containing rare species will have been identified for special management. A recovery strategy for native fish assemblages will have been developed.

RESTORATION ACTIONS

The target for hardhead is to increase their abundance and distribution.

Hardhead would benefit from the following general restoration activities:

- adding and modifying physical habitat,
- restoring riparian areas,
- protecting existing shallow-water habitat from erosion,
- installing screens on unscreened diversions,
- removing predators at diversions,
- relocating or consolidating diversions,
- reducing concentrations of toxins in Bay-Delta waters, and
- preventing further introductions of non-native aquatic organisms.

MSCS CONSERVATION MEASURE

The following general conservation measure was included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- To the extent consistent with Program objectives, manage lands purchased or acquired under conservation easements to maintain or increase current population levels of resident evaluated species.

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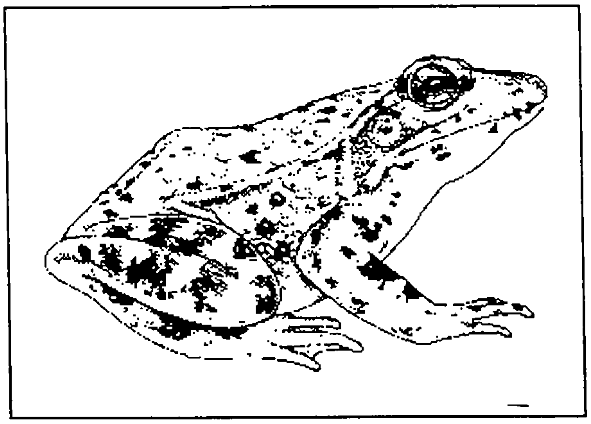
◆ California Red-Legged Frog



Introduction

The California red-legged frog is California's largest native frog. Its habitat is characterized by dense, shrubby riparian vegetation associated with deep, still, or slow-moving water that supports emergent vegetation. The distribution and population of this species has declined substantially, primarily as a result of habitat loss or degradation and excessive predation. The loss of habitat and declining condition of the species' population have warranted its listing as threatened under the federal Endangered Species Act and a Species of Special Concern by DFG. Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of the loss or degradation of critical wetland and riparian habitats and the introduction of non-native predators.

Resource Description

The California red-legged frog historically occurred throughout the Central Valley and now exists only in small isolated populations scattered throughout its historical range. Its current range is chiefly west of the Cascade-Sierra crest from Redding in Shasta County, California, to northwest Baja California. Small populations still exist in the Central Valley and Sierra Nevada, but numbers appear to be declining in both places. Reasons for the decline of this species include the degradation and loss of critical wetland breeding and adjacent terrestrial habitats.

Human-caused stressors add to the species decline. In occupied species-areas, some agricultural practices, such as discing, mowing, burning, and pest control, result in direct mortality or degradation of habitat. The introduction of non-native fish, bullfrogs, and crayfish, all of which prey on larval, juvenile, or adult red-legged frogs increases the threat to the survival of this species. Some introduced predatory fish are large enough to injure some adults and eat juvenile red-legged frogs. The only reasonably protected population in the Central Valley is the Corral Hollow Ecological Reserve. However, this reserve is currently threatened by siltation from off-road vehicle use and livestock grazing.

Vision

The vision for the California red-legged frog is to maintain populations of this federally listed threatened species.

Achieving this vision will contribute to the overall species richness and diversity and to reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta.

Protecting existing and restoring additional suitable aquatic, wetland, and riparian habitats and reducing mortality from non-native predators will be critical to achieving recovery of the California red-legged frog. Restoration of aquatic, wetland, and riparian habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will help in the recovery of this species by increasing habitat quality and area. Establishing emergent vegetation (*Salix* sp., *Typha* sp., and *Scirpus* spp.) in canals, side channels, and backflow pools would provide breeding habitat, forage and escape cover for the California red-legged frog. Establishing these habitats in each ecological unit of the Sacramento-San Joaquin Delta Ecological Management Zone would create migration corridors by linking habitat areas.

Restoration of ecosystem processes and habitats in other ecological management zones will also allow natural floodplains, stream meanderings, and seasonal pools to develop that will assist in the recovery of population elsewhere in the red-legged frog's range. Restoring optimal red-legged frog habitat will also reduce its susceptibility to predation and will reduce suitable habitat conditions for non-native predators.

California red-legged frog cannot be adequately restored to the Central Valley or the foothill areas without re-introduction. Recovery strategies should focus on property acquisition to preserve areas where the frog is present and to conduct detailed surveys in the western valley and Sierran foothills for remnant populations. Bullfrog predation is a major concern and focused predator management should be developed and implemented on a case-by-case basis in areas identified as important to frog populations. Reintroductions on State and Federal refuge lands with a predator management scheme should be considered.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Wetland restoration and management programs that would improve habitat for the California red-legged frog include:

- the Agricultural Stabilization and Conservation Service's Wetland Reserve Program,
- the Wildlife Conservation Board's Inland Wetlands Conservation Program,
- restoration programs administered by Ducks Unlimited and the California Waterfowl Association, and
- ongoing management of State and federal wildlife refuges and private duck clubs.

Restoration efforts will be conducted in cooperation with agencies or organizations with responsibility or authority for restoring wetland aquatic habitats including:

- California Department of Fish and Game,
- California Department of Water Resources,
- U.S. Fish and Wildlife Service,
- U.S. Army Corps of Engineers, and
- Delta Protection Commission.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of the red-legged frog populations is integrally linked with restoration of riparian and wetland habitat in the Central Valley.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

The Strategic Objective is to maintain abundance and distribution.

SPECIES TARGET: An increase in or no discernable adverse effect on the size or distribution of species populations.

LONG-TERM OBJECTIVE: Develop refuges in habitats throughout its former range that will each maintain 100+ breeding pairs of red-legged frogs, established from reintroductions.

SHORT-TERM OBJECTIVE: Locate and protect any remaining populations of red-legged frogs in the Bay-Delta watershed.

RATIONALE: Red-legged frogs are virtually extinct in the region, with just a handful of tenuous populations remaining in the Central Valley and bay region (none near the estuary). Their inability to recover from a presumed major population crash in the 19th century (due to overexploitation) has been the result of a combination of factors (in approximate order of importance): (1) predation and competition from introduced bullfrogs and fishes; (2) habitat loss, (3) pesticides and other toxins, (4) disease, and (5) other factors. Because of the poor condition of the few remaining frog populations and the continued existence of major causes of their decline, this objective may not be achievable in either the short or long term. Any refuge developed for this species will require continuous intensive management and development of experimental barriers to exclude non-native species. The long-term goal will be achievable only if the refuge experiments work and are cost-effective (e.g., it might be better to put dollars into restoring areas outside the region where red-legged frogs still maintain populations naturally). Refuges for red-legged frogs will benefit other at-risk species as well, such as giant garter snakes, Pacific pond turtles, and tiger salamanders.

STAGE 1 EXPECTATIONS: All red-legged frogs populations in the region will have been located and protective measures taken where feasible. At least one experimental population will have been established.

RESTORATION ACTIONS

The general target is to increase the population size and distribution of the red-legged frog.

General programmatic actions to assist in reaching the target include:

- acquire land to preserve areas where frogs are present,
- develop predator (bullfrog) control programs,
- increase wetland and riparian habitats in the Central Valley;
- reduce the use of herbicides that adversely affect red-legged frog and their habitats; and
- use fumigants to control rodents from only October to March in known occupied habitats.

MSCS CONSERVATION MEASURES

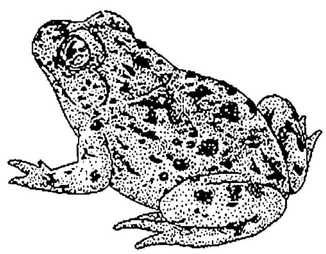
The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- To the extent consistent with CALFED objectives, enhance or restore suitable habitats near occupied habitat.
- Avoid or minimize CALFED actions that could increase or attract non-native predator populations to occupied habitat.

REFERENCES

Multi-Species Conservation Strategy. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.



INTRODUCTION

The western spadefoot occurs throughout much of the Central Valley, San Francisco Bay, and coast ranges and foothills below 3,000 feet, as well as along the coast in the southern portion of the State. Declining populations have warranted their designation as species of special concern and species of concern by the California Department of Fish and Game (DFG) and U.S. Fish and Wildlife Service, respectively. Major factors that limit these resources' contribution to the health of the Delta are related to adverse effects of conversion of seasonal wetlands and adjacent uplands to other land uses and excessive mortality resulting from introduction of non-native predators and some land use practices.

RESOURCE DESCRIPTION

Western spadefoot toad populations have declined primarily as a result of habitat loss or degradation and competition or predation from non-native species. The abundance from population to population is unknown but is influenced by the size and quality of individual habitat patches within the fragmented pockets that the species are known to inhabit.

The western spadefoot toad is primarily a lowlands species, frequenting washes, river floodplains, alluvial fans, playas, and alkali flats, but also ranges into the foothills and mountain valleys. Vernal pools covering more than 250 square feet, with fairly turbid water, provide optimal habitats. Most surface movements of the western spadefoot, including breeding activity, are associated with the onset of fall and spring rains that fill traditional breeding ponds. Warm days followed by rains or high humidity levels at night trigger reproductive and foraging activities and adults of these species sometimes appear in large numbers.

The greatest threat to the continued existence of the toad is habitat loss and competition by non-native species. Habitat loss is a result of increased urbanization and conversion of native grasslands to agriculture. The spadefoot may be found in high densities in isolated areas but adjacent breeding habitat is increasingly being converted for other uses.

Introduction of predatory fish and bullfrogs in known breeding ponds is also an important factor attributed to the decline of these species. Juvenile and adult bullfrogs can prey on larvae and terrestrial forms of these native species. Other important stressors that affect the spadefoot are rodent control activities, which reduce the availability of summer estivation (burrowing) sites. The use of rodent burrows may be more important for the California tiger salamander than for western spadefoot because spadefoots can build their own burrows and also use other appropriate niches. Research on the extent and necessity of burrow use by both species would be valuable. In addition to rodent control activities, development of roads between breeding ponds and terrestrial habitats, resulting in deaths from automobiles during the species' migrations, has also contributed to the decline.

VISION

The vision for the western spadefoot toad is to maintain this California species of special concern in the Bay-Delta.

Achieving this vision will contribute to overall species richness and diversity and reduce conflict between the need for their protection and other beneficial uses of land and water in the Bay-Delta.

Protecting and restoring existing and additional suitable aquatic, wetland, and floodplain habitats and reducing the effect of other factors that can suppress breeding success will be critical to the recovery of the western spadefoot. Restoration of vernal pool habitats in the Sacramento-San Joaquin Delta Ecological

Management Zone will help recover this species by increasing habitat quality and area. Restoration of ecosystem processes and habitats in other ecological management zones will also allow natural floodplains, meander corridors, seasonal pools, and vernal pools to develop that will assist in the recovery of spadefoot populations.

Implementing guidelines developed by DFG for vegetation, grazing, traffic, and pest management would increase these species' reproductive success and reduce the level of mortality from unnatural sources. These guidelines could be implemented through cooperative agreements with land management agencies and organizations and development and implementation of incentive programs to encourage land use practices that improve habitat conditions for and reduce mortality on these species.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Wetland restoration and management programs which contribute to restoration or maintenance of vernal pools that would improve habitat for the western spadefoot include:

- the Agricultural Stabilization and Conservation Service's Wetland Reserve Program, and
- the Wildlife Conservation Board's Inland Wetlands Conservation Program.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of the spade foot toad population is integrally linked with restoration of riparian and wetland habitat in the Central Valley.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

> The Strategic Objective is to maintain abundance and distribution.

SPECIES TARGET: An increase in or no discernable adverse effect on the size or distribution of species populations.

LONG-TERM OBJECTIVE: Establish refuges for California spadefoot toad throughout its range.

SHORT-TERM OBJECTIVE: Identify and protect remaining spadefoot toad populations in the Bay-Delta watershed.

RATIONALE: Spadefoot toad populations are disappearing rapidly in the Bay-Delta watershed because of habitat alteration, especially urban development, and introductions of non-native fishes into their breeding ponds. They require fish-free breeding ponds next to upland habitat in which they can burrow for over summering. These habitats are naturally somewhat isolated from one another, promoting genetic diversity within the species which presumably reflects adaptations to local habitat conditions. Long-term survival of these diverse populations depends on protected areas containing both breeding ponds and upland habitats.

STAGE 1 EXPECTATIONS: A thorough survey of spadefoot toad populations in the Bay-Delta watershed will have been completed and actions taken to protect remaining populations in counties bordering the Bay-Delta system.

RESTORATION ACTIONS

The general target for western spadefoot is to increase the population size of each species.

General programmatic actions that will assist in reaching the targets include:

- protecting existing habitats from urbanization and conversion to irrigated pasture,
- improve degraded habitats,
- increase vernal pool habitats in the Central Valley;
- reduce the use of herbicides that adversely affect western spadefoot and California tiger salamander and their habitats;
- reduce mowing, to the extent feasible, to control vegetation and livestock grazing near occupied seasonal wetlands from October to March;
- reduce traffic, where feasible, on roads crossed by these species during migration periods;

- develop alternative control measures to replace the use fumigants to control rodents; and
- drain waterways used by the spadefoot and salamander during the periods when these species are dormant could be beneficial by reducing populations of non-native predatory fish and bullfrogs.

MSCS Conservation Measures

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

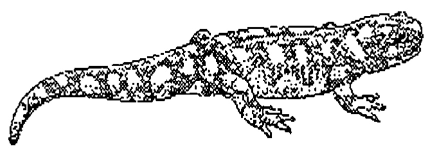
- To the extent consistent with CALFED objectives, enhance or restore suitable habitats near occupied habitat.
- Avoid or minimize CALFED actions that could increase or attract non-native predator populations to occupied habitat.

References

Multi-Species Conservation Strategy. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

◆ California Tiger Salamander



Introduction

The California tiger salamander occur throughout much of the Central Valley, San Francisco Bay, and coast ranges and foothills below 3,000 feet, as well as along the coast in the southern portion of the State. Declining populations have warranted their designation as species of special concern and species of concern by the California Department of Fish and Game (DFG) and U.S. Fish and Wildlife Service, respectively. Major factors that limit these resources' contribution to the health of the Delta are related to adverse effects of conversion of seasonal wetlands and adjacent uplands to other land uses and excessive mortality resulting from introduction of non-native predators and some land use practices.

Resource Description

California tiger salamander populations have declined primarily as a result of habitat loss or degradation and competition or predation from non-native species. The abundance from population to population is unknown but is influenced by the size and quality of individual habitat patches within the fragmented pockets that the species are known to inhabit.

Tiger salamanders typically inhabit scattered ponds, intermittent streams, or vernal pools that are associated with grassland-oak woodland habitat below Elevation 1500. Vernal pools covering more than 250 square feet, with fairly turbid water, provide optimal habitats. Most surface movements of the western spadefoot and California tiger salamander, including breeding activity, are associated with the onset of fall and spring rains that fill traditional breeding ponds. Warm days followed by rains or high humidity levels at night trigger reproductive and foraging activities and adults of these species sometimes appear in large numbers.

The greatest threat to the continued existence of the tiger salamander is habitat loss and competition by non-native species. Habitat loss is a result of increased urbanization and conversion of native grasslands to agriculture. The spadefoot and salamander may be found in high densities in isolated areas but adjacent breeding habitat is increasingly being converted for other uses.

Introduction of predatory fish and bullfrogs in known breeding ponds is also an important factor attributed to the decline of these species. Juvenile and adult bullfrogs can prey on larvae and terrestrial forms of these native species. Other important stressors that affect the spadefoot and salamander are rodent control activities, which reduce the availability of summer estivation (burrowing) sites. The use of rodent burrows may be more important for the California tiger salamander than for western spadefoot. Research on the extent and necessity of burrow use by both species would be valuable. In addition to rodent control activities, development of roads between breeding ponds and terrestrial habitats, resulting in deaths from automobiles during the species' migrations, has also contributed to the decline.

Vision

The vision for the California tiger salamander is to maintain existing populations of this Federal candidate species in the Bay-Delta.

Achieving this vision will contribute to overall species richness and diversity and reduce conflict between the need for their protection and other beneficial uses of land and water in the Bay-Delta.

Protecting and restoring existing and additional suitable aquatic, wetland, and floodplain habitats and reducing the effect of other factors that can suppress breeding success will be critical to the recovery of the California tiger salamander. Restoration of vernal pool habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will help recover this species by increasing habitat quality and area. Restoration of ecosystem processes and habitats in other ecological management zones will also allow natural floodplains, meander corridors, seasonal pools, and vernal pools to develop that will assist in the recovery of populations of these species elsewhere in their range.

Implementing guidelines developed by DFG for vegetation, grazing, traffic, and pest management would increase these species' reproductive success and reduce the level of mortality from unnatural sources. These guidelines could be implemented through cooperative agreements with land management agencies and organizations and development and implementation of incentive programs to encourage land use practices that improve habitat conditions for and reduce mortality on these species.

Integration with Other Restoration Programs

Wetland restoration and management programs which contribute to restoration or maintenance of vernal pools that would improve habitat for the California tiger salamander include:

- the Agricultural Stabilization and Conservation Service's Wetland Reserve Program, and
- the Wildlife Conservation Board's Inland Wetlands Conservation Program.

Linkage with Other Ecosystem Elements

Restoration of the salamander populations is integrally linked with restoration of riparian and wetland habitat in the Central Valley.

Objective, Targets, Actions, and Measures

> The Strategic Objective is to maintain abundance and distribution.

Species Target: An increase in or no discernable adverse effect on the size or distribution of species populations.

Long-Term Objective: Establish refuges for California tiger salamander throughout its range that will maintain its present genetic and ecological diversity.

Short-Term Objective: Identify and protect remaining California tiger salamander populations in the Bay-Delta watershed.

Rationale: California tiger salamander populations are disappearing rapidly in the Bay-Delta watershed because of habitat alteration, especially urban development, and introductions of non-native fishes into their breeding ponds. They require fish-free breeding ponds next to upland habitat containing rodent burrows in which they can over-summer. Patches of suitable habitats are naturally somewhat isolated from one another, promoting genetic diversity within the species which presumably reflects adaptations to local conditions. Long-term survival of these diverse populations depends on numerous protected areas containing both breeding ponds and upland habitats.

Stage 1 Expectations: A thorough survey of tiger salamander populations in the Bay-Delta region will have been completed and actions taken to protect remaining populations in counties bordering the Bay-Delta system.

Restoration Actions

The general target for California tiger salamander is to increase the population size.

General programmatic actions that will assist in reaching the targets include:

- protecting existing habitats from urbanization and conversion to irrigated pasture,
- improve degraded habitats,
- increase vernal pool habitats in the Central Valley;
- reduce the use of herbicides that adversely affect California tiger salamander and its habitats;

- reduce mowing, to the extent feasible, to control vegetation and livestock grazing near occupied seasonal wetlands from October to March;
- reduce traffic, where feasible, on roads crossed by these species during migration periods;
- develop alternative control measures to replace the use fumigants to control rodents; and
- drain waterways used by the spadefoot and salamander during the periods when these species are dormant could be beneficial by reducing populations of non-native predatory fish and bullfrogs.

MSCS CONSERVATION MEASURE

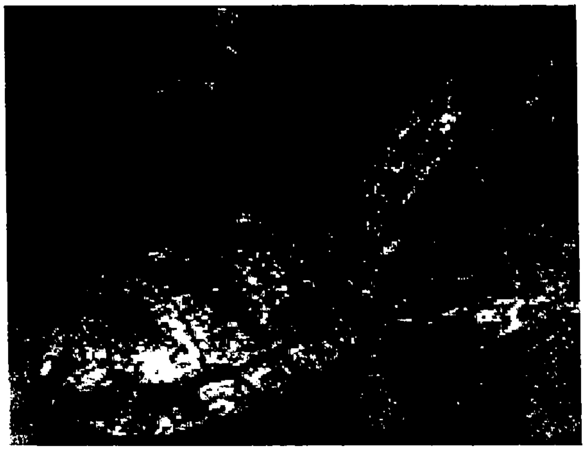
The following conservation measure was included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- To the extent consistent with ERP objectives, enhance or restore suitable habitats near occupied habitat areas.

REFERENCES

Multi-Species Conservation Strategy. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.



INTRODUCTION

The loss of habitat and declining condition has warranted the listing of the western pond turtle as a species of concern by U.S. Fish and Wildlife Service (USFWS) and a Species of Special Concern by California Department of Fish and Game (DFG).

Major factors that limit these resources' contribution to the health of the Delta are related to adverse effects of conversion of aquatic, wetland, riparian, and adjacent upland habitats to other land uses and land use practices that degrade the value of otherwise suitable habitat areas.

RESOURCE DESCRIPTION

The western pond turtle inhabits ponds, rivers, streams, lakes, marshes, and irrigation ditches with rocky or muddy bottoms. Dense cover and exposed basking sites are important components of these wetland habitat types. The western pond turtle inhabits every region of California except drainages on the eastern slope of the Sierra Nevada. Population densities vary, however, and are highly influenced by the quality of isolated habitats. A disproportionately large percentage western pond turtle populations are adults, indicating poor reproductive success.

Historic habitat areas used by these species have been substantially reduced as a result of converting land for agriculture, urban, or industrial uses or degraded as a result of ongoing land-use practices. Remaining habitat areas, such as ponds, rivers, streams, lakes, marshes, and irrigation ditches, are largely fragmented. Associated uplands, used for reproduction and hibernation, are largely unavailable. Upland habitats adjacent to aquatic habitats are now mostly isolated in small riparian bands along the tributaries that supply water to the Sacramento and San Joaquin rivers and along canals with small levees.

Because much of the original habitat used by these species has been lost, irrigation canals and ditches (especially canals with nearby vegetation) now provide important replacement habitat for these species. Rice farming makes up a significant portion of the agricultural activity in the Sacramento Valley, and drainage ditches associated with rice farming practices provide much of this surrogate habitat. Adjacent breeding and hibernating cover, however, is often limiting for these species.

Other factors that limit these species populations include:

- some agricultural practices (e.g., discing, mowing, burning, and applying herbicides and rodenticides) that degrade habitat or cause mortality;
- introduced large predatory fish that prey on juveniles and injure adults; and
- mortality caused by flooding of hibernation sites during heavy rains, floods, or for waterfowl.

> **VISION**
>
> The vision for the western pond turtle is to maintain the abundance and distribution of this California species of special concern in order to contribute to the overall species richness and diversity.

Achieving this vision will reduce the conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta.

Protecting existing and restoring additional suitable wetland and upland habitats will be critical to achieving recovery of the giant garter snake and western pond turtle. The Ecosystem Restoration Program Plan's (ERPP's) proposed restoration of aquatic, wetland, riparian, and upland habitats in the

Sacramento-San Joaquin Delta Ecological Management Zone will help in the recovery of these species by increasing habitat quality and area.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Restoration projects to improve upland and wetland agriculture and seasonal wetland and riparian habitats would be closely linked to the restoration of these species.

Efforts to recover western pond turtle populations will involve cooperation and support from other established programs aimed at restoring habitat and populations.

Wetland restoration and management programs that would improve habitat for these species include the Agricultural Stabilization and Conservation Service's Wetland Reserve Program, the Wildlife Conservation Board's Inland Wetlands Conservation Program, restoration programs administered by Ducks Unlimited and the California Waterfowl Association, and ongoing management of State and federal wildlife refuges and private duck clubs. Restoration efforts will be conducted in cooperation with agencies or organizations with responsibility or authority for restoring wetland and aquatic habitats, including DFG, California Department of Water Resources, USFWS, U.S. Army Corps of Engineers, and the Delta Protection Commission. USFWS is also preparing a recovery plan for the giant garter snake that will establish population recovery goals.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of ecosystem processes and habitats proposed by ERPP in other ecological management zones will also allow natural floodplains, stream meanders, and seasonal pools to develop that assist in the recovery of their populations elsewhere in their historic ranges.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

The Strategic Objective is to maintain abundance and distribution.

SPECIES TARGET: An increase in or no discernable adverse effect on the size or distribution of species populations.

LONG-TERM OBJECTIVE: Restore self- sustaining populations of western pond turtles to habitats throughout the Bay-Delta watershed including the Delta.

SHORT-TERM OBJECTIVE: Determine the status and habitat requirements of pond turtles throughout the region and develop a conservation strategy in concert with habitat protection measures.

RATIONALE: The western pond turtle is the only turtle native to the Central Valley region and to much of the western United States. Although considered to be just one widely distributed species, it is likely that the pond turtle is a complex of closely related species, each adapted for a different region. The Pacific pond turtle is still common enough in the Bay-Delta watershed so that it is not difficult to find them in habitats ranging from sloughs of the Delta and Suisun Marsh to pools in small streams. The problem is that most individuals seen are large, old individuals; hatchlings and small turtles are increasingly rare. The causes of the poor reproductive success are not well understood but factors that need to be considered include elimination of suitable breeding sites, predation on hatchlings by non-native predators (e.g., largemouth bass, bullfrogs), predation on eggs by non-native wild pigs, diseases introduced by non-native turtles, and shortage of safe upland over-wintering refuges. If present trends continue, the western pond turtle will deserve listing as a threatened species (it may already).

STAGE 1 EXPECTATIONS: Populations of turtles that appear to still have successful reproduction will have been located and protected, in conjunction with other habitat protection measures. Causes of the decline should be determined and a recovery plan developed based on the findings.

RESTORATION ACTIONS

The general target is to increase the population size of western pond turtles.

General programmatic actions to protect occupied habitat areas include the following:

- Implement a preservation plan to protect these areas from adverse effects associated with human encroachment and recreation,
- Create canals, side channels, and backflow pools containing emergent vegetation within the South, East, and North Delta Ecological Management Units of the Sacramento-San Joaquin Delta Ecological Management Zone to provide forage habitat and escape cover, and create dispersal corridors by linking habitat areas.
- Restore suitable adjacent upland habitat or modify land use practices to render existing uplands as suitable habitat and reestablish connectivity between wetland and upland habitat areas, provide nest and hibernation sites, and provide refuge habitat during floods.
- Create buffer zones where none currently exist to improve habitat value.

MSCS CONSERVATION MEASURE

The following conservation measure was included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- To the extent practicable, capture individuals from habitat areas that would be affected by CALFED actions and relocate them to nearby suitable existing, restored, or enhanced habitat areas.

REFERENCES

Multi-Species Conservation Strategy. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

◆ California Freshwater Shrimp

Introduction

The California freshwater shrimp is found in three California counties, Marin, Napa, and Sonoma. The shrimp has apparently been extirpated from five of ten streams in which it occurred during 1964 (Eng 1981). During a subsequent distribution study of the species, shrimp were found to inhabit six additional streams (Serpa 1991). Habitat loss and alteration have been the primary causes for is demise. Urbanization, agricultural development, overgrazing, and dam and road construction have contributed to habitat loss.

Resource Description

The California freshwater shrimp is a small shrimp, measuring less than 2.5 inches in length. It is native to Marin, Sonoma and Napa counties and represents the only remaining species of this genus. The freshwater shrimp is found in freshwater sand and gravel bottom streams at low elevation which have a gentle gradient. The shrimp occurs primarily in pool areas away from the main streamflow. The pools have undercut bands and exposed roots. The exposed roots are the preferred winter habitat. Bankside bushes, vines and sedges that extend into the water provide favorable conditions for the shrimp, especially in the late spring and summer months.

Freshwater shrimp appear to tolerate warm water temperatures ($\geq$73°F) and no-flow conditions that are detrimental or fatal to native salmonids. Laboratory studies indicate the freshwater shrimp should be able to tolerate brackish water conditions for short periods.

The health of California freshwater shrimp populations is adversely affected by the following general types of activities or conditions:

- urbanization
- agricultural practices
- livestock grazing and dairy farming
- timber harvesting
- gravel mining
- water development
- summer dams
- urban runoff
- wastewater discharge
- flood control
- bank protection
- culverts and grade control structures
- introduced predators.

Vision

The vision for the California freshwater shrimp is to maintain populations of this federally listed endangered species by maintaining its existing distribution and abundance.

Conservation of the California freshwater shrimp would contribute to overall species richness and diversity. Achieving this vision will reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.

Protecting existing populations from activities that could result in their loss or degradation and restoring ecological process of confined channel migration will be critical to the recovery of the shrimp. The Ecosystem Restoration Program Plan's proposed restoration of stream meander and riparian habitat in the North San Francisco Bay/Suisun Marsh Ecological Management Zones will help to protect the remaining populations in the Napa River and its tributary, Garnett Creek, Sonoma Creek and its tributary, Yulupa Creek, and Huichica Creek. Protecting the remaining populations is an essential requirement to preventing the shrimp populations from declining to a point where restoration efforts may offer little help to the species.

Restoring these habitats while protecting and restoring streamside banks and levees would also help maintain or increase existing shrimp populations.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Other programs linked to restoring riparian systems and California freshwater shrimp habitat include:

- Huichica Creek Land Stewardship group,
- Napa County Resource Conservation District's Natural Resource Protection and Enhancement Plan,
- Napa County's integrated resource management plan for the Napa River,
- Napa County Resource Conservation District's "Adopt-A-Watershed" program,

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of the California freshwater shrimp population and its habitat will be integrally linked to restoration of natural stream meander corridors in the rivers of the Central Valley.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

> The Strategic Objective is to maintain abundance and distribution.

SPECIES TARGET: An increase in or no discernable adverse effect on the size or distribution of species populations.

LONG-TERM OBJECTIVE: Increase and maintain populations of California freshwater shrimp.

SHORT-TERM OBJECTIVE: Implement restoration measures designed to protect existing populations and initiate design of a long-term conservation and restoration program.

RATIONALE: California freshwater shrimp is an endangered species that needs protection and restoration. Other restoration efforts within tributaries to the North Bay may affect the distribution and abundance of the shrimp. Specifically, management and restoration actions for the Napa River and Sonoma Creek ecological management areas must integrate actions to benefit numerous species.

STAGE 1 EXPECTATIONS: The abundance of the California freshwater shrimp will have increased and measures instituted to protect and restore the long-term viability of the shrimp populations.

RESTORATION ACTIONS

The general target is to protect exist populations in the North Bay.

General programmatic actions which will contribute to reaching the target include:

- remove existing threats to known populations of shrimp through management of shrimp populations and habitat,
- restore habitat conditions favorable to shrimp and other native aquatic species,
- protect and monitor shrimp populations and habitat once the threats have been removed and restoration has been completed,
- assess effectiveness of various conservation efforts for shrimp,
- conduct research on the biology of the species,
- restore and maintain viable shrimp population at extirpated and existing localities,
- increase public awareness and involvement in the protection of shrimp and native cohabitating species.

MSCS CONSERVATION MEASURE

The following conservation measure was included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- To the extent consistent with ERP objectives, enhance or restore suitable habitats near occupied habitat areas.

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♦EEL-GRASS PONDWEED

INTRODUCTION

Aquatic habitats associated with shorelines of rivers and the Delta include shaded riverine aquatic and riparian habitats. Riverine aquatic habitat shaded by riparian vegetation provides important habitat for many species of fish, waterfowl, and wildlife. Nontidal perennial aquatic habitat is another aquatic habitat that occurs in the Bay-Delta as permanent open water that is no longer subject to tidal influences.

Riverine aquatic habitat is characterized by the relatively shallow submerged and seasonally flooded areas in estuary and river channel beds. Channel beds contain gravel beds, bars, and riffles; transient sandy shoals; waterlogged woody debris piles; and the shaded riverine aquatic habitat zone. This habitat zone is located where the river meets the riparian canopy. Riverine aquatic zones provide spawning substrate, rearing and escape cover, feeding sites, and refuge from turbulent stormflows for fish and other aquatic organisms. Riparian and riverine aquatic habitats are created and sustained by natural fluvial processes associated with rivers.

The nontidal perennial aquatic habitat is present in certain low-elevation areas in the Bay-Delta estuary. In many places within the Delta, this habitat type has replaced the native tidal aquatic habitats that existed prior to reclamation. Most nontidal perennial aquatic habitat areas were established by constructing dikes and levees as part of reclamation activities. As land was converted to agricultural uses, perennial aquatic habitats established in large agricultural drains; small farm ponds; industrial ponds; ponds managed for waterfowl and other wildlife; and Delta island blowout ponds, which were created by levee failures that scoured island interiors deeply enough to maintain permanent water through seepage. Some historical nontidal perennial habitat was created naturally as a result of shifts in river alignments that occasionally resulted in establishment of isolated oxbow lakes. Eel-grass pondweed *(Potamogeton zosteriformis)* is the only aquatic habitat special-status plant species that is expected to occur in the study area.

SPECIES DESCRIPTION

Eel-grass pondweed *(Potamogeton zosteriformis)* is an annual aquatic plant with narrow linear leaves that grows less than 24 inches tall and is submerged in ditches, ponds, lakes, and slow-moving streams generally below the 5,000-foot elevation (Mason 1957, Hickman 1993). Eel-grass pondweed is more common outside the State of California, although suitable habitat exists for it in the Central Valley, where it is considered rare. It is known to have occurred in Lassen, Shasta, and Modoc Counties in the State based on six records in the California Department of Fish and Game Natural Diversity Data Base (1996) that were documented between 1897 and 1949. Eel-grass pondweed is expected to occur in the San Joaquin River Delta (Mason 1957, Munz and Keck 1973). The species has not been listed for protection by the State or the federal government. It has been assigned to List 2 by the California Native Plant Society (Skinner and Pavlik 1994).

VISION

The vision for eel-grass pondweed is to maintain populations of this California Native Plant Society List 2 plant species.

The overall vision for aquatic habitat plant species is to provide protection for and enhance existing populations. The vision for eel-grass pondweed and other aquatic habitat plant species should be initiated by conducting surveys in the project area to identify locations of sites. Following identification of sites, it will be necessary to conduct site-based evaluations of populations, develop criteria on habitat and population conditions, and rank all sites based on the criteria in terms of low- to high-quality. Higher ranked sites should be identified for protection. Restoration efforts should be focused on restoring existing habitat and promoting establishment of aquatic plant species on restored sites or at other sites with suitable habitats.

Existing populations of aquatic species should be protected through acquisition or cooperative efforts with landowners, beginning with the highest quality sites.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to achieve the vision for riverine aquatic habitat (including riparian habitat) may involve coordination with other programs. These include:

- U.S. Army Corps of Engineers proposed reevaluation of the Sacramento River flood control project and ongoing bank protection project, including more comprehensive floodplain management and river ecosystem restoration opportunities;
- SB 1086 Advisory Council efforts and river corridor management plan for the Sacramento River;
- the San Joaquin River Parkway and Management plans;
- ongoing Sacramento Valley conservation planning by the Nature Conservancy and other private nonprofit conservation organizations;
- expansion plans and conservation easements underway for the Sacramento River National Wildlife Refuge and California Department of Fish and Game Sacramento River Wildlife Management Area; and
- ongoing coordination efforts and programs of the Wildlife Conservation Board, including the Riparian Habitat Joint Venture.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Riverine aquatic habitat is important to many fish, wildlife, and plant species and communities. It is adversely affected by stressors that include levee construction, gravel mining, flow patterns, fragmentation of existing stands of riparian vegetation, competition and displacement by non-native plant species.

Restoration of nontidal perennial aquatic habitat is linked with ecosystem processes including:

- the geologic and hydrologic condition, stream meander, and tidal function necessary to maintain permanent surface water;
- a range of elevations sufficient to support deep-water (greater than 3 feet in depth) and shallow-water areas; and
- adjacent wetland and riparian (streambank) vegetation.

The value of nontidal perennial aquatic habitat to wildlife greatly increases if emergent vegetation is present along shorelines and in shallow-water areas. Adjacent dense upland herbaceous vegetation and riparian woodland further increase the value to wildlife.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

> The Strategic Objective is to maintain abundance and distribution.

SPECIES TARGET: An increase in or no discernable adverse effect on the size or distribution of species populations.

LONG-TERM OBJECTIVE: Have self-sustaining populations of eel-grass pondweed located throughout their original native range in marshes associated with the Bay-Delta estuary.

SHORT-TERM OBJECTIVE: Protect existing populations of the species and restore habitat to provide sites for expansion of all rare native species that require nontidal aquatic habitat.

RATIONALE: Eel-grass pondweed requires nontidal aquatic habitat. The restoration of nontidal aquatic habitat should provide for a diversity of plant and animal species including eel-grass pondweed.

STAGE 1 EXPECTATIONS: The status of eel-grass pondweed will have improved. Surveys of present ranges of the species, studies of its ecological requirements, and identification of key restoration sites will have been completed. On-going nontidal perennial aquatic habitat restoration projects in the Bay-Delta will have been evaluated according to their success or potential support for restoring rare native plant species and lessons learned applied to new projects.

RESTORATION ACTIONS

The targets for eel-grass pondweed include identifying and protecting high-quality habitats and populations throughout the range of this species in the study area, and ensuring the long-term viability of the species on higher ranked sites. Implementation of the following actions would contribute to achieving the targets:

- Conduct a site-based evaluation of populations, develop criteria on habitat and population conditions, and rank all sites based on the criteria in terms of low- to high-quality. Based on the ranking of sites identify the higher ranked sites for protection.
- Protect higher ranked sites through acquisition or cooperative efforts with landowners.
- Conduct studies to determine the microhabitat requirements of eel-grass pondweed and determine reasons for limited distribution.
- Develop and implement a habitat management plan to protect eel-grass pondweed on higher ranked sites.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Conduct surveys in suitable habitat areas that could be affected by CALFED actions to determine whether species are present before implementing actions that could result in loss or degradation of occupied habitat.

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◆ VERNAL POOL SPECIAL-STATUS PLANT SPECIES

INTRODUCTION

Vernal pools are seasonally flooded depressions that support a distinctive biota adapted to periodic or continuous inundation during the wet season and desiccated soils during the dry season (Holland and Jain 1977, Holland 1978, Thorne 1984, Jones & Stokes Associates 1990). Vernal pools usually occur in troughs between the ridges of a gently rolling or reticulated landscape, in the depressions between small mounds in a landscape dotted by "mima mounds", or on localized flats or steps in a seasonally wet swale. Some appear as isolated anomalies on ridge tops or flat terrain. Vernal pools vary in size from several yards to well over 1 acre, but most range from several thousandths to a few tenths of an acre. The largest vernal pools are really seasonal lakes, like Olcott Lake at the Jepson Prairie Preserve in Solano County and Boggs Lake at the Boggs Lake Preserve in Lake County.

Vernal pools support a unique associated of plant species. Some of the plants are restricted to vernal pools, while others occur primarily in vernal pools but also occur in other seasonal wetland habitats. Vernal pools are well known for their high level of endemism (Jain 1976) and abundance of rare, threatened, or endangered species (Skinner and Pavlik 1994, Jones & Stokes Associates 1990).

SPECIES DESCRIPTIONS

DESIGNATED FOR CONTRIBUTE TO RECOVERY

ALKALI MILK-VETCH *(Astragalus tener var. tener)* is rare, threatened, or endangered in California and elsewhere by CNPS (List 1B). Historical distribution of Alkali milk-vetch includes Alameda, contra Costa, Merced, Monterey, Napa, San Benito, San Francisco, San Joaquin, Solano, Sonoma, Stanislaus, and Yolo Counties. Currently its distribution is Merced, Napa, Solano, and Yolo Counties. The primary threat to this species is sheep and cattle grazing (NDDB 1996).

CRAMPTON'S TUCTORIA *(Tuctoria mucronata)* is a sticky, aromatic annual grass, with a dense spike of overlapping flower spikelets that emerge from the upper leaves. Crampton's tuctoria is state and federally listed as endangered and CNPS list 1B. It occurs in only two counties Solano and Yolo. It grows in the clay bottoms of drying vernal pools and lakes. The Nature Conservancy owns and protects a portion of the habitat at the Jepson Prairie Preserve, but the plant has not been seen since 1987 at the preserve (DFG 1992). Threats to the two known occurrences include alternation of local drainage patterns that feed the pools, off-road vehicle recreation, local farming operations, and trampling by livestock. Roads and transmission corridors have also degraded the habitat. Most of Crampton's tuctoria habitat is privately owned. The USFWS has prepared a recovery plan for Crampton's tuctoria which provides management recommendations (DFG 1992).

> **VISIONS**
>
> The vision for alkali milkvetch is to contribute to the recovery of this California Native Plant Society List 1B plant species.
>
> The vision for Crampton's tuctoria is to contribute to the recovery of this federally and State-listed endangered species.

DESIGNATED FOR MAINTAIN

COLUSA GRASS *(Neostapfia colusana)* is a pale green annual member of the grass family (Poaceae), with several stems of loosely folded, clasping leaves and thick terminal spikes of flowers. Colusa grass is state listed as endangered and federally listed as threatened. It is considered rare, threatened, or endangered in California and elsewhere by the California Native Plant Society (CNPS) List 1B. Colusa grass grows in the bottoms of large or deep vernal pools with substrates of adobe mud and is somewhat resistant to light grazing. Colusa grass is endemic to the southern Sacramento and northern San Joaquin Valleys. Its historical distribution included Merced, Stanislaus, Solano and Colusa Counties, but is now extirpated from Colusa County. Two new populations have been found in Yolo

County. The primary reasons for decline of Colusa grass include the conversion of vernal pools to agricultural and developed lands, heavy grazing by cattle, and competition from introduced weedy species that tend to displace it. (DFG 1992)

BOGGS LAKE HEDGE-HYSSOP *(Gratiola heterosepala)* is a small, semi-aquatic, herbaceous annual in the figwort family (Scrophulariaceae). It has opposite leaves, blunt, unequal sepals, and yellow and white flowers on short stalks. Boggs Lake hedge-hyssop is state endangered and considered rare, threatened, or endangered in California and elsewhere by CNPS (List 1B). Boggs Lake hedge hyssop is found in Fresno, Lassen, Lake, Madera, Modoc, Placer, Sacramento, Shasta, San Joaquin, Solano, and Tehama counties and in Oregon. This species is found in shallow waters or moist clay soils of vernal pools and lake margins. Boggs Lake hedge hyssop has undergone substantial habitat reduction from development and agricultural conversion. Current threats include agriculture, development, grazing, and ORV's. Many occurrences are on privately owned land. (DFG 1992)

CONTRA COSTA GOLDFIELDS *(Lasthenia conjugens)* is a showy spring annual in the aster family (Asteraceae) that grows 10 to 30 centimeters tall with opposite light green leaves. Contra Costa goldfields is federally listed as endangered and is on CNPS list 1B. The historical distribution of Contra Costa goldfields extended from Mendocino to Santa Barbara Counties. Currently its distribution is limited to a few locations in Solano and Napa Counties. It inhabits vernal pools and seasonally moist grassy areas. In the past, the species may have also occurred in coastal prairies (Ornduff 1979). The decline of the Contra Costa goldfields has been attributed to the loss of vernal pools by development and agriculture. Continued threats include urbanization and overgrazing.

LEGENERE *(Legenere limosa)* is a slender annual that grows in wet margins of deep vernal pools. Legenere is considered by the U.S. Fish and Wildlife Service (USFWS) to be a species of concern and CNPS list 1B. Historical distribution of Legenere includes Lake, Napa, Placer, Sacramento, San Mateo, Solano, Sonoma, Stanislaus and Tehama Counties. It has now become extirpated from Sonoma and Stanislaus Counties. At the Jepson Prairie Preserve it is found in the bottom of hogwallow. Threats to this species are primarily loss of vernal pools by agriculture. Other threats include grazing and development.

HEARTSCALE *(Atriplex cordulata)* is considered by the USFWS to be a species of concern and CNPS list 1B. Distribution of heartscale includes Alameda, Contra Costa, Butte, Fresno, Glenn, King, Kern, Madera, Merced, Solano, and Tulare Counties and no longer occurs in San Joaquin, Stanislaus or Yolo Counties (NDDB 1996).

VISIONS

The vision for Colusa grass is to maintain populations of this federally listed threatened and State-listed endangered species.

The vision for Boggs Lake hedge-hyssop is to maintain populations of this State-listed endangered species.

The vision for Contra Costa goldfields is to maintain populations of this federally listed endangered species.

The vision for legenere is to maintain populations of this California Native Plant Society List 1B plant species.

The vision for heartscale is to maintain populations of this California Native Plant Society List 2 species.

The vision for vernal pool plant species is to provide protection for and enhance existing populations. Existing populations should be protected through acquisition or cooperative efforts with landowners, beginning with the highest quality sites. Preservation and proper management of all existing populations would ensure the long-term viability of the species. To provide for proper management on protected sites, research would be conducted to determine the optimal conditions for the growth. For example, on sites with a high cover of non-native species, experimental burning and/or grazing would be conducted to determine if such treatments are beneficial for the species. Colusa grass's response to light and moderate grazing could also be investigated. Research on reproduction and recruitment would be conducted to better understand the species' biology.

Following experimental research, habitat management techniques to promote conditions suitable for the growth and establishment would be implemented. This may include, but is not limited to, reduction in grazing; use of prescribed burns, restoration of winter flood/summer drought regime; and removal of other stresses.

Integration with Other Restoration Programs

Efforts to restore seasonal wetlands would involve cooperation with other restoration programs, including:

- Upper Sacramento River Fisheries and Riparian Habitat Council,
- California Department of Fish and Game wildlife areas,
- Jepson Prairie Preserve,
- Ducks Unlimited Valley Care Program,
- California Waterfowl Association,
- the Nature Conservancy,
- U. S. Fish and Wildlife Service,
- Yolo County Habitat Conservation Plan,
- and Central Valley Habitat Joint Venture.

Two occurrences of Colusa grass are currently protected: the Solano County occurrence at the Nature Conservancy's (TNC) Jepson Prairie Preserve and the Flying M Ranch in Merced County, where conservation easements protect some of the large vernal pools. Heartscale occurs with two other species dwarf downingia and legenere at the Nature Conservancy's Jepson Prairie Preserve.

Linkage with Other Ecosystem Elements

The vernal pool guild of plant species is linked with the restoration of vernal pool habitat. Stressors that could effect these species include: non-native weedy grasses and grazing.

Objective, Targets, Actions, and Measures

> The Strategic Objective is to contribute to the recovery of at-risk native species in the Bay-Delta estuary and its watershed.

Species Target

Alkali milk-vetch: Protect extant populations and reintroduce species near extirpated populations.

Crampton's tuctoria: Review and update recovery plan targets, protect all extant occurrences, and manage habitat to benefit Crampton's tuctoria.

> The Strategic Objective is to maintain abundance and distribution.

Species Target: An increase in or no discernable adverse effect on the size or distribution of species populations for Colusa grass, Boggs Lake hedge-hyssop, Contra Costa goldfields, legenere and heartscale.

Long-term Objective: Have self-sustaining populations of Colusa grass, Boggs Lake hedge-hyssop, Contra Costa goldfields, legenere, alkali milk-vetch, Crampton's tuctoria, and heartscale and similar declining endemic species located throughout their original native range in vernal pools associated with the Bay-Delta estuary.

Short-term Objective: Protect existing populations of the species and restore habitat to provide sites for expansion of all rare native species that require vernal pool or other wetland habitat.

Rationale: The seven species listed here are examples of plants that are largely endemic to vernal pool and other wetland areas throughout the Bay-Delta estuary and watershed. Restoration of these species to the point where they were no longer in danger of extinction would indicate that major perennial grassland-vernal pool-wetland restoration projects in the region had succeeded.

STAGE 1 EXPECTATIONS: The status of the eight species listed here will have improved. Surveys of present ranges of the species (and other rare vernal pool plants), studies of their ecological requirements, and identification of key restoration sites will have been completed. On-going marsh restoration projects in the Bay-Delta will have been evaluated according to their success at restoring rare native plant species and lessons learned applied to new projects.

RESTORATION ACTIONS

The targets for vernal pool special-status species include identifying high-quality habitats and populations and restoration and reestablishment of populations in order to maintain diversity and ensure the sustainability of each species.

- Protect existing habitat and restore and reestablish vernal pool habitats within and adjacent to existing ecological reserves.
- Implement restoration of habitat and reintroduction of species on historic sites in conjunction with long-term monitoring and maintenance of existing and newly established populations.
- Conduct reproduction and recruitment research to better understand the species biology.
- Conduct site-based evaluation of populations and develop criteria for ranking sites and protection of high-quality sites.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

BOGGS LAKE HEDGE-HYSSOP AND GREENE'S LEGENRE

- To the extent consistent with ERP objectives, enhance or restore suitable habitats to benefit these species in occupied habitat areas.

HEARTSCALE

- Develop a seedbank from all populations affected by implementation of CALFED actions and use the collected seed for inoculating unoccupied suitable habitat.
- To the extent consistent with ERP objectives, enhance or restore suitable habitats to benefit these species in occupied habitat areas.

COLUSA GRASS AND CONTRA COSTA GOLDFIELDS

- Before implementing actions that could result in the loss or degradation of occupied habitat, conduct surveys in suitable habitat that could be affected by CALFED actions to determine whether species are present.

CRAMPTON'S TUCTORIA

- Establish three new self-sustaining populations in conjunction with establishment of Delta green ground beetle populations.
- Maintain existing populations.

ALKALI MILKVETCH

- Protect extant populations and reintroduce species near extirpated populations.
- Monitor status and distribution of populations for the duration of the Program and design and implement conservation measures if a decline in population size or vigor is observed.

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◆ PERENNIAL GRASSLAND SPECIAL-STATUS PLANT SPECIES

INTRODUCTION

Perennial grassland was historically common throughout the Central Valley. Most perennial grassland has been lost or converted into annual grassland dominated by non-native species. Perennial grassland provides important breeding and foraging habitat for many wildlife species and supports several special-status plant species, including the recurved larkspur (*Delphinium recurvatum*).

SPECIES DESCRIPTION

RECURVED LARKSPUR (*Delphinium recurvatum*) is a perennial herb with light blue and white flowers in the Buttercup family (Ranunculaceae). It is considered a species of concern by the USFWS and is considered rare, threatened, or endangered by the California Native Plant Society (List 1B). Recurved larkspur inhabits poorly drained, fine, alkaline soils in grassland in the Central Valley and surrounding foothills of the Coast Ranges from Colusa County to Kern County (NDDB 1996). Much of the larkspur's habitat has been converted to agriculture, and is also threatened by grazing.

VISION

The vision for recurved larkspur is to maintain populations of this California Native Plant Society List 1B plant species.

The vision for the recurved larkspur and other perennial grassland species is to protect existing populations, promote the recovery of the species' habitat, establish new populations, and manage occupied sites properly to ensure the long-term viability of the species. A site-based evaluation of existing populations would be conducted, criteria on habitat and populations conditions developed, and all sites ranked based on the criteria in terms of low to high quality habitat. Based on the site rankings, the highest quality populations would be protected.

To ensure the long-term viability of the species, lower quality sites would be evaluated for potential habitat restoration or enhancement opportunities. Existing populations would be expanded through habitat restoration, enhancement, and appropriate management. The species' grassland habitat would be protected from overgrazing and trampling by livestock. Appropriate management techniques, such as lowered grazing regime, prescribed burns, and exotics control would be evaluated and appropriate techniques implemented to promote The health and vigor of existing and restored populations.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Restoring perennial grassland is an objective of the Cache Creek Corridor Restoration Plan and Yolo County Habitat Conservation Plan. Additional efforts to restore habitat for the recurved larkspur will involve cooperation with programs managed by several agencies and organizations. These include:

- Cosumnes River Preserve,
- Grizzly Slough Wildlife Area,
- Jepson Prairie Preserve,
- Putah Creek South Fork Preserve,
- Stone Lakes National Wildlife Refuge, and
- Woodbridge Ecological Reserve.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Recurved larkspur is linked with a habitat ecosystem element, perennial grassland. Land use, human disturbance, and non-native species are stressors that could adversely affect the perennial grassland special-status plants.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

The Strategic Objective is to maintain abundance and distribution.

SPECIES TARGET: An increase in or no discernable adverse effect on the size or distribution of species populations.

LONG-TERM OBJECTIVE: Preserve and restore perennial grassland habitat that provides for special status plant species.

SHORT-TERM OBJECTIVE: Develop or utilize existing GIS overlays which depict specific sites supporting special status perennial grassland plant species and compare these sites to other proposed restoration measures for the restoration of wetland and riparian habitat.

RATIONALE: Protection and restoration of special status plant species is closely linked to actions to protect and restore perennial grasslands. In addition to supporting vernal pools, perennial grasslands provide valuable habitat for many wildlife species and provide important transitional habitat and support area for adjacent habitat. The design of restoration actions for perennial grasslands must include consideration and modification to accommodate special status plants.

STAGE 1 EXPECTATIONS: Distribution surveys will have been conducted or competed to identify special status plant habitats. This information will have been integrated into project planning for wetland and perennial grassland restoration actions.

The targets for these species include identifying and protecting high-quality habitats and populations and ensuring the long-term viability of the species on higher ranked sites.

- Acquire lands supporting existing populations or develop cooperative relationships with landowners to protect existing populations, beginning with the highest quality sites.
- Develop appropriate methods to protect and restore habitat and populations of special-status plant species.
- Manage protected areas occupied by the species to promote conditions favorable for the establishment, growth, and vigor of the species.
- Conduct a site-based evaluation of populations and rank sites based on criteria developed to assess habitat and populations conditions.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve recurved larkspur habitat or population targets.

- To the extent consistent with ERP objectives, enhance or restore suitable habitats to benefit these species in occupied habitat areas.
- Develop a seedbank from all populations affected by implementation by CALFED actions and use the collected seed for inoculating unoccupied suitable habitat.

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◆ SPECIES ASSEMBLAGES AND COMMUNITIES DESIGNATED FOR ENHANCE AND CONSERVE

INTRODUCTION

The Strategic Plan for Ecosystem Restoration presents 6 goals to guide the implementation of restoration actions during the 20-30 year program.

The first Strategic Goal focuses on at-risk species:

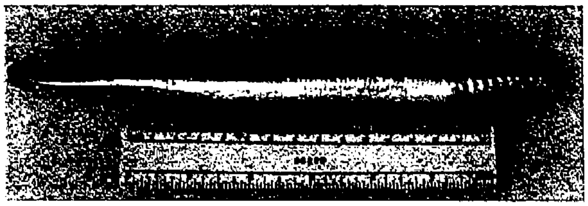
> *STRATEGIC GOAL 1: Achieve, first, recovery and then large self-sustaining populations of at-risk native species dependent on the Delta and Suisun Bay; support similar recovery of at-risk native species in the Bay-Delta estuary and its watershed; and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed.*

This section addresses those species designated as "Enhance and/or conserve" in the ERP.

ENHANCE AND/OR CONSERVE"E": For those biotic assemblages and communities (aquatic, terrestrial, and plant) designated "E", the CALFED Program will undertake actions to maintain and enhance their diversity, distribution and abundance in the Bay-Delta estuary and watershed as appropriate to reverse their declines or to keep abundances and distributions at their present levels.

The "enhance and/or conserve" species addressed in this section include:

- lamprey family
- native resident fishes
- native anuran amphibians
- migratory waterfowl
- shorebird guild
- wading bird guild
- neotropical migratory birds
- Bay-Delta foodweb organisms
- aquatic habitat plant community
- tidal brackish and freshwater habitat plant community, and
- seasonal wetland habitat plant community.



INTRODUCTION

Like any native species the lamprey is an indicator of ecosystem health. Although the lamprey does not hold any commercial or recreational value in California, its life history is similar to that of other anadromous species (salmonids). Loss of suitable spawning habitat and disturbance by humans has impacted the population of native lampreys. Even though these fish are predaceous in nature, they appear to have little affect on other resident fish species. Some California Native American tribes and European countries consider the lamprey a delicacy.

Factors that will limit the lamprey's ability to contribute to a healthy ecosystem are Delta outflow and spawning habitat in the upper rivers.

Little recent information regarding the abundance and distribution of lampreys in the Central Valley is available. This lack of information needs to be remedied by research into the basic biology of the genus, including life history studies, and data collection regarding abundance and distribution.

RESOURCE DESCRIPTION

The lamprey is the most primitive of all fish species that reside in California waters. Of the four species of lamprey that can be found in California only three have life stages in the Sacramento-San Joaquin system. These are the river lamprey (*Lampetra ayresi*), Pacific lamprey (*Lampetra tridentata*) and the Pacific brook lamprey (*Lampetra pacifica*). Access to spawning grounds has been blocked by dams on both the Sacramento and San Joaquin rivers and their tributaries.

The river lamprey is an anadromous fish that is predaceous on fish in both salt- and fresh-waters. Adults migrate from the ocean and move into smaller tributary streams in April and May to spawn and die shortly afterwards. Juveniles, called ammocoetes, remain in this life stage until they reach about 117 mm standard length (SL) and transform into adults and emigrate to the ocean.

The Pacific lamprey is an anadromous fish that spends its predatory phase in the ocean. Migration occurs between April to late-July with adults moving upstream several month prior to spawning. After spawning, the adults die and the eggs settle and adhere to the substrate. Between 140 mm and 160 mm the ammocoetes begin the transformation into adults and migrate to the ocean.

The Pacific brook lamprey is a relativity small, (when compared to other lampreys) non-predaceous fish that resides in the lower reaches of the Sacramento-San Joaquin rivers. Spawning is believed to occur from July through September in the upper reaches of the San Joaquin River.

The health of lamprey populations is adversely affected by the following general types of activities or conditions:

- urbanization
- agricultural practices
- livestock grazing and dairy farming
- timber harvesting
- gravel mining
- water development
- summer dams
- urban runoff
- wastewater discharge, and
- flood control and bank protection.

VISION

The vision for anadromous lampreys is to maintain and restore population distribution and abundance to higher levels than at present.

The vision is also to understand life history better and identify factors which influence abundance. Better knowledge of these species and restoration would ensure their long-term population sustainability. A major focus of the efforts would be to improve access to historic spawning grounds within California. Many of the efforts described in the Stage 1 Actions that would benefit anadromous fish species would directly effect all lamprey populations due to their similarities in spawning habitat and flow requirements.

On the Sacramento side of the system efforts to expand access to spawning habitats would need to be accomplished. On the San Joaquin side of the system, efforts would need to be directed towards improving the overall health of the river (water quality) in addition to improving access to historic spawning grounds.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Other programs linked to restoring habitat used by anadromous lamprey include all the programs directed at the restoration of habitat for chinook salmon and steelhead. Although lamprey are not directly targeted by these restoration programs, lamprey will derive benefits directly from programs that address habitat. Lamprey habitat will also improve with the implementation of improved watershed management program. The CALFED Watershed Management Coordination component is not an element of the ERPP.

- Central Valley Project Improvement Act: The Secretary of the Interior is required by the Central Valley Project Improvement Act to double the natural production of Central Valley anadromous fish stocks by 2002 (USFWS 1995) by implementing a variety of measures including habitat restoration.
- Salmon, Steelhead Trout and Anadromous Fisheries Program Act: The California Department of Fish and Game (DFG) is required under State legislation (the Salmon, Steelhead Trout and Anadromous Fisheries Program Act of 1988) to double the numbers of salmon that were present in the Central Valley in 1988 (Reynolds et al. 1993). Implementation of this program will increase the suitability of aquatic habitats required by lamprey.
- CALFED Watershed Management Coordination Program: The watershed program is designed to reduce stressors resulting from mining practices, agricultural discharges, excessive runoff and erosion, wildfire, excessive timber harvest, livestock grazing, and damaging land use practices that constrain ecological health of the streams.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of the lamprey populations and their habitats will be integrally linked to:

- maintaining essential fish habitats,
- restoration of natural stream meander corridors,
- providing suitable water temperatures for rearing,
- providing flows for migration, and
- reducing or eliminating the adverse effects of stressors such as contaminants, gravel mining, unscreened diversions, and other sources of mortality.

OBJECTIVE, TARGETS, AND ACTIONS

> The Strategic Objective is to enhance and/or conserve native biotic communities in the Bay-Delta estuary and its watershed.

SPECIES TARGET: Evaluate the status and life history requirements of Pacific lamprey and river lamprey in the Central Valley and determine their use of the Delta and Suisun Bay for migration, breeding, and rearing.

LONG-TERM OBJECTIVE: Restore wild self-sustaining populations of anadromous lampreys to all accessible rivers in which they historically occurred.

SHORT-TERM OBJECTIVE: Evaluate the status and life history requirements of Pacific lamprey and river lamprey in the Central Valley and determine their use of the Delta and Suisun Bay for migration, breeding, and rearing.

RATIONALE: Lampreys are anadromous species that clearly have declined in the Central Valley although the extent of the decline has not been documented. Pacific lamprey probably exist in much of the accessible habitat available today but this is not known. The decline of lampreys is presumably due to the decline of salmonids (major prey species), to deterioration of their spawning and rearing habitat, to entrainment in diversions, and to other factors affecting fish health in the system. As for salmonids, much of the habitat previously available for wild-spawning lampreys is permanently disconnected from the migration corridors. However, the remaining habitat or, the "new" habitat in the tailwaters of large dams, should be useable for spawning. Presumably, restoration of salmonid populations will also benefit lampreys, although this assumption should be regarded as a hypothesis, not a fact. If the assumption is not true, lampreys may have to be treated as Priority Group I species.

STAGE 1 EXPECTATIONS: Surveys will have been conducted to determine the status of lampreys in the Central Valley and a status report should be in place that recommends restoration actions.

RESTORATION ACTIONS

The target for lamprey populations would be to double and maintain the population of all lampreys within the Central Valley.

All lamprey populations would benefit from the following restoration activities and actions:

- restoration activities to spawning sites in the upper rivers and tributaries of the Central Valley,
- increased river flows,
- removal of barriers to historic spawning grounds,
- improved water quality in the San Joaquin River System,
- remove existing threats to known populations,
- restore habitat conditions favorable to the survival of lampreys and other native aquatic species, and
- protect and monitor lamprey populations and habitat once the threats have been removed and restoration has been completed.

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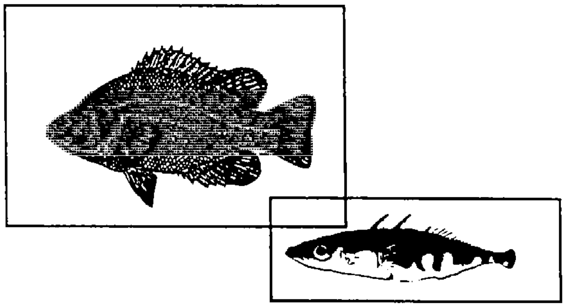
◆ NATIVE RESIDENT FISH SPECIES



INTRODUCTION

Native resident fish species of the Delta are important ecologically and as indicators of ecosystem health. Some, such as the tule perch, Sacramento sucker, and threespine stickleback, are important elements of the Bay-Delta foodweb. Other, such as the Sacramento pikeminnow (Sacramento squawfish), are important predators. Native resident fishes have declined as a percent of the total fish species abundance of the Bay-Delta and its watershed.

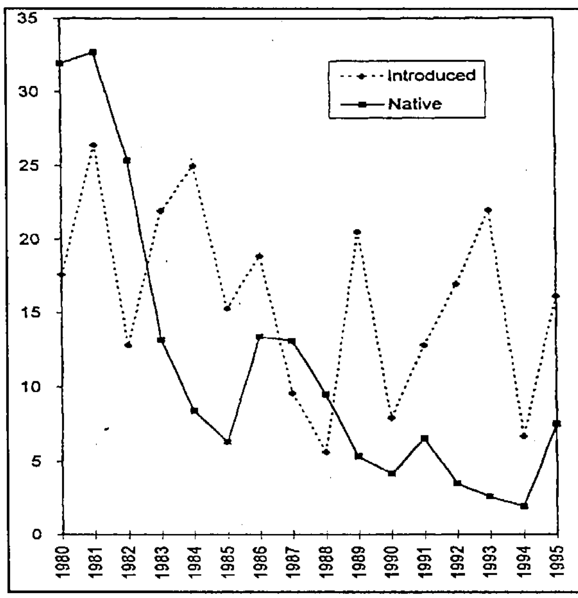
Factors contributing to the decline of some important native resident species include predation and competition of non-native species, loss and degradation of habitat, poor foodweb productivity, losses to water diversions, and reduced survival from exposure to toxins in the water.

RESOURCE DESCRIPTION

Native resident species compose the bulk of species found in fresh and low-salinity water (i.e., less than 4 parts per thousand salinity) of the Sacramento-San Joaquin Delta estuary. Resident species represent an important component of sport catch and the historical native fish fauna (e.g., tule perch, Sacramento blackfish). In addition, other native minnows such as hardhead, hitch, and California roach are important species occupying important and diverse ecological niches in Central Valley low to mid-elevation streams.

As with other Delta species, the habitat of resident fishes has been greatly diminished by human-caused actions. Increased habitat and expanded distribution and abundance of resident species can be realized through restoring habitat together with improving natural ecological processes and functions.

Spawning and rearing habitat includes shallow edgewaters bordered by healthy riparian and aquatic plants that provide protective, food-rich environments. Productive edgewater habitats are currently very limited in the Delta. Many resident Delta species inhabit shallow areas that have structural diversity provided by riparian and aquatic vegetation. Levee construction in the 1800s created narrow channels and eliminated vast areas of tule marsh, areas most likely important as spawning and rearing habitat for Delta species. Levee maintenance programs that remove riparian vegetation and dredging continue to reduce the quality of shallow water habitat used by resident species. Erosion caused by increased flow velocity, changes in channel structure, and boat wakes continues to reduce remnant riparian, marsh, and channel island habitats. Water hyacinth and other exotic aquatic plants now clog many sloughs that are important habitat of resident fish.



Index of Native and Introduced Fishes in Suisun Marsh Trawl Survey

Losses to Delta diversions (e.g., hundreds of small agricultural diversions, Central Valley Project and State Water Project export pumps, and Pacific Gas & Electric power generation facilities) may reduce resident species abundance through direct entrainment or indirect effects on the prey of resident fish.

Food availability, toxic substances, and competition and predation are among the factors influencing abundance of resident species. In addition, harvest of many resident species for food and bait by sport anglers may affect abundance.

VISION

The vision for native resident fish species is to maintain and restore the distribution and abundance of native species to contribute to the overall species richness and diversity.

Achieving this vision will reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta.

Ecosystem processes are closely tied to habitat restoration needs and actions. Resident species would benefit from conditions to maintain productivity and suitability of spawning and rearing habitat (including production of food). Actions to rehabilitate ecosystem processes include: changing Delta configuration, facility operations (including Delta diversions and channel barriers and gates), and Delta inflow and outflow.

Stressor reduction is a major component of restoration and maintenance of resident species populations. A primary concern with regard to vulnerable species is the reduction of losses to diversions. Actions to reduce losses include upgrading existing fish protection facilities, installing fish screens on currently unscreened facilities, removing predators associated with diversions and fish protection facilities, relocating and consolidating existing diversions, changing seasonal timing of diversions, and reducing the number of diversions. Resident species would also benefit from actions to reduce pollutant input to streams and rivers in the Sacramento-San Joaquin River basin and may benefit from actions to prevent introduction of non-native species that would prey upon or compete with native species for habitat and food supply.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore and maintain resident species would involve cooperation and support from other established programs that protect and improve conditions for delta smelt, striped bass, and other species.

- The Recovery Plan for the Sacramento/San Joaquin Delta native fishes will be considered in the development of actions.
- Central Valley Project Improvement Act will implement actions that will benefit resident species, including changing the timing of diversions and restoring habitat.
- The State Water Resources Control Board will implement the Water Quality Control Plan for the San Francisco/Sacramento-San Joaquin Delta estuary that will include provisions to limit entrainment in diversions and protect habitat conditions for Sacramento splittail, chinook salmon, striped bass, and other species.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration efforts relating to resident fish will be closely tied with efforts for delta smelt, longfin smelt, and splittail.

OBJECTIVE, TARGETS, AND ACTIONS

The Strategic Objective is to enhance and/or conserve native biotic communities in the Bay-Delta estuary and its watershed.

SPECIES TARGET: Maintain self-sustaining populations of all native resident fishes throughout their native ranges in the ERP Ecological Management Zones.

LONG-TERM OBJECTIVE: Within 25 years, all resident native fishes will have stable or increasing populations, in multiple localities, with localities interconnected as much as feasible.

SHORT-TERM OBJECTIVE: Determine the distribution, status, and habitat requirements of all native resident fishes in the Bay-Delta watershed to see if species-specific strategies are needed to reverse declines or if habitat-oriented restoration strategies will be adequate.

RATIONALE: The Central Valley has a native resident fish fauna that is largely endemic to the region. Some species are extinct (thicktail chub) or nearly extinct (Sacramento perch) in the wild. While some native species (e.g., Sacramento pikeminnow [squawfish], Sacramento sucker) are clearly thriving under altered conditions, others are not (e.g., hitch, Sacramento blackfish, hardhead). Although most of these species may benefit from actions listed under goal 2, there is a need to determine if some have unique problems or requirements that will prevent them from responding to general habitat improvements.

STAGE 1 EXPECTATIONS: A distribution and status survey of native stream fishes will have been completed. Sites with high species richness or containing rare species will have been identified for special management. A recovery strategy for native fish assemblages will have been developed.

RESTORATION ACTIONS

The target for resident fishes is to increase their abundance indices in the DFG fall midwater trawl survey and Suisun Marsh Trawl Survey to historical levels (e.g., 20 units or higher in the Suisun marsh Trawl survey).

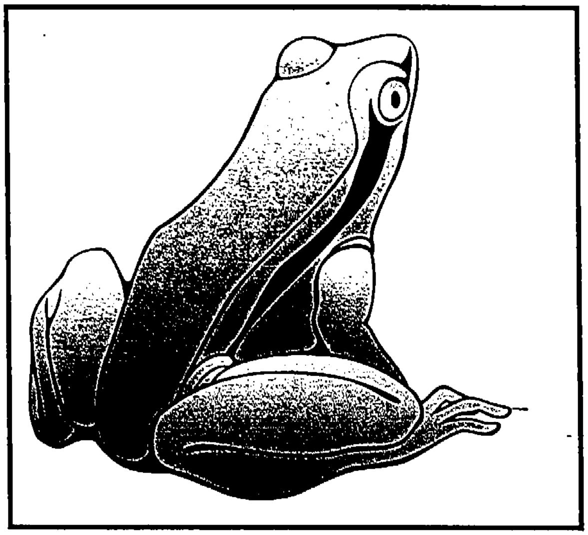
Resident species would benefit from the following general restoration activities:

- adding and modifying physical habitat,
- breaching levees to inundate existing islands,
- setting levees back to increase shallow-water habitat along existing channels,
- restoring riparian areas,
- protecting existing shallow-water habitat from erosion,
- filling relatively deep water areas with sediment to create shallow-water habitat,
- eliminating water hyacinth and other noxious aquatic plants from Delta channels and sloughs,
- upgrading existing fish protection facilities at South Delta pumping plants,
- installing screens on unscreened diversions,
- removing predators at diversions,
- relocating or consolidating diversions,
- reducing concentrations of toxins in Bay-Delta waters, and
- preventing further introductions of non-native aquatic organisms.

REFERENCE

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

◆ Native Anuran Amphibians



Introduction

Anuran amphibians include tailed frogs, spadefoot toads, true toads, treefrogs, and true frogs. There are several species that have been listed in California that could be further impacted by CALFED, including the Yosemite toad, western spadefoot, California red-legged frog, Cascades frog, foothill yellow-legged frog, and mountain yellow-legged frog. These species have been impacted by habitat loss as well as by predation by introduced species. For more specific information on western spadefoot and California red-legged frogs refer to their previously presented sections.

Resource Description

The species that may be affected by CALFED occur in different areas in the valley and watersheds of California and there are differing resource requirements for each species. Habitat requirements are varied including vernal pools, grassland, valley-foothill hardwood woodlands, montane wet meadows, and hardwood-conifer seasonal ponds associated with lodgepole pine, ponderosa pine, and subalpine conifer forests, quiet pools in marshes, stock ponds, mountain lakes and streams, valley-foothill riparian, coastal scrub, and mixed chaparral. Water is essential for the anurans, yellow-legged frogs prefer partially shaded, moving water that stays cool all year. Stream alteration such as dams, clearing and destruction of natural water courses, and ponds increases ambient water temperatures and makes habitat unsuitable. Cascades frogs need standing water for reproduction and hibernate at the bottom of mountain lakes and ponds during the winter. Optimal habitat for Yosemite toads is mountain ponds and wet meadows where they lay their eggs in still water. During inactive periods they will hide in rodent burrows or move to adjacent forests. When disturbed they will often hop into nearby water.

Reproductive methods and habitat selection for spawning varies among the species. Foothill and mountain yellow-legged frogs lay egg masses on cobble sized gravel or rocks. Foothill yellow-legged frogs need cool water for proper development. Mountain yellow-legged frogs do not start reproduction until the ice melts in the lakes and streams and tadpoles may need up to two over-wintering periods to complete their development. The Cascades frog deposits eggs in clear shallow water with gravelly, sandy or silty bottoms, while the Yosemite toad lays its eggs in shallow, quiet pools. Most eat terrestrial and aquatic insects, worms, fish, smaller amphibians, and other tadpoles.

The populations have declined due to habitat loss and predation by bullfrogs and centrarchids. Introduction of bullfrogs and centrarchids to many inland streams and ponds has resulted in predation of all life stages of the native anurans. They have not been found to coexist with bullfrogs without bullfrogs becoming the prevailing species.

Vision

The vision for native anuran amphibians is to contribute to their restoration.

This will be accomplished by stopping habitat loss and the introduction of other species that prey on the different life stages of these amphibians. Ongoing surveys to monitor known populations and find subsequent populations is essential to gauge the health of the species. To stabilize and increase anuran populations, non-native predator species should be eliminated from historical habitat ranges. Increasing suitable habitat and having clean water supplies that fit the needs for the different species is essential. It will be essential to reintroduce anurans to a reclaimed area after habitat requirements are met.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Restoration and management programs that could benefit anuran populations and that would improve habitat include:

- the Agricultural Stabilization and Conservation Service's Wetland Reserve Program,
- the Wildlife Conservation Board's Inland Wetlands Conservation Program,
- restoration programs administered by Ducks Unlimited and the California Waterfowl Association,
- on going management of State and Federal wildlife refuges and private duck clubs, and
- Efforts by CALFED Common Programs will benefit some anuran species in the upper watersheds.

Restoration efforts will be in cooperation with other agencies that have authority to conduct restoration projects including:

- California Department of Fish and Game
- California Department of Water Resources
- U.S. Fish and Wildlife Service, and
- U.S. Army Corp of Engineers.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of native anuran amphibian populations will also effect restoration of reptiles and other amphibians that coexist in the same types of habitats. It will be linked to restoring the overall health to many different types of habitats within the Central Valley as well as the Cascade, Coast, and Sierra mountain ranges.

OBJECTIVE, TARGETS, AND ACTIONS

> The Strategic Objective is to enhance and/or conserve native biotic communities in the Bay-Delta estuary and its watershed.

SPECIES TARGET: Maintain self-sustaining populations of all native anuran amphibians throughout their native ranges in the ERP Ecological Management Zones.

LONG-TERM OBJECTIVE: Have self-sustaining populations of all native anuran amphibians (frogs, toads) present throughout their native ranges, in all major watersheds in the Bay-Delta watershed.

SHORT-TERM OBJECTIVE: Determine the causes of anuran amphibian declines in the Bay-Delta watershed, develop restoration strategies, and implement them where feasible.

RATIONALE: The frogs and toads of California are in a general state of decline, but especially in the Central Valley watershed. The ranid frogs (red-legged frog, foothill yellow-legged frog, mountain yellow-legged frog, cascades frog) are in steep decline. Foothill yellow-legged frogs, for example, have virtually disappeared from the San Joaquin drainage since the 1970s (when they were still common). Red-legged frogs have become so rare they are federally listed as endangered (and are treated separately as a consequence). Although the decline of these amphibians can be tied to global amphibian declines, the principal causes are probably regional: introduced species and airborne pesticides. Because pesticides also have effects on human health, any changes in farming practices to protect humans also should be designed to protect amphibians.

STAGE 1 EXPECTATIONS: Complete status surveys of all anuran amphibians will have been completed and the major causes of declines should be determined. Long-term plans will have been developed and instituted to create conditions that will allow populations to recover throughout their ranges.

Restoration Actions

The general target is to increase population sizes and distribution of the native anurans through out historical habitat ranges.

General programmatic actions to assist in reaching the target include:

- acquire land that would increase anuran habitat and develop good water sources that meet population needs.
- develop predator control plans for bullfrogs and centrarchids,
- reintroduce native anurans to habitats that predators are eliminated.

References

Multi-Species Conservation Strategy. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

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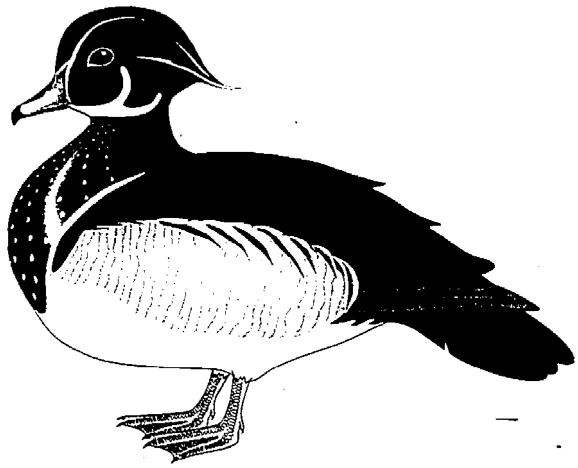


INTRODUCTION

Central Valley waterfall populations are a highly valued and diversified biological resource and are found in all ecological management zones within the study area. Large numbers of ducks, geese, and swans winter in the Central Valley after migrating from northern breeding areas. Some species, such as the mallard, gadwall, and Canada goose, are also year-long residents and breed locally in wetlands and nearby uplands. Waterfowl are a significant component of the ecosystem, are of high interest to recreational hunters and bird watchers, and contribute to California's economy through the sale of hunting and related equipment. Historical waterfowl wintering habitat areas have declined by approximately 95% and, as a result of substantial losses of wetland and grassland habitats, waterfowl breeding populations have declined from historical levels.

Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of conversion of wetland and grassland habitats to agricultural, industrial, and urban uses.

RESOURCE DESCRIPTION

Migration over long distances requires a great amount of energy. Upon arrival to wintering grounds, waterfowl depend on high-quality foraging habitat with sufficient grains, insects, and aquatic plants to replenish their energy reserves. These habitats include seasonal, permanent, tidal, and agricultural wetlands; deepwater; riparian woodlands; grasslands; and agricultural uplands and other associated habitats.

Recent declines in waterfowl populations are attributed primarily to the cumulative degradation or loss of breeding, wintering, and foraging habitats in the Central Valley and outside of California. Population declines are most likely caused by a combination of factors that have reduced or eliminated important ecosystem processes. These factors include:

- loss of natural wetlands because of altered flow regimes, resulting in the loss of natural floodplains;
- fragmentation or loss of large areas of wetlands as a result of land reclamation;
- loss of shallow-water habitat as a result of flood management practices;
- loss of riparian habitat resulting from channelization and levee protection practices;
- loss of tidal wetlands as a result of dikes and levees for flood control;
- heavy metal contamination from sources such as subsurface agriculture drainage; and
- loss of the natural mosaic of habitats required to meet the life requirements of waterfowl.

Many other factors have also contributed to the decline of waterfowl, although perhaps to a lesser degree. These include high concentrations of waterfowl in relatively small areas, which exposes greater portions of the population to diseases (such as botulism and cholera) and predation on nests and young by non-native species. Other factors that can affect waterfowl populations, such as extended periods of drought, are natural and will remain.

The Aleutian Canada goose is one of the MSCS evaluated species for which a MSCS species goal of maintain has been established. Although this federally listed species is not discussed in a separate section, it is included in the overall discussion of waterfowl. The MSCS provides one conservation measure for this species (see MSCS Conservation Measures later in this section).

> **VISION**
>
> The vision for waterfowl is to maintain healthy populations at levels that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses consistent with the goals and objectives of the Central Valley Habitat Joint Venture as part of the North American Waterfowl Management Plan.

Protecting existing and restoring additional suitable seasonal, permanent, and tidal wetlands; deepwater; riparian woodlands; and grasslands; and other associated habitats and improving agricultural land management and reducing the effect of breeding stressors will be critical to maintaining healthy waterfowl populations in the Bay-Delta. Large-scale restoration of nesting, brood, and foraging habitat will help to reduce predation on nests and young. Diverse and wide-spread habitats decrease the likelihood of large-scale outbreaks of disease. Habitat restoration in the Sacramento-San Joaquin Delta and Suisun Marsh/North San Francisco Bay Ecological Management Zones will help to maintain healthy populations of waterfowl by increasing the quality and quantity of habitats used by these species.

Efforts under existing migratory bird management programs have significantly improved critical habitats, including water management for seasonally managed agriculture fields, development of permanent habitat on federal refuges in the State wildlife areas, and incentives for private landowners to provide wintering habitat for migratory waterfowl.

Restoration of ecosystem processes and habitats proposed by ERPP in other ecological management zones will also allow floodplain wetland, riparian, and upland habitats to develop that will provide habitat for waterfowl elsewhere in the Central Valley.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Some of the programs that are restoring populations and habitat for waterfowl in the study area include:

- Upper Sacramento River Fishery and Riparian Habitat Council (SB 1086) Program,
- Suisun Marsh Protection Plan,
- California Department of Fish and Game wildlife areas,
- U.S. Fish and Wildlife Service refuges,
- The Nature Conservancy's Jepson Prairie Preserve,
- Ducks Unlimited Valley Care Program
- California Waterfowl Association,
- Cache Creek Corridor Restoration Plan,
- Putah Creek South Fork Preserve,
- Woodbridge Ecological Reserve,
- Yolo County Habitat Conservation Plan, and
- Central Valley Habitat Joint Venture

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Protection and restoration of waterfowl populations is integrally linked with restoration of perennial aquatic, wetland, tidal slough, riparian, grassland, and agricultural habitats and reduction in contaminants such as selenium in Central Valley breeding and wintering areas.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

> One Strategic Objective for waterfowl is to enhance and/or conserve native biotic communities in the Bay-Deta estuary and its watershed.

> A second Strategic Objective is to enhance populations of waterfowl and upland game for harvest by hunting and for nonconsumptive recreation.

SPECIES TARGET: Improve populations and distribution of waterfowl.

LONG-TERM OBJECTIVE: Substantially increase the numbers of resident and migratory ducks and geese that use the Bay-Delta watershed by increasing habitat available to them.

SHORT-TERM OBJECTIVE: Continue restoration of wetlands suitable for waterfowl production and over-wintering, while developing strategies for management of waterfowl areas that are compatible with other species, habitat, and ecosystem process restoration goals.

RATIONALE: Waterfowl resources will be enhanced by protecting existing and restoring additional seasonal, permanent, and tidal wetlands. Improved management of agricultural lands using wildlife friendly methods will contribute to sustaining waterfowl resources in the Bay-Delta. The focus for seasonal wetlands should be in areas that may be too deep for tidal marsh restoration over the next 20 years. In concert with efforts to reduce or reverse subsidence, selected areas or islands would be managed as waterfowl habitat. Besides increasing waterfowl resources, efforts to sustain waterfowl and their habitat will help offset some of the effects of converting agricultural or seasonal wetlands to tidal action when such actions may reduce the value of an area to waterfowl such as white-fronted geese or mallard. Efforts should also be focused on improving waterfowl nesting success by improving nesting and brood habitat. Improving waterfowl populations will be done in a manner that reduces conflict with broader ecosystem restoration goals or with goals to recover endangered species. For example: Flooding of rice fields for waterfowl in late winter may require water needed by migratory salmon. Careful management of the amount and timing of those diversions and the manner in which the diversions occur (e.g. through screened diversions) can help reduce conflicts. Management of waterfowl areas will occur using management strategies developed for existing and new waterfowl areas that provide benefits to at-risk species.

STAGE 1 EXPECTATIONS: Acquisition and development of new wetlands favorable for wintering and nesting waterfowl (e.g., Yolo Basin Wildlife Area) will have continued. Significant areas of existing agriculture will be managed using wildlife friendly practices. For existing public wildlife areas, plans to reduce conflicts between waterfowl management and management for other native species, including provisions for emergency situations (e.g., levee repairs), will have been developed. For private waterfowl areas, incentives for implementing broader, ecosystem-based management goals will have improved.

RESTORATION ACTIONS

The following general targets will assist in meeting the implementation objective:

- Increase waterfowl populations, and
- Increase distribution of waterfowl.

The following general programmatic actions will assist in meeting the targets:

- implementing management strategies to protect important existing habitat areas,
- increasing the quantity and quality of breeding habitat and forage on agricultural land,
- establishing new programs or expanding existing programs to provide incentives for landowner participation,
- restoring and improving wetlands in conjunction with adjacent herbaceous uplands to improve breeding habitat,
- expanding existing State and Federal wildlife areas by creating additional wetland complexes,
- improving water quality, and
- establishing programs that allow government agencies and waterfowl conservation organizations to work cooperatively to increase the efficiency of existing strategies and waterfowl management plans.

MSCS CONSERVATION MEASURES

The following conservation measure was included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets for Aleutian Canada goose.

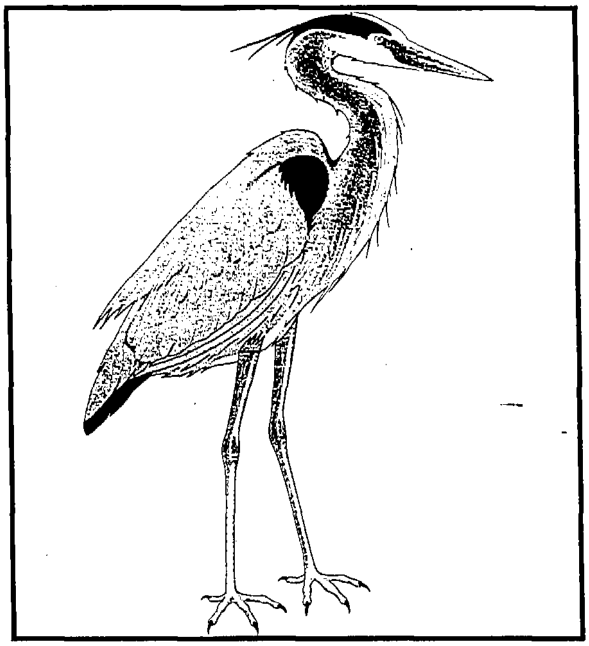
- To the extent consistent with ERP objectives, direct proposed actions for improving agricultural habitats for wildlife to protecting and improving traditional wintering habitat use areas.

REFERENCES

Multi-Species Conservation Strategy. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

◆ SHOREBIRD AND WADING BIRD GUILD



INTRODUCTION

Over a million shorebirds and wading birds annually migrate through, winter, or breed in the Bay-Delta. Representative species of the shorebird and wading bird guild include the great blue heron, great egret, western sandpiper, and long-billed dowitcher. These species are a significant component of the ecosystem, are of high interest to recreational bird watchers, and contribute to California's economy through sales of equipment and other bird-watching-related expenditures. There have been substantial losses of historic habitat used by these species and available information suggests that population levels of many of these species are declining. Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of conversion of native habitats for agricultural, industrial, and urban uses and land and water management practices that degrade habitats used by these species.

RESOURCE DESCRIPTION

Some shorebird and wading bird species are winter migrants limited to shallow water areas and shorelines. Others are statewide, year-round residents. Shorebirds and wading birds are dependent on many different habitats, although each species may be dependent on only one or a few habitats. These habitats include perennial aquatic, tidal slough, seasonal and emergent wetland, midchannel island and shoal, riparian, and agricultural.

Shorebirds and wading birds are present throughout the Central Valley. Herons and egrets are common year-round residents that breed and winter throughout the study area. Most shorebirds are only winter residents, with a small number remaining to breed. Wetland habitat conversion has eliminated 95% of the historic wetland habitat, resulting in smaller, detached patches of suitable habitat for nesting and foraging. Riparian habitats suitable for use by colonial-nesting species, such as egrets, have been lost or fragmented and are subject to increased disturbance during the nesting period.

VISION

The vision for the shorebird and wading bird guild is to maintain healthy populations of shorebirds and wading birds through habitat protection and restoration and reduction in stressors.

Protecting existing and restoring additional suitable perennial aquatic, tidal slough, seasonal and emergent wetland, midchannel island and shoal, and riparian habitats and improving management of agricultural lands and reducing the effect of factors that can suppress breeding success will be critical to maintaining healthy shorebird and wading bird populations in the Bay-Delta. Restoration of these habitats in the Sacramento-San Joaquin Delta and Suisun Marsh/North San Francisco Bay Ecological Zones will help to maintain healthy populations by increasing the quality and quantity of habitats used by these species.

Shorebirds and wading birds would also benefit from:

- management strategies that protect and maintain important existing habitat areas,
- project wetlands and wading bird nesting areas,
- improve habitat quality for shorebirds and wading birds.

Such strategies could be implemented through cooperative agreements with land management agencies or through conservation easements or purchase from willing sellers.

Restoration of ecosystem processes and habitats proposed by ERPP in other ecological management zones will also allow natural floodplains, meander corridors, seasonal pools, and riparian vegetation to develop that will provide habitat for these species elsewhere in the Central Valley.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Other existing programs that will directly or indirectly improve and restore habitat for shorebirds and wading birds include:

- Bay Area Wetlands Planning Group,
- Central Valley Habitat Joint Venture,
- Cosumnes River Preserve,
- Grizzly Slough Wildlife Area,
- San Francisco Bay National Wildlife Refuge,
- Sonoma Baylands Project,
- Tidal Wetlands Species Recovery Plan,
- Yolo Basin Wetlands Project, and
- San Francisco Bay Wetlands Ecosystem Goals Project.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Protection and restoration of shorebirds and wading birds is integrally linked with restoration of perennial aquatic, wetland, and riparian habitats and reduction in human disturbance.

OBJECTIVE, TARGETS, AND ACTIONS

SHOREBIRDS

The Strategic Objective is to enhance and/or conserve native biotic communities in the Bay-Delta estuary and its watershed.

SPECIES TARGET: Improve populations and distribution of shorebirds birds.

LONG-TERM OBJECTIVE: Provide sufficient high-quality tidal and shallow water foraging habitat and upland roosting habitat to maintain large populations of all members of this guild that now occur in central California, while also providing sufficient nesting habitat for species that breed in the state.

SHORT-TERM OBJECTIVE: Maintain wintering and breeding populations at their present levels and increase populations of all threatened species sufficiently to be able remove them from lists of threatened species.

RATIONALE: The shorebird guild is an extremely diverse group of migratory and resident species (e.g., sandpiper, plover, curlew, avocet) that forage, often in mixed flocks, on invertebrates in tideflats, beaches, shallow ponds, and other shallow water areas. The Central Valley, Delta, Suisun Bay and Marsh, and San Francisco Bay are a major wintering areas for birds that breed in more northern areas, as well as staging areas for birds headed further south. Habitats suitable for shorebirds were once abundant throughout the region. However, human disturbance, filling of shallow water areas, and other forms of degradation have caused suitable foraging habitats to become diminished. These smaller and more disjunct patches of habitat have made concentrations of shorebirds more susceptible to human disturbance and to increased predation. This guild contains species that are listed as threatened by both state and federal governments (e.g., snowy plover) while others are considered to be species of special concern.

STAGE 1 EXPECTATIONS: CALFED will have cooperated with the Central Valley Habitat Joint Venture to implement the Venture's goals and objectives that relate to creating habitat for shore birds. An evaluation of threats to foraging and breeding habitats will have been conducted and ways found to alleviate threats. Areas that can restored as foraging areas, especially tide flats, will have been identified and restoration work begun.

WADING BIRDS

> The Strategic Objective is to enhance and/or conserve native biotic communities in the Bay-Delta estuary and its watershed.

SPECIES TARGET: Improve populations and distribution of wading birds.

LONG-TERM OBJECTIVE: Provide sufficient high-quality breeding and foraging habitat for all wading bird species so that the guild will continue to be diverse and abundant.

SHORT-TERM OBJECTIVE: Maintain wading bird numbers and diversity at their present level, as a minimum.

RATIONALE: The wading bird guild is a group of mostly conspicuous birds (herons, egrets, bitterns, ibis) that wade in the water to forage on fish and other aquatic organisms. Because egrets and herons are so conspicuous along the waterways of the Bay-Delta watershed, they have high symbolic value for ecosystem restoration. Some members of the guild (least bittern [treated separately] and white-faced ibis) are state species of special concern. Habitats suitable for foraging of wading birds are still common throughout the Bay-Delta watershed. However, human disturbance and degradation has caused many of these habitats to become isolated, polluted, or subject to high levels of disturbance. For many of the species, the principal limiting factor is availability of adequate nesting (rookery) habitats. Long-term persistence of this group of birds in abundance depends on extensive areas of shallow water (less than 1.5 feet deep) containing abundant food, in conjunction with riparian habitats suitable for breeding.

STAGE 1 EXPECTATIONS: CALFED will have cooperated with the Central Valley Habitat Joint Venture to implement the Venture's goals and objectives that would increase foraging habitat for this guild. In addition, existing heron and egret rookeries will have been protected and other potential rookery areas identified.

RESTORATION ACTIONS

The following general targets will assist in meeting the implementation objective:

- Increase the number of shorebirds and wading birds over present levels.
- Increase the distribution of shorebirds and wading birds.
- Increase the quantity and quality of overwintering and resting habitat.

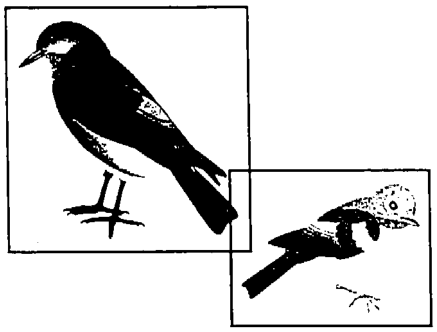
The following general programmatic actions will assist in meeting the targets:

- Increase the amount of riparian habitat in the Central Valley.
- Increase the amount of perennial aquatic habitat in the Central Valley.
- Increase the amount of emergent and seasonal wetlands in the Central Valley.
- Improve water management and land use practices to benefit wading birds' and shorebirds.
- Limit disturbance to nesting, roosting, and foraging habitats.

REFERENCE

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

◆ NEOTROPICAL MIGRATORY BIRD GUILD



INTRODUCTION

Neotropical species breed in North America and winter in Central and South America. Many species of neotropical migratory birds migrate through or breed in the Bay-Delta. These species are a significant component of the ecosystem. These species are of high interest to recreational bird watchers, and contribute to California's economy through sales of equipment and other bird-watching-related expenditures. There have been substantial losses of historic habitat used by these species and available information suggests that population levels for many of these species is declining.

Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of conversion of native habitats for agricultural, industrial, and urban uses, and land use practices that degrade habitats used.by these species.

RESOURCE DESCRIPTION

The neotropical migratory bird guild comprises bird species that breed in North America and winter in Central and South America. Representative species of the neotropical migratory bird guild are the western kingbird, western wood-pewee, tree swallow, cliff swallow, northern oriole, Wilson's warbler, and yellow-breasted chat. Individual visions are developed for some neotropical migrants, such as the Swainson's hawk and yellow-billed cuckoo, and those visions contain more specific targets relating to those species. All species of the neotropical migratory bird guild depend on the flora of California to forage and reproduce, typically from about May until September. The birds normally spend the rest of the year in Central and South America.

Neotropical birds occur throughout the California and are associated with most of California's habitat types, including forested woodlands, riparian and montane riparian habitats, unforested lowlands, grasslands, shrub habitats, valley foothill hardwood, valley foothill hardwood-conifer, and wetlands. Population levels of many of these species has declined, primarily as a result of the loss and degradation of habitats on which they depend, both in California and on their Central and South American wintering areas. In California, the quality and quantity of important neotropical migrant bird habitats have been substantially reduced primarily by their conversion to agricultural, industrial, and urban uses, and land use practices that degrade the values provided by these habitats.

VISION

The vision for the neotropical migratory bird guild is to maintain and increase healthy populations of neotropical migratory birds through restoring habitats on which they depend.

Protecting existing and restoring additional suitable wetland, riparian, and grassland habitats will be critical to maintaining healthy neotropical migrant bird populations in the Bay-Delta. Large-scale restoration of nesting habitat will help reduce nest parasitism and predation by creating habitat conditions that render neotropical birds less susceptible to these stressors. Restoration of these habitats in the Sacramento-San Joaquin Delta and Suisun Marsh/North San Francisco Bay Ecological Management Zones will help maintain healthy populations by increasing the quality and quantity of habitats used by these species. Restoration of ecosystem processes and habitats in other ecological management zones will also allow natural floodplains, stream meanderings, seasonal pools, and riparian vegetation to develop that will provide habitat for these species elsewhere in the Central Valley.

Integration with Other Restoration Programs

Related restoration programs include:

- Central Valley Project Improvement Act,
- Cache Creek Corridor Restoration Plan,
- Cosumnes River Preserve,
- Riparian Habitat Joint Venture,
- Upper Sacramento River Advisory Council's Riparian Habitat Committee (SB1086 program),
- San Joaquin River Management Program, and
- U.S. Fish and Wildlife Service's Anadromous Fish Restoration Plan.

Linkage with Other Ecosystem Elements

Restoration of neotropical migratory birds is integrally linked with restoration of wetland, riparian, grassland, and forest habitats.

Objective, Targets, and Actions

> The Strategic Objective is to enhance and/or conserve native biotic communities in the Bay-Delta estuary and its watershed.

Species Targets: Increase the abundance and distribution of neotropical migratory birds in the Central Valley.

Long-Term Objective: Substantially improve breeding and migration habitats for all neotropical migrant birds to increase their rates of reproduction and survival.

Short-Term Objective: Maintain neotropical migratory bird breeding populations at present levels and develop restoration projects that will benefit migrating individuals.

Rationale: Neotropical migratory birds constitute a diverse group of largely passerine songbirds that overwinter in the tropics but breed in or migrate through the Central Valley and Bay-Delta region. As a group, they are in decline because of loss of habitat on their breeding grounds, in their migratory corridors, and in their wintering grounds. The species within this group are good indicators of habitat quality and diversity and their popularity with birders means that populations are tracked and have high public interest. They can also be good indicators of contaminant levels, by monitoring reproductive success and survival in areas near sources of contamination. Riparian forests are particularly important to this group because they are major migration corridors and breeding habitat for many species. By providing improved nesting and migratory habitat, it may be possible to partially compensate for increased mortality rates in the wintering grounds. Improved habitat for songbirds also provides habitat for many other species of animals and plants.

Stage 1 Expectations: A "master plan" for the conservation of neotropical migrants in the Bay-Delta watershed that includes status reports and habitat requirements for all species will have been completed. This information will have been used to integrate neotropical migrant conservation into various CALFED restoration projects or to develop restoration projects specifically aimed at improving migration and breeding habitat for selected members of this group.

Restoration Actions

The following general targets will assist in meeting the implementation objective:

- Increase populations of neotropical birds in the Central Valley.
- Increase the distribution of neotropical birds in the Central Valley.

The following general programmatic actions will assist in meeting the targets:

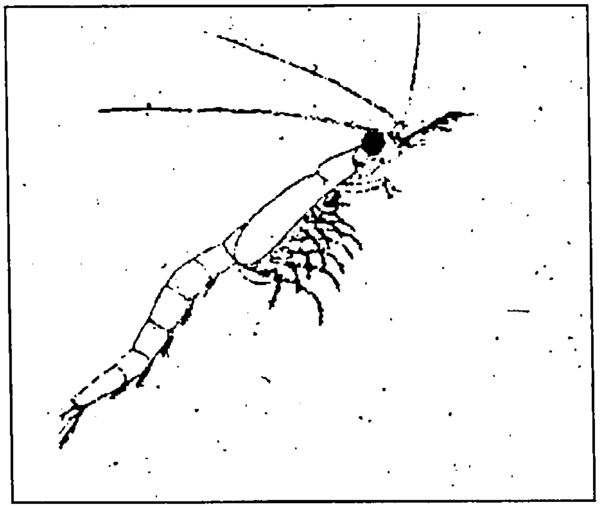
- Increase wetland, riparian, grassland and habitats in the Central Valley.
- Improve upper watershed health.
- Improve specific nesting habitats for individual species within their existing and restored habitats.

- Protect nesting habitats from predators and human disturbance.

REFERENCE

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

◆ BAY-DELTA AQUATIC FOODWEB ORGANISMS



INTRODUCTION

Bay-Delta aquatic foodweb organisms include bacteria, algae, zooplankton (e.g., copepods and cladocerans), epibenthic invertebrates (e.g., crayfish, Neomysis and Crangon shrimp), and benthic invertebrates (e.g., clams). Foodweb organisms are essential for the survival and productivity of fish, shorebird and other higher order animal populations in the Bay-Delta estuary. Some organisms are non-native species (e.g., certain zooplankton and Asian clams) that may be detrimental to native species and the foodweb in general. Recent declines in aquatic foodweb organisms of the Bay-Delta, particularly in drier years, has caused a reduction in overall Bay-Delta productivity. Important aquatic foodweb organisms include algae, bacteria, rotifers, copepods, cladocera, and mysid shrimp.

RESOURCE DESCRIPTIONS

The foodweb of the Bay-Delta ecosystem consists of all the plants, invertebrates, and other lower trophic-level organisms that serve as prey for fish, water birds, and other higher trophic-level resources of the ecosystem. Foodweb productivity of the Bay-Delta estuary is dependent primarily on the supply of nutrients and plant biomass production and transport (See Bay-Delta Aquatic Foodweb Process).

Plant communities in the Bay-Delta aquatic foodweb consist mostly of benthic algae and phytoplankton produced in the estuary and its watershed, and vascular-plants in riparian and wetland communities adjacent to the system. Algae are generally small (diameter <0.1 millimeters [mm]), easily transported, and highly nutritious. Phytoplankton are related to algae but small enough to float in the water. Most vascular-plants, by contrast, are much larger.

The Bay-Delta foodweb has undergone a number of changes since the 1960s. Most notably, phytoplankton abundance has declined in important fish nursery areas of Suisun Bay and the western Delta (Lehman 1996). A pattern of very low phytoplankton levels in Suisun Bay and the Delta beginning in 1987 concerns many scientists. Low levels in Suisun Bay and the Delta since 1986 may be the result of high densities of Asian clams (*Potamocorbula amurensis*) that colonized the Bay after being accidentally introduced from the ballast waters of ships. Large numbers of the clams colonized this area of the estuary during the drought period from 1987 to 1992 (Kimmerer and Orsi 1996).

Aquatic invertebrate population trends followed those of phytoplankton over the past three decades. Species that once dominated the aquatic invertebrate community have become relatively scarce, while some others have increased in relative abundance. Many native species have become less abundant or more narrowly distributed, while dozens of new non-native species have become well established and widely dispersed. In general, the abundance of plankton has declined, while populations of many bottom-dwelling invertebrates, most notably Asian clams, have increased. This transition has been most evident in Suisun Bay and other traditionally important fish-rearing areas. Also in these areas, populations of rotifers, copepods, and other relatively small species have declined substantially since monitoring began in the 1960s (Kimmerer and Orsi 1996). This pattern is perhaps most dramatic for the mysid shrimp, which have declined to less than one-tenth of their former abundance, particularly since 1986 (Orsi and Mecum

1996). The continued decline from 1993 to 1995, despite the return of higher flows, is of particular concern. These declines in zooplankton abundance have roughly coincided with the decline in algae, one of the main food sources for the zooplankton.

The deterioration of the zooplankton community and its algal food supply in key habitat areas of the Bay-Delta is a serious problem because striped bass, delta smelt, chinook salmon, and other species that use Suisun Bay and the Delta as a nursery area feed almost exclusively on zooplankton during early stages of their life cycles. Research indicates that survival and growth of fish larvae generally increase with increased concentration of zooplankton. Declines in the production of juveniles of these fish species appear to coincide with the declines in algae and zooplankton. Modifying the Bay-Delta ecosystem in ways that will lead to increased algae and zooplankton abundance may be critical to restoring Bay-Delta fish populations and improving the health of its ecosystem.

Areas of the Bay-Delta where hydraulic conditions allow food resources to accumulate in the water column rather than settling or washing out are important habitats for plankton foodweb organisms. This accumulation of food resources results from passive processes and from active algal, microbial, and zooplankton reproduction. The comparatively benign hydraulic conditions and abundant food resources characterizing the western Delta and Suisun Bay permit the development of high zooplankton populations on which many estuarine resident and anadromous fish depend during their early life stages. Horizontal salinity stratification enhances this process, especially when the salinity front (sometimes referred to as X2) or the "entrapment zone" is in Suisun Bay (Arthur and Ball 1979).

The decline of plankton populations in the Bay-Delta may also be a result, at least in part, of the effects of heavy metals, herbicides, pesticides or other toxic substances. Low concentrations of these substances in the water column may act individually or in combination to reduce productivity of plant and animal plankton. Research to determine the effects of these toxicants on plankton is currently underway.

Vision

The vision for the Bay-Delta aquatic foodweb organisms is to restore the Bay-Delta estuary's once-productive food base of aquatic algae, organic matter, microbes, and zooplankton communities.

Restoring the Bay-Delta foodweb organisms would require enhancing plankton growth and reducing loss of plankton to water exports, particularly in drier years. Several options exist for enhancing plankton growth. Improving Delta inflow and outflow in spring of drier years will be an essential element of any plan. Other elements include reducing losses to exports from the system and reducing the amount of toxic substances entering the system.

Additional improvements can be gained by increasing shallow-water habitat and tidal wetlands in the Bay and Delta. Increasing the acreage of floodplain lakes, sloughs, and other backwaters in the Sacramento River drainage will increase organic matter inputs to the Delta. This increase in plankton food supply will help increase population growth.

Restoring tidal action to leveed lands in San Pablo Bay and Suisun Marsh will increase habitat for aquatic foodweb organisms. The Yolo and Sutter Bypasses offer potential opportunities to produce more permanent slough, riparian, and wetland habitats in the Sacramento River floodplain. Setback levees or improved riparian and shallow-water habitat along leveed reaches of the rivers and Delta offer additional opportunities to increase the abundance of foodweb organisms in the Bay and Delta.

Integration with Other Restoration Programs

Efforts to restore the abundance of Bay-Delta aquatic foodweb organisms would involve the cooperation and support from established programs underway to restore habitat and fish populations in the Bay-Delta including the following:

- The Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes calls for improving flows, reducing diversions, and increasing habitat.
- The Salt Marsh Ecosystem Recovery Plan calls for improving wetland habitat in the Bay.

- The Central Valley Project Improvement Act (PL 102-575) and its associated Anadromous Fish Restoration Plan include provisions to reduce losses of organisms into water diversions, to restore aquatic habitat, to improve water quality, to improve freshwater flows, and to restore wetland and riparian habitats in the rivers and Bay-Delta.
- The Steelhead Trout, and Anadromous Fisheries Program Act of 1988 includes elements to improve freshwater flows and riparian habitats in the Sacramento and San Joaquin Rivers and their tributaries.
- The Delta Wildlife Habitat Protection and Restoration Plan include protection and improvements to riparian and wetland habitats of the Bay-Delta.
- Central Valley Habitat Joint Venture includes restoration of riparian and wetlands of the rivers, Delta, and Suisun Marsh.
- California Senate Concurrent Resolution 28 has set a goal of doubling wetland acreage by the year 2000.
- San Francisco Estuary Project planning for wetland protection and restoration, and water quality protection and improvement.
- San Joaquin River Management Plan is a plan to restore riparian and wetland habitat and improve water quality in the San Joaquin River and its tributaries.
- SWRCB and RWQCB efforts to restore wetlands and improve water quality of the rivers and Bay-Delta.
- Suisun Resource Conservation District is developing wetlands restoration and management plans.
- Riparian Habitat Joint Venture will restore riparian habitats.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Improving the abundance and distribution of important aquatic foodweb organisms of the Bay-Delta is integrally linked with wetland and riparian habitat restoration, water quality (contaminants) improvement, and Central Valley streamflow improvements.

OBJECTIVE, TARGETS, AND ACTIONS

> The Strategic Objective is to enhance and/or conserve native biotic communities in the Bay-Delta estuary and its watershed.

SPECIES TARGET: Increase populations and distribution of important foodweb organisms in Delta channels and reduce competition with invasive non-native species.

LONG-TERM OBJECTIVE: Increase abundance of zooplankton to the levels that existed prior to the introduction of the Asiatic clam, Potamocorbula amurensis, with zooplankton communities containing native species as significant components.

SHORT-TERM OBJECTIVE: Maintain the planktonic assemblages at roughly the range of variability of abundance and composition that they have been since the Asiatic clam became established by preventing new introductions and determining conditions that favor native organisms such as Neomysis mercedis.

RATIONALE: The long-term objective is quite likely impossible to achieve because recent invading species, from the Asiatic clam to various crustacean zooplankters, will continue to play major ecological roles in the system, to the detriment of native organisms. However, at the very least it is possible to stop further introductions of non-native species which have the potential to further change the system unpredictably. This objective is also a call to develop a thorough understanding of the planktonic portion of the Bay-Delta system to predict and understand the impacts of large-scale ecosystem alteration projects on the plankton.

STAGE 1 EXPECTATIONS: Major steps will have been taken to halt activities (e.g., dumping of contaminated ballast water) that result in the establishment of new species of invertebrates and fish in the estuary. Further development of our understanding of the how the Bay-Delta system functions should allow recommendations on how to maintain native zooplankton species, in the context of broader ecosystem management goals.

RESTORATION ACTIONS

General targets that will assist in meeting the implementation objective include:

- Increase abundance of important food web organisms to 1960s level of abundance
- Reduce influence of non-native species in foodweb communities
- Improve distribution of important foodweb organisms in Bay-Delta.

General programmatic actions that will contribute to achieving the targets include:

- increase late winter and spring Delta outflow
- reduce losses to water diversions
- opening leveed lands to tidal or seasonal floodflows
- increasing the array of sloughs in the Delta
- reduce influx of non-native species
- protecting and restoring shallows, shoals, and channel islands in the Delta; and
- providing more natural floodplains and meander belts along rivers.

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AQUATIC HABITAT PLANT COMMUNITY GROUP

INTRODUCTION

Aquatic plant habitat in the Bay-Delta area is present in permanently flooded and intermittently exposed shallow water areas. These shallow water areas present important wetland habitat for dependent plant, wildlife, and fish species. The substantial loss of historic shallow water aquatic plant habitat has primarily resulted from reclamation and channel dredging and scouring. Loss of such habitat has reduced primary (plant) and secondary (invertebrate) productivity in the Bay-Delta area, changing important characteristics of the natural foodweb of the system and therefore leading to the decline of many native plant, fish, and wildlife species.

RESOURCE DESCRIPTION

PONDWEEDS WITH FLOATING AND SUBMERGED LEAVES. Aquatic plant habitat in the Bay-Delta area is dominated by pondweeds (*Polygonum* spp.) with floating or submerged leaves. Pondweeds are the sole or dominant herb in this community. Pondweeds with submerged leaves include crispate pondweed (*P. crispus*), eel-grass pondweed (*P. zosteriformis*), fennelleaf pondweed (*P. pectinatus*), leafy pondweed (*P. foliosus*), Nevada pondweed (*P. latifolius*), Richardson pondweed (*P. richardsonii*), Robbin pondweed (*P. robbinsii*), slenderleaf pondweed (*P. filiformis*), small pondweed (*P. pusillus*), and whitestem pondweed (*P. praelongus*). Pondweeds with floating leaves include alpine pondweed (*P. alpinus*), broadleaf pondweed (*P. amplifolius*), diverseleaf pondweed (*P. diversifolius*), floatingleaf pondweed (*P. natans*), grassleaf pondweed (*P. gramineus*), longleaf pondweed (*P. nodosus*), Nuttall pondweed (*P. epihydrus*), and shinning pondweed (*P. illinoensis*). The vegetative cover in the aquatic plant habitat ranges from continuous to intermittent or open.

VISION

The vision for plant community groups is to maintain and restore existing and rehabilitate degraded habitats that support the diverse assemblages of plants in the Bay-Delta.

The vision will be attained by protecting and restoring large areas of perennial shallow water that provide habitat for pondweeds and other associated plant and wildlife species. Areas protected and restored as aquatic plant habitat would be closely associated with areas protected and restored as tidal brackish and freshwater marsh plant habitat and tidal riparian plant habitat to promote habitat diversity.

Initial efforts should focus on protecting existing aquatic habitat plant community areas. Restored areas should be linked with existing healthy habitats where feasible to provide a source of vegetative propagules and to create large contiguous areas of aquatic plant habitat. Establishing the proper gradients relative to water levels will be key in promoting the establishment of the aquatic habitat plant community. Restored habitats should have natural gradients of open water, shallow water that is suitable for supporting pondweeds, marsh, riparian, and upland habitats to increase the habitat value for a greater diversity of species.

Many leveed lands in the Bay and Delta have subsided and are too low to support shallow waters inhabited by pondweeds, and thus cannot be readily restored. The greatest subsidence has occurred in the Central and West Delta Ecological Management Unit. A comprehensive long-term program would be developed to reverse this process. Changes in land use management, and use of suitable dredged materials or other "natural materials" should be implemented to restore land elevations to suitable ranges.

Restoration efforts should focus on those leveed lands that have not yet been subjected to severe subsidence. Prime candidates are existing managed marshes and salt ponds adjacent to San Pablo and Suisun Bays. Leveed agricultural lands and some industrial lands adjacent to Suisun Bay can be readily restored to the aquatic habitat plant community.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Many programs and projects aim to protect, restore, and enhance wetland and open water habitats in the San Francisco-San Joaquin Bay-Delta estuary. These include:

- Bay Area Aquatic Habitats Planning Group;
- Cache Creek Corridor Restoration Plan;
- California Wetland Riparian Geographic Information System Project;
- Governor's California Wetland Conservation Policy;
- Inland Wetlands Conservation Program;
- Montezuma Wetlands Project;
- National Estuarine Reserve Research System;
- North Bay Initiative;
- North Bay Wetlands Protection Program;
- San Francisco Bay Regional Water Quality Control Board, and San Francisco Bay Conservation and Development Commission - Regional Wetlands Management Plan;
- San Francisco Estuary Project;
- Tidal Wetlands Species Recovery Plan;
- Wetland Reserve Program; and
- Yolo Basin Wetlands Project.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

The aquatic habitat plant community group is linked to other habitats that include open water, shallow water, emergent wetland, and riparian areas, and to associated wildlife guilds. It is also linked to physical processes that include streamflow, sediment supply, geomorphology, and tides. Secondary ecosystem functions and processes that are linked with the aquatic habitat plant community group include current velocities; floodwater and sediment detention and retention; vegetation succession, overbank flooding, and floodplain inundation; and primary production. Stressors that affect this plant community group include levees, bridges, and bank protection; dredging; non-native species; dams, reservoirs, and other human-made structures; water management; gravel mining; contaminants; and human disturbance.

OBJECTIVE, TARGETS, AND ACTIONS

The Strategic Objective is to enhance and/or conserve native biotic communities in the Bay-Delta estuary and its watershed.

SPECIES TARGETS: The target for all plant communities is to maintain the present distribution and abundance and ensure self-sustaining communities in the long-term.

LONG-TERM OBJECTIVES: Develop protocols that protect existing and newly established shallow-water aquatic habitat plant communities within the Sacramento-San Joaquin Estuary from stressors and other factors. Additional efforts will need to be taken that assure newly established shallow-water aquatic plant communities consist of native aquatic vegetation and not introduced aquatic plant species (i.e. water hyacinth, hydrilla, and other aquarium trade plants).

SHORT-TERM OBJECTIVES: Establish aquatic habitat plant community in suitable areas within the Delta and Suisun Marsh. Evaluate and remove exotic plant species (i.e. water hyacinth) that out compete native aquatic vegetation. In addition, identify, reclaim, and protect areas that provide shallow-water aquatic plant communities from future development and dredging activities.

RATIONALE: Shallow-water plant communities were once abundant throughout the Sacramento-San Joaquin Estuary. Their decline came when the Delta and its associated channels were altered and dredged to form islands and exotic aquatic water plant species came into the system. The reduction in these shallow-water areas has resulted in the loss of both rearing and escape cover for many fish species that either reside in or pass through the Delta. In addition, increased shallow-water plant communities will assist in reducing turbidity and contaminate levels that exist within the system.

STAGE 1 EXPECTATIONS: Efforts will need to be undertaken that evaluate the extent of existing aquatic habitat plant community groups within the Estuary and the likely locations were additional habitats can be created and protected. Methods will also need to be developed that examine the extent of exotic aquatic plant species within the Estuary and a method of control.

RESTORATION ACTIONS

The general target for restoring the aquatic habitat plant community group is to provide 500 acres in the Sacramento-San Joaquin Delta Ecological Management Zone and 500 acres in the Suisun Marsh/North San Francisco Bay Ecological Management Zone.

The following actions would help to achieve targets for the aquatic habitat plant community group restoration:

- Restore perennial shallow water habitat in concert with restoration of tidal brackish and freshwater marsh and tidal riparian plant habitat.
- Link restored areas with existing healthy habitats to provide a source of vegetative propagules and to create large contiguous areas of aquatic habitat.
- Focus restoration effort on leveed lands that have not yet experienced severe subsidence, such as leveed agricultural lands and industrial lands adjacent to Suisun Bay.
- Restore permanent open-water areas by establishing elevation gradients sufficient to maintain surface water through natural groundwater or surface-water recharge, or by pumping water into lowland areas.
- Propagate restored areas with pondweeds and control invasion by exotics until the community has become established.

TIDAL BRACKISH AND FRESHWATER MARSH HABITAT PLANT COMMUNITY GROUP

INTRODUCTION

Tidal brackish marsh habitat is located along the western edge of the Delta and in Suisun marsh. Most tidal freshwater marshes in the Delta occur as narrow, fragmented bands along island levees, channel islands, shorelines and levee blowout ponds.

Tidal brackish and freshwater marshes are important habitat areas for fish and wildlife dependent on marshes and tidal shallows and support several special-status plant species. The loss or degradation of historic tidal brackish and freshwater marshes has substantially reduced the habitat area available for associated plant, fish and wildlife species. Major factors that limit this resource's contribution to the health of the Bay-Delta are related to adverse effects of wetlands conversion to agricultural, industrial, and urban uses.

The vision for tidal brackish and freshwater marsh habitats is to restore large areas of connecting waters associated with tidal emergent wetlands and their supporting ecosystem processes. Achieving this vision will assist in the recovery of special-status plant populations depending on these habitats. It will also assist in the recovery of special-status fish populations and provide high-quality aquatic habitat for other fish and wildlife dependent on the Bay-Delta. Restoring tidal brackish and freshwater marsh would also result in higher water quality and increase the amount of shallow-water habitats; foraging and resting habitats and escape cover for water birds; and rearing and foraging habitats, and escape cover for fish. The vision for this habitat type is to protect existing tidal brackish and freshwater marshes from degradation or loss and to increase wetland habitat. Achieving this vision will assist in the recovery of special-status plant, fish, and wildlife populations, and provide high-quality habitat for other fish and wildlife dependent on the Bay-Delta.

RESOURCE DESCRIPTION

Tidal brackish marshes were once continuous from San Francisco Bay into the western Delta. Most remnants of these wetlands are narrow bands along the margins of San Pablo Bay and Suisun Marsh and Bay. Tidal brackish marshes have been substantially reduced as a result of reclamation and land use conversions to agricultural uses, actions that reduced the amount of land subject to tidal flooding.

Tidal brackish marshes are important habitats for plant, fish and wildlife species that are dependent on marshes and tidal shallows. These wetland areas serve as an important transitional habitat between open water and uplands. Furthermore, tidal exchange is the primary process that supports healthy tidal brackish marshes in the Bay-Delta. Tides flush the wetland system, replacing nutrients and balancing salinity concentrations. Land management practices such as diking have isolated most of the remaining brackish marsh wetlands from tidal flows.

Five distinct plant series are found in tidal brackish marshes; each of these is briefly described below.

PICKLEWEED SERIES: Pickelweeds (*Salicornia* species) are the dominant plants in this series. Other associated plant species can include alkali heath (*Frankenia salina*), arrow-grasses (*Triglochin* species), dense-flowered cordgrass (*Spartina densiflora*), dodder (*Cuscuta salina*), fat-hen (*Atriplex patula*), jaumea (*Jaumea carnosa*), saltgrass (*Distichlis spicata*), saltwort (*Batis maritima*), sea-blite (*Suaeda californica*), and/or sea-lavender (*Limonium californicum*). This plant series is generally less than 5 feet tall and the canopy can be continuous or intermittent.

SALTGRASS SERIES: Saltgrass (*Distichlis spicata*) is the sole or dominant grass in this series. Other associated plant species can include alkali cordgrass (*Spartina gracilis*), alkali muhly (*Muhlenbergia asperifolia*), alkali sacaton (*Sporobolus airoides*), Baltic rush (*Juncus balticus*), common pickleweed (*Salicornia virginica*), Cooper rush (*Juncus cooperi*), one-sided bluegrass (*Poa secunda*), sea-lavender (*Limonium californicum*), slender arrow-grass (*Triglochin concinna*), and/or yerba mansa (*Anemopsis californica*). Emergent alkali rabbitbrush (*Chrysothamnus albidus*) or iodine bush (*Allenrolfea occidentalis*) may be present. This plant series is generally less than 3.5 feet tall and the canopy can be continuous or intermittent.

BULRUSH SERIES: Bulrushes (*Scirpus* spp.) are the dominant species in this series. Common plant species include California bulrush (*Scirpus californicus*), common three-square (*Scirpus americanus*), common tule (*Scirpus acutus*), Nevada bulrush (*Scirpus nevadensis*), river bulrush (*Scirpus fluviatilis*), and saltmarsh bulrush (*Scirpus maritimus*). Other associated plant species can include broadleaf cattail (*Typha latifolia*), narrowleaf cattail (*Typha angustifolia*), saltgrass (*Distichlis spicata*), slenderbeaked sedge (*Carex athrostachya*), southern cattail (*Typha domingensis*), umbrella flatsedge (*Cyperus eragrostis*), water-plantain (*Alisma plantago-aquatica*), and/or yerba mansa (*Anemopsis californica*). The species in this series are generally less than 13 feet tall and the cover can be continuous or intermittent.

CATTAIL SERIES: Cattails, including broadleaf cattail (*Typha latifolia*), narrowleaf cattail (*Typha angustifolia*), and southern cattail (*Typha domingensis*)(*Typha* spp.) are the dominant plants in this series. Associated plant species can include California bulrush (*Scirpus californicus*), common three-square (*Scirpus americanus*), common tule (*Scirpus acutus*), Nevada bulrush (*Scirpus nevadensis*), river bulrush (*Scirpus fluviatilis*), saltgrass (*Distichlis spicata*), saltmarsh bulrush (*Scirpus maritimus*), slender-beaked sedge (*Carex athrostachya*), umbrella flatsedge (*Cyperus eragrostis*), water-plantain (*Alisma plantago-aquatica*), and/or yerba mansa (*Anemopsis californica*). The plants in this series are generally less than 13 feet tall and the cover can be continuous, intermittent, or open.

COMMON REED SERIES: Common reed (*Phragmites australis*) is the dominant plant in this series. The community may include emergent shrubs and trees. However, few other species are generally present. Common reed generally grows less than 13 feet tall and the cover is typically be continuous.

Diking of historic wetlands greatly reduced the amount of tidally influenced marshes in the Delta. Reservoir operations and other water management practices that control California's inland water supplies have reduced saltwater intrusion into the Delta by retaining water during winter and releasing water during summer. These complex water management activities resulted in reduced saltwater intrusion into the Delta, thereby reducing the area that can support brackish wetlands. Preservation of the largest single area of brackish marsh habitat in California has been accomplished at Suisun Marsh through implementation of a complex water control system.

Prior to the mid-1800s, extensive areas of tidal freshwater marsh habitat occurred throughout the Central Valley, particularly in the Delta. A complex network of rivers, sloughs, and channels connected low islands and basins that supported a diverse and dense variety of freshwater marsh vegetation. This freshwater marsh vegetation supported a diversity of plant, fish and wildlife species and ecological functions. Vast areas of the Sacramento-San Joaquin Valleys were commonly flooded in winter by a slow-moving blanket of silt-laden water. Flood control activities and land settlements in the late 1800s and early 1900s led to the development of leveed Delta islands. Levees and other land uses led to the loss of freshwater marshes in the Delta. Loss of wetlands has substantially reduced habitat for wetland wildlife species in the Bay-Delta system. Freshwater marsh losses have also substantially reduced the area available for the biological conversion of nutrients in the Delta. The Delta contains insufficient wetland area to provide adequate levels of nutrient transformation, which results in lower quality water in San Francisco Bay.

The loss of freshwater marshes has substantially reduced the habitat of several plant and wildlife species. Some species have been designated as California or federal special-status species and are threatened with local extermination. At least eight special-status plant species, Suisun Marsh aster, California hibiscus, bristly sedge, Jepson's tule pea, Mason's lilaeopsis, marsh mudwort, Sanford's arrowplant, and marsh scullcap, are native to the Delta. Most of these plants are adapted to a complex tidal cycle and are typically found with more common vegetation such as tule, cattails, common reed, and a great diversity of other herbaceous plant species. Changes in habitat conditions have allowed the invasion of hundreds of non-native weedy plant species. Some of these species, such as water hyacinth, now clog waterways and irrigation ditches and reduce overall habitat quality for native plants and wildlife. Over 50 species of birds, mammals, reptiles, and amphibians use freshwater marshes in the Delta. Populations of some wildlife species that are closely dependent on freshwater marshes, such as the California black rail, giant garter snake, and western pond turtle, have been substantially reduced in the Delta and designated as special-status species. A few wetland-associated species, such as waterfowl and egrets, have successfully adapted to foraging on some types of Delta croplands converted from historic wetland areas.

Isolating wetlands from tidal flows and removing Delta island freshwater marshes changed the ecological processes that support wetlands. Removing the perennial water and vegetation from the organic soils of Delta islands resulted in soil oxidation and, subsequently, the subsidence of the interior islands. Loss of these tidal flows to islands has reduced habitat for native species of fish, plants, and wildlife; reduced water quality; and decreased the area available for floodwater dispersion and suspended silt deposition.

High tidal velocities in confined Delta channels continue to erode remaining freshwater marshes at a greater rate than habitat formation. Continued erosion reduces the amount of freshwater marshes and changes the elevation of the land. Elevation affects the types of plant species that can grow depending on a species' ability to tolerate flooding. Flood protection and levee maintenance continue to impair wetland vegetation and prevent the natural reestablishment of freshwater marshes in some locations.

Wind, boat-wake waves, and high water velocities in confined channels actively erode the soil needed to support remnant freshwater marshes. Continued erosion of existing habitat, such as midchannel islands and levees and levee berms, is currently the primary cause of habitat loss in the Delta.

VISION

Restoration of tidal brackish and freshwater marsh habitat would focus on protecting and improving important existing wetlands, such as channel islands, and restoring wetlands in the Sacramento-San Joaquin Delta and Suisun Marsh/North San Francisco Bay Ecological Management Zones.

Restoring tidal brackish marsh is dependent on restoring tidal flows, establishing and maintaining healthy estuarine salinity gradients appropriate, and reestablishing elevation gradients from open water to uplands. The following actions would help achieve saline emergent wetlands restoration:

- restore tidal flows to diked wetlands by breaching dikes in suitable areas;
- establish desirable estuarine salinity gradients by managing water diversions and water releases from upstream reservoirs to control seasonal freshwater inflows to the Delta;
- balance seasonal flows from reservoirs for fisheries, water conveyance, flood control, and the needs of other habitats; and
- restore a more natural elevation gradient in wetlands to allow a greater diversity of native saline plant species, including special-status species, that are adapted to different elevations and provide a broader range of habitats for wildlife.

Enhancing and increasing tidal brackish marsh habitat would also help to increase water quality. Areas restored to tidal flow will contribute to the aquatic foodweb of the Bay-Delta and provide fish rearing habitat. Restoring tidal brackish marshes would improve the ecological value of adjacent associated habitats, including tidal aquatic habitats, and will provide an important transitional zone between open water and uplands.

Other habitat restoration efforts will be directed toward reestablishing native plant species, controlling competitive weedy plants, increasing the quality of adjacent upland habitats to provide refuge for wildlife during high tides, and modifying land use practices that are incompatible with maintaining healthy wetlands. Restoring saline emergent wetlands would be coordinated with restoration of other habitats to increase overall habitat values. For example, saline emergent wetland greatly increases wildlife habitat quality of deep and shallow open-water areas and adjacent grasslands.

To prevent further loss of existing freshwater marshes, erosion rates must be reduced. Inchannel islands and levee berms are of particular concern. Erosion losses could be offset by allowing deposition and wetland establishment. Wetlands erosion could be reduced by reducing boat speeds where wetlands are subject to boat-wake-induced erosion (e.g., Snodgrass Slough). Constructing protective structures around eroding channel islands would weaken wave action (e.g., wave barriers and riprap groins) in a way that retains habitat value for fish and wildlife. Protecting inchannel islands from further erosion and connecting with larger islands would provide greater protection for this unique habitat.

Restoring freshwater marsh habitat is dependent on local hydrological conditions (e.g., water depth, water velocity, and wave action); land elevation and slope; and the types and patterns of sediment deposition. The approach to restoring freshwater marshes would include:

- reestablishing the hydraulic, hydrologic, and depositional processes that sustain freshwater marshes and inchannel islands;
- restoring a full spectrum of wetland elevations to allow the establishment of a greater diversity of plant species, including special-status species adapted to different elevations within the tidal or water (nontidal sites) column; and
- providing a broader range of habitats for wildlife.

Restoration of freshwater marshes would be coordinated with restoration of other habitats to increase overall habitat values. Restoration would also include reestablishment of the full diversity of freshwater marsh plant associations to ensure that the habitat needs of special-status and other species that are dependent on specific vegetation associations are met.

Protecting and restoring freshwater marshes could be accomplished by implementing elements of existing restoration plans such as Central Valley Habitat Joint Venture; expanding State and federal wildlife areas to create additional wetland complexes; improving management of existing and restoring additional freshwater marshes on private lands; and reestablishing connectivity between the Delta and Delta islands, and between channels with their historic floodplains.

Major opportunities exist for restoring tidal freshwater marshes. Actions that would help restore fresh emergent wetlands include:

- Setbacks or breaches of island levees to allow water flows to naturally reestablish wetlands.
- Increase land elevations in the interior of Delta islands where subsidence has lowered land elevations below tidal emergent wetlands
- Use substrate materials to create levee berms at elevations necessary for freshwater emergent vegetation
- Modify, where consistent with flood control objectives, levee vegetation management practices to allow wetland vegetation to naturally reestablish.
- Reintroduce native wetland plants into suitable sites.

These protection and restoration strategies could be implemented by:

- establishing cooperative efforts between government and private agencies to coordinate the efficiency of implementing existing restoration strategies and plans;
- developing and implementing alternative land management practices on public lands to improve wetland habitat quality or promote habitat recovery, and provide incentives to private landowners to implement desirable land use practices;
- establishing additional incentive programs to encourage landowners to establish and maintain freshwater marsh wetlands; and
- protecting existing habitat areas from potential future degradation through acquisition of conservation easements or purchase from willing sellers.

Restoration of stream meander belts and the process of overbank flooding along major tributaries to the Bay-Delta as proposed in the ERPP in other ecological management zones will also create the conditions necessary for the natural reestablishment of freshwater marshes elsewhere in the Central Valley.

These protection and restoration needs could be met by establishing cooperative efforts between government and private agencies. This effort would coordinate implementation of existing restoration strategies and plans; develop and implement alternative land management practices on public lands to improve wetland habitat quality or promote habitat recovery; provide incentives to private landowners to implement desirable land use practices; establish additional incentive programs to encourage landowners to create and maintain saline emergent wetlands; and protect existing habitat areas from future degradation through acquisition of conservation easements or purchase from willing sellers.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore tidal brackish and fresh emergent marsh habitat would involve cooperation with other wetland restoration and management programs. These include:

- Agricultural Stabilization and Conservation Service's Wetland Reserve Program.
- Wildlife Conservation Board's Inland Wetland Conservation Program
- restoration programs administered by Ducks Unlimited and the California Waterfowl Association
- the Suisun Marsh Protection Plan
- ongoing management of State and federal wildlife refuges and private duck clubs
- and the San Francisco Bay Wetlands Ecosystem Goals Project

Proposed ERPP targets may be adjusted to reflect goals identified by the San Francisco Bay Wetlands Ecosystem Goals Project. Restoration efforts would be conducted in cooperation with agencies or organizations with responsibility or authority for restoring wetland and aquatic habitats, including:

- U.S. Bureau of Reclamation
- California Department of Fish and Game,
- California Department of Water Resources,
- U.S. Fish and Wildlife Service,
- U.S. Army Corps of Engineers,
- and the Delta Protection Commission

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Tidal brackish and freshwater marshes are linked to other ecological elements in the Bay. Tidal exchange is an important ecological function that restores the proper salinity and nutrient balance and mixed fresh and estuarine waters.

Tidal brackish and freshwater marshes are closely linked to open water areas and upland habitats. The value of each habitat is increased by the presence and quality of the adjacent types of habitats. A variety of aquatic and terrestrial fish, wildlife and plant communities depend on healthy tidal brackish and freshwater marshes. These include Suisun Marsh aster, California hibiscus, bristly sedge, Jepson's tule pea, Mason's lilaeopsis, marsh mudwort, Sanford's arrowplant, and marsh scullcap and the salt marsh harvest mouse.

Tidal brackish marshes are impaired by reduced seasonal inflows of fresh water, land use, and loss of upland habitat, and introduction an proliferation of invasive salt marsh plant species. Stressors that have reduced the extent of fresh emergent wetlands include flood protection practices, levee construction, and the loss of tidal flow. Increased velocities in Delta channels causes erosion of wetlands and changes the elevation of the land. Wind and boat wake erosion also contribute to the loss of soil needed to support fresh emergent wetlands in area where midchannel islands and levee berms are present.

OBJECTIVE, TARGETS AND ACTIONS

> The Strategic Objective is to enhance and/or conserve native biotic communities in the Bay-Delta estuary and its watershed.

SPECIES TARGETS: The target for all plant communities is to maintain the present distribution and abundance and ensure self-sustaining communities in the long-term.

LONG-TERM OBJECTIVES: Protect and restore, on a self-sustaining basis, throughout the Bay-Delta, multiple large areas of tidal brackish and freshwater marsh in association with tidal perennial and perennial grassland to a point where all at-risk species that depend on the habitat are no longer at risk.

SHORT-TERM OBJECTIVES: Identify, locate, and conserve existing, high quality tidal brackish and freshwater marsh. Restore several large areas of tidal brackish marsh in the Suisun Marsh and several large areas of tidal freshwater marsh in the Delta.

RATIONALE: Tidal brackish and freshwater marsh wetlands are two habitats that support a diverse and unique plant assemblage. Some of the most endangered plants, such as the Suisun thistle, is found only in tidal brackish marsh wetlands in the Suisun Marsh. They merit special attention because their restoration is urgently needed for the benefit of many species, both plant and animal. They also represent, by acreage, some of the largest restoration projects that are likely to be attempted in the system. Prior to implementing larger scale tidal restoration projects, a determination will be made about whether suitable elevation, topography, and geomorphological conditions exist to allow the successful restoration of natural marsh building processes.

STAGE 1 EXPECTATIONS: Ongoing efforts to restore large expanses of tidal brackish and freshwater marsh will have continued and experimental pilot projects to restore tidal marshes to areas in the Suisun Marsh and San Pablo Bay and Delta islands will have been undertaken. .

RESTORATION ACTIONS

The following action would help achieve tidal brackish marsh restoration:

- restore tidal flows to diked wetlands by breaching dikes in suitable areas;
- establish desirable estuarine salinity gradients by managing water diversions and water releases from upstream reservoirs to controls seasonal freshwater inflow into the Delta;
- balance seasonal flows from reservoirs for fisheries, water conveyance, flood control, and the need of other habitats;
- restore a more natural elevation gradient in wetlands to allow a greater diversity of native saline plants species, including special-status plant species that are adapted to different elevations and provide a broader range of habitats for wildlife.

Actions that would help restore tidal freshwater marsh include:

- setbacks or breaches of island levees to allow water flows to naturally reestablish wetland;
- increase land elevations in the interior of Delta islands where subsidence has lowered land elevation below tidal emergent wetlands;
- use of substrate materials to create levee berms at elevations necessary for freshwater marshes;
- modify, where consistent with flood control objectives, levee vegetation management practices to allow wetland vegetation to naturally establish;
- reintroduce native plants into suitable sites.

These protection and restoration strategies could be implemented by:

- establishing cooperative efforts between government and private agencies to coordinate the efficiency of implementing existing restoration strategies and plans;
- developing and implementing alternative land management practices on public lands to improve wetland habitat quality or promote habitat recovery, and provide incentives to private landowners to implement desirable land use practices;
- establish additional incentive programs to encourage landowners to establish and maintain freshwater marshes; and
- protecting existing habitat areas from potential future degradation through acquisition of conservation easements or purchase from willing sellers.

Restoration of stream meander belts and the process of overbank flooding along major tributaries to the Bay-Delta as proposed in the ERPP in other ecological management zones will also create the conditions necessary for the natural reestablishment of tidal brackish and freshwater marsh habitats elsewhere in the Central Valley.

Seasonal Wetland Habitat Plant Community Group

Introduction

The Bay-Delta seasonal wetland habitat plant community group includes vernal pools and seasonally flooded areas. Vernal pools are probably best described as specialized components of terrestrial (land-based) habitats and requiring specific geomorphic features. Other seasonally flooded areas may be described as areas which flood for periods that are too long to support characteristic upland vegetation. Seasonally flooded areas may occur in low grassland basins, the perimeter of the permanent marshes, and within a stream course or its floodplain. Historically, seasonal wetlands occurred throughout the Central Valley. Loss of seasonal wetland habitat, vernal pools in particular, has directly resulted in the listing of several species as threatened or endangered under the federal Endangered Species Act.

Major factors that limit the contribution of this habitat type to the health of the Bay-Delta are related to adverse effects of land conversion, and substantial reductions in seasonal overbank flooding.

Resource Description

Vernal pools are associated with soils (claypan, hardpan) that maintain standing water after winter and spring rains. In some areas of the Central Valley, high spring flows from the rivers and creeks saturate soils. Seasonal wetlands are created when puddles or small ponds form in depressions or standing water remains in low-lying grass fields after river flows recede. Although aquatic plants can establish in areas that are frequently flooded, upland plants cannot survive.

Vernal pools are seasonally flooded depressions formed where a barrier, such as a clay pan or cemented hard pan, restricts percolation of rainwater and runoff from adjacent areas during the winter rainy season. They support a distinctive herbaceous biota adapted to periodic or continuous inundation during the wet season and desiccated soils during the dry season (Holland and Jain 1977, Holland 1978, Thorne 1984, Zedler 1987, Jones & Stokes Associates 1990). Vernal pools usually occur in depressions between small mounds or ridges in a hummocky, rolling, or reticulated landscape. They vary in size from several yards to well over 1 acre and the largest pools are really seasonal lakes, like Olcott Lake at the Jepson Prairie Preserve in Solano County. Vernal pools are common in grasslands in northern Central Valley where the natural geomorphology remains relatively unchanged.

Species commonly found as dominants in vernal pools include goldfields (*Lasthenia* spp.), navarretia (*Navarretia leucocephala*), prostrate pigweed (*Polygonum arenastrum*), coyote thistle (*Eryngium* spp.), woolly marbles (*Psilocarphus* spp.), popcorn flowers (*Plagiobothrys* spp.), downingias (*Downingia* spp.), annual hairgrass (*Deschampsia danthonioides*), and common spikerush (*Eleocharis macrostachya*). Many State- and federally listed plants, invertebrates, and wildlife, including Contra Costa goldfields (*Lasthenia conjugens*), legenere (*Legenere limosa*), western spadefoot toad (*Scaphiopus hamondii*), California tiger salamander (*Ambystoma tigrinum*), and various fairy shrimp, are native to or associated with vernal pools. In addition, a variety of birds, including migrating waterfowl, shorebirds, and ground-nesting birds such as meadowlarks, commonly use seasonal wetlands habitat.

Vernal pools are best distinguished from one another by specific geomorphic features then by plant species composition. This is because the species composition and the relative cover by each species varies not only between pools, but varies from season to season within the pools. Two vernal pool ecosystem types are recognized in the Bay-Delta region. They are northern claypan vernal pools and northern hardpan vernal pools.

Northern claypan vernal pools contain mixo-saline water to freshwater ponded over claypans. They occur on neutral to alkaline, silica-cemented hardpan soils which are often saline. They are more widespread in the south San Joaquin Central Valley but range north into the Sacramento Central Valley area. Alkaline types of claypan vernal pools are characterized by a high alkaline salt content and dominance by plant species adapted to these conditions. Alkaline pools occur on extremely salty soils such as the Pescadero clay series underlying Olcott Lake in the Jepson Prairie Preserve. Alkaline pools support common alkaline plants such as alkali heath (*Frankenia salina*), alkali mallow (*Malvella leprosa*), and alkali weed (*Cressa truxillensis*). Some special status plants found in alkaline pools include bearded popcorn flower (*Allocarya histriculus*), Solano grass (*Tuctoria mucronata*), and Colusa grass (*Neostapfia colusana*).

Northern hardpan vernal pools contain mixo-saline water to freshwater impeded by hardpans. They occur on old, acidic, iron-silica cemented soils including Corning, Redding, and San Joaquin soil series. They are typically found on old alluvial fans ringing the Central Valley.

Seasonally flooded areas play a vital role in the natural succession of plant communities. Seasonally flooded areas that maintain surface water for long periods may support herbaceous plant dominants in three recognized plant communities - cattails, bulrushes, and sedges. Historically, these emergent plant species were probably prevalent along natural stream courses where long-standing water reduced the ability of upland species to establish. These types of wetlands provide the essential building blocks for the future establishment of riparian (streambank) scrub and eventually riparian woodland. Beyond the normal river flows, wetlands probably formed where rains and high flows left areas too wet for terrestrial plants to establish. These wetland areas provide high-quality habitat for a special status plant, Sanford's arrowhead (*Sagittaria sanfordii*), and a variety of wildlife including waterfowl, other migratory birds, shorebirds, red-legged frogs, giant garter snakes, and tricolored blackbirds.

The continued existence of the seasonal wetland habitat plant community group is closely linked to overall ecosystem integrity and health. Although many species that use seasonal wetlands are migratory (e.g., waterfowl and sandhill cranes), many others have evolved (e.g., spadefoot toad, fairy shrimp, and many specialized plants) and adapted to seasonal wetlands.

The extent and quality of the seasonal wetland habitat plant community group has declined because of cumulative effects of many factors, including:

- modification of natural geomorphology such as ground leveling for agriculture and development,
- adverse effects of overgrazing,
- contamination from herbicides,
- establishment of non-native species that have an adverse effect on native wetland plants and wildlife,
- flood control and water supply infrastructure that reduces overbank flooding and floodplain size, and
- reduction of the natural underground water table that supported wetlands.

Existing wetland regulations have been in effect for several years in an attempt to prevent the further loss of wetlands. The protected status of wetlands has resulted in an extensive permitting process for construction in wetland areas. Mitigation measures have been developed to offset loss of existing wetlands as a result of construction activities. These efforts have slowed the rate of wetland loss in many areas. Large-scale efforts in areas such as the Suisun Marsh, Grasslands Resource Conservation District, Yolo Bypass, Cosumnes River Preserve, Jepson Prairie Preserve, and Butte Sink have been successful in maintaining and restoring seasonal wetlands.

VISION

The vision for the seasonal wetland habitat plant community group is to improve the quality and extent of these habitat plant community group by restoring ecosystem processes that sustain them, preserving and enhancing their linkage to important other habitat plant community groups and reducing the effect of stressors.

Restoration of seasonal wetland habitat will focus on protecting and improving important existing wetlands, reestablishing vernal pools within and adjacent to existing ecological reserves, and restoring seasonal wetlands in the Sacramento-San Joaquin Delta and Suisun Marsh/North San Francisco Bay Ecological Management Zones. Seasonal wetland restoration will be coordinated with restoration of other habitats, including shallow-water and riparian woodland and scrub. Restoration would include reestablishment of the full diversity of seasonal wetland plant associations to ensure that the habitat needs of special-status and other species that are dependent on specific vegetation associations are met.

Actions that would help protect and restore seasonal wetland habitat plant communities are contained in the Vision for Seasonal Wetland habitat.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore seasonal wetland habitat plant communities would involve cooperation with other restoration programs, including:

- Upper Sacramento River Fisheries and Riparian Habitat Council,
- Suisun Marsh Protection Plan,
- California Department of Fish and Game wildlife areas,
- U.S. Fish and Wildlife Service refuges,
- Cosumnes River Preserve,
- Jepson Prairie Preserve,
- Solano County Farmland and Open Space Land Trust,
- Ducks Unlimited Valley Care Program,
- California Waterfowl Association,
- Cache Creek Corridor Restoration Plan,
- The Nature Conservancy,
- California Native Plant Society,
- Putah Creek South Fork Preserve,
- Woodbridge Ecological Reserve,
- Yolo County Habitat Conservation Plan,
- and Central Valley Habitat Joint Venture.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

The seasonal wetland habitat plant community group is linked to other ecosystem elements in the ERPP Study Area. The seasonal wetland habitat plant community group includes vernal pools and seasonally flooded areas that support many species and communities of wildlife and plants. Seasonal wetland habitat plant communities are linked to primary and secondary physical processes including geomorphology, vegetation succession, overbank flooding, and floodplain inundation. Seasonal wetland habitat plant communities are linked to stressor elements including land use, non-native species, water management, and human disturbance. Seasonal wetland habitat plant communities are linked to habitat elements including vernal pool, seasonal wetland, and emergent wetland habitats. Links to wildlife elements include the greater sandhill crane, fresh emergent wetland wildlife guild, riparian wildlife guild, shorebird and wading bird guild, waterfowl guild, and native amphibians and reptiles. Vernal pool special-status plant species is also linked to seasonal wetland habitat plant communities.

OBJECTIVE, TARGETS, AND ACTIONS

> The Strategic Objective is to enhance and/or conserve native biotic communities in the Bay-Delta estuary and its watershed.

SPECIES TARGETS: The target for all plant communities is to maintain the present distribution and abundance and ensure self-sustaining communities in the long-term.

LONG-TERM OBJECTIVES: Restore, protect and manage, throughout the watershed, multiple large areas of seasonal wetlands in association with other aquatic, wetlands, riparian, and perennial grassland habitat types in the Central Valley to a point where the needs of seasonal wetland associated plants such as Sanford's arrowhead and alkali heath are met and all at-risk species that depend on the habitat are no longer at risk.

SHORT-TERM OBJECTIVES: in the Bay-Delta, and begin implementation of action plans for restoring significant, large areas of seasonal wetland.

RATIONALE: Restoring seasonal wetlands in combination with other wetland and upland habitat types will help restore and maintain the ecological health of aquatic, terrestrial, and plant resources in the Delta and other areas of the Central Valley. Foodweb processes will be supported and the effects of contaminants reduced. Seasonal wetlands will provide high quality foraging and resting habitat for wintering waterfowl, greater sandhill cranes, and migratory and wintering shorebirds. Restoration of seasonal wetlands will occur as a by product of restoring floodplain processes in a manner that improves spawning habitat for fish species such as splittail while avoiding concurrent increases in non-native predatory fish. Furthermore, restoring other wetland habitats in the Delta, such as tidal emergent wetland and tidal perennial aquatic habitat, can reduce habitat values for species such as waterfowl and the State listed greater sandhill crane. Increasing seasonal wetlands in the Delta will ensure that any adverse impacts associated with those habitat losses will be fully mitigated. Each habitat, including seasonal wetlands, supports a different assemblage of organisms and quite likely many of the invertebrates and plants are still unrecognized as endemic forms. Thus systematic protection of examples of the entire array of habitats in the region provides some assurance that rare and unusual aquatic organisms and rare plants will also be protected, preventing contentious endangered species listings.

STAGE 1 EXPECTATIONS: Several large seasonal wetland projects will have been initiated in the Delta. At least two of the projects will be associated with floodplain process restoration projects. At least two projects will be associated with restoring seasonal wetlands in heavily subsided areas where land elevations are too low to support actions to restore aquatic habitat. At least one project will be associated with expanding the vernal pool wetlands in the northeastern Suisun Marshlands and Bay Ecological Management Unit adjacent to the Yolo Basin Ecological Management Zone.

RESTORATION ACTIONS

Actions that would help protect, restore, and enhance seasonal wetlands are contained in the Vision for Seasonal Wetlands and as follows:

- implement existing restoration plans,
- expand public and private preserves and wildlife areas to create additional wetland complexes, including vernal pools and seasonally flooded areas,
- improve management of existing wetlands and restore seasonal wetlands on private lands,
- reconnect channelized streams and rivers to their historic floodplains,
- develop and implement alternative land use practices on public and private lands that will protect and improve vernal pools and seasonally flooded areas and allow existing, compatible land uses, such as seasonally-managed grazing, to continue,
- establish incentive programs to encourage landowners to establish and maintain seasonal wetlands, and
- develop vegetation management programs to enhance habitat value and reduce impacts from stressors such as introduced species.

Inland Dune Habitat Plant Community Group

Introduction

Inland dune scrub is associated with inland sand dunes and is limited to the Delta in the vicinity of the Antioch Dunes Ecological Reserve. This habitat area supports two plant and one butterfly species listed as endangered under the federal Endangered Species Act. Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of sand mining, dune conversion to other land uses, dune stabilization, and land use practices that maintain the dominance of non-native plants.

Resource Description

Antioch Dunes. Inland dune scrub is localized in areas of wind-modified stream deposits in the south and western Delta. Inland dune scrub exists between Antioch and Oakley, south of Rio Vista, and on Brannan Island. Soil information indicates that the total inland sand-dune habitat within Contra Costa, Solano, and Sacramento Counties was historically less than 10,000 acres. Remaining habitat areas are being protected. Most protected inland dune scrub is located within the Antioch Dunes Ecological Reserve and Brannan Island State Park. These protected areas represent important, but small, relictual examples of this unique habitat.

The vegetation at Antioch Dunes consists of scattered forbs and grasses that form a ground canopy. Characteristic plant species include Antioch dunes evening-primrose (*Oenotherea deltoides* ssp. *howellii*), California croton (*Croton californicus*), California matchweed (*Gutierrezia californica*), Contra Costa wallflower (*Erysimum capitatum*), devil's-lettuce (*Amsinckia tesselata*), lessingia (*Lessingia glandulifera*), nude buckwheat (*Eriogonum nudum* var. *auricalataum*), and telegraph weed (*Heterotheca grandiflora*). Individual emergent shrubs or coast live oak (*Quercus agrifolia*) trees may be present over the ground canopy. The ground layer is generally open, and annual plants are seasonally present. The low nutrient conditions of the soils and natural instability of dune sands limit the amount of vegetation that establishes on the inland dunes.

Direct and indirect disturbances are reducing the extent and health of inland dune scrub habitat and its associated plants and animals. Sand mining directly removes habitat. Urban development has moved onto historical dune habitat and changed wind-flow patterns. Excessive foot traffic, off-road vehicle traffic, and grazing disturb dune surfaces, which makes dunes more susceptible to erosion. Application of herbicides, pesticides, and fertilizers change ecological processes that may encourage or support non-native species. Structures or activities that reduce or accelerate winds, wind-disturbances, or barriers to wind-driven sand movement disrupt the process that sustain dunes. Wind patterns blow river-deposited sand into shifting dunes. Shifting sand offers little stability for establishing plant root systems. Plant species characteristic of dunes survive within a disturbance threshold. Direct disturbances inhibit the ability of dune-associated plants to establish and result in loss of plant vigor or mortality. Sand movement barriers create conditions unfavorable for establishing native dune vegetation. These types of disturbances create site conditions conducive to establishing invasive weedy plants. Non-native weeds compete with native dunes plants and reduce overall habitat quality. Continued disturbance of potentially restorable adjacent habitat could interfere with protecting and restoring additional areas of high-quality habitat by affecting dune structure and destroying buckwheat which serves as foot for the Lange's metalmark, a federally listed as endangered species, as well as the federally listed Antioch dunes evening primrose and Contra Costa wallflower.

Vision

The vision for inland dune scrub habitat is to protect and enhance existing areas and restore former habitat areas.

Achieving this vision will provide high-quality habitat for associated special-status plant and animal populations.

Restoration of inland dune scrub would focus on protecting and improving important existing habitat areas. Historic inland dunes adjacent to existing ecological reserves in the Sacramento-San Joaquin Delta Ecological Management Zone would be reestablished. Protecting and restoring inland dune scrub habitat would begin by identifying areas that are not currently managed for their resource values. Appropriate methods to protect and restore identified areas would be developed. Protected habitat areas would be evaluated to determine effective restoration management practices to increase habitat value. The results of these evaluations would determine how habitat would be protected and restored. For example, importing sand from areas proposed for development into low-quality areas proposed for restoration will provide important natural substrate that will increase the restoration potential. Management of the inland dune areas that are currently protected should focus on maintenance of the natural conditions to assure the natural dune ecosystem process is continued.

Reduction of stressors will be the key in establishing a long-term protection programs. In protected areas, management would include reducing human access to dune areas. Development of small boardwalks will reduce human disturbance in areas where recreational access or interpretive trails are needed. Access to the dunes by motorized or other vehicles would be prevented except as part of restoration and enhancement activities. Management activities would include exotic weed plant species removal and habitat enhancement to allow the establishment of native inland dune species. Use of herbicides, pesticides, and fertilizers would be eliminated except if it is necessary for specific non-native weedy plant species removal.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore inland dune habitat will involve cooperation with programs managed by the Antioch Dunes National Wildlife Refuge. Cooperation from agencies with responsibility or authority for restoring inland dune habitat will be solicited. These include:

- California Department of Fish and Game,
- U.S. Fish and Wildlife Service,
- U.S. Army Corps of Engineers, and
- Delta Protection Commission.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Inland dune scrub habitat is limited to the area near the Antioch Dunes Ecological Reserve. This type of habitat is important for two plant and one butterfly species listed as endangered under the federal Endangered Species Act.

It is adversely affected by human caused actions that contribute to erosion and spread of non-native species.

OBJECTIVE, TARGETS, AND ACTIONS

> The Strategic Objective is to enhance and/or conserve native biotic communities in the Bay-Delta estuary and its watershed.

SPECIES TARGETS: The target for all plant communities is to maintain the present distribution and abundance and ensure self-sustaining communities in the long-term.

LONG-TERM OBJECTIVE: Protect, manage, and restore, on a self-sustaining basis, inland dune habitat in the vicinity of Antioch Dunes Ecological Reserve and the invertebrate and plants species that depend on this habitat.

SHORT-TERM OBJECTIVE: Improve or restore existing dune habitat within the Antioch Dunes Ecological Reserve and identify and conserve existing inland dune scrub habitat adjacent to the reserve.

RATIONALE: Inland dune scrub is associated with inland sand dunes and is limited to the vicinity of the Antioch Dunes National Wildlife Refuge. Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of sand mining, dune conversion to other land uses, dune stabilization, and land use practices that maintain the dominance of non-native plants. Two special-status plant species, the Antioch Dunes evening primrose and the Antioch Dunes wallflower, are found with inland dune scrub. The Lange's metalmark, a butterfly listed as endangered under the federal Endangered Species Act (ESA), is known only from the Antioch Dunes, where it feeds on naked buckwheat. The low nutrient conditions of the soils and natural instability of dune sands limit the amount of vegetation that establishes on the inland dunes. The dunes represent a localized habitat that does not support other types of upland vegetation.

STAGE 1 EXPECTATIONS: The feasibility of reestablishing inland dune scrub habitat on historic dunes adjacent to the existing ecological reserve will have been completed. The most appropriate means to protect and restore identified areas adjacent to and within the reserve will have been completed and at least partially implemented. Small boardwalks will have been constructed to reduce human disturbance in areas where access or interpretive trails are required.

RESTORATION ACTIONS

Managing protected areas could include reducing disturbance of dunes and dune vegetation. This could be accomplished by reducing vehicle and pedestrian access to dune areas. Protective structures, such as small boardwalks could be built. These actions would reduce habitat disturbance while maintaining recreational access. The following actions would help restore inland dune habitat:

- remove barriers to wind-driven sand-dune movement to increase the area that would be available for natural expansion of the sand-dune base.
- import sands from areas being developed or clean sand dredged from Bay-Delta channels to increase restoration potential and dune area.
- control non-native weeds to recreate conditions suitable for reestablishment of native dune plants.
- reduce the use of herbicide, pesticides, and fertilizers that adversely effect native dune vegetation and wildlife.

Dune habitat protection and restoration strategies could be implemented through cooperative efforts with existing ecological reserves. Restoration efforts should focus on implementing existing protection and restoration programs, establishing cooperative agreements with land management agencies, and establishing conservation easements of purchasing land from willing sellers.

TIDAL RIPARIAN HABITAT PLANT COMMUNITY GROUP

INTRODUCTION

The tidally influenced shorelines of rivers and the Delta are often vegetated with woody riparian trees and shrubs. The structure of this riparian vegetation can be like that of a forest, woodland, or scrub or may be a mosaic of these formations. Riparian vegetation supports a great diversity of wildlife species and serves as important habitat for a variety of resident and migratory songbirds. Riparian vegetation also shades riverine aquatic habitat which is important habitat for many species of fish, waterfowl, and wildlife.

Major factors that limit these plant communities' contribution to the health of the Bay-Delta include historic riparian vegetation loss or degradation and nearshore aquatic habitat alteration from channelization, stabilization of channel banks with riprap, construction of levees, and control of flows.

Restoring riparian vegetation will involve reactivating or improving natural physical processes. Natural streamflows, stream meanders, and sediment transport create and sustain these vegetation types and increase the complexity and structural diversity of the habitat. Natural sources of gravel and other sediments along rivers and floodplains provide materials needed to create and sustain healthy riparian vegetation. Where improvements to physical processes do not adequately restore riparian vegetation, direct modification may be necessary to restore vegetation to its target acreage and quality.

A major increase in tidal riparian plant community groups will improve the foodweb and provide important habitat for threatened and endangered terrestrial wildlife species, such as the yellow-billed cuckoo and Swainson's hawk. More extensive and continuous riparian vegetation cover on along rivers and in the Delta will stabilize channels; help to shape submerged aquatic habitat structure; benefit the aquatic environment by contributing shade, overhead canopy, and instream cover for fish; and reduce local water temperatures. More extensive and continuous riparian vegetation associated with woody debris (branches and root wads) and leaf and insect drop in shallow aquatic habitats will increase the survival and health of juvenile salmonids and resident Delta native fish. Achieving this objective will also greatly enhance the scenic quality and recreational experience of the Delta and its waterways.

RESOURCE DESCRIPTIONS

Tidal riparian habitat includes several plant community groups. Environmental factors such as substrate, hydrology, and degree of salt water influence determine which plant community group will occur in a given area. The plant community groups that comprise tidal riparian habitat include black willow, sandbar willow, white alder, buttonbush, Mexican elderberry, and valley oak series.

Historically the Central Valley floor had approximately 922,000 acres of riparian vegetation (Katibah 1984) supported by a watershed of more than 40,000 square miles. Today, approximately 100,000 acres of riparian forest remain. About half of this riparian habitat is in a highly degraded condition, representing a decline of 90% (Katibah 1984). The Sacramento River once supported 500,000 acres of riparian forest; it now supports 10,000 - 15,000 acres, or just 2-3% of historic levels (McGill 1979, 1987). From about 1850 to the turn of the century, most of the forest was destroyed for fuel as a result of the Gold Rush and river navigation, and by large agricultural clearing. Additional clearing in the early and mid 1900s coincided with the aftermath of flood control reservoir and levee projects. These projects allowed for the clearing of floodplain riparian vegetation for orchards, crops, flood bypasses, and urban areas. Similar activities have occurred on the San Joaquin River and other rivers in the Central Valley.

Riparian areas along rivers within the Delta, and areas within the Delta itself, are influenced by the daily ebb and flow of the tide in the Pacific Ocean. Six distinct plant series are found within these tidal riparian areas: black willow series, narrowleaf willow series, white alder series, buttonbush series, Mexican elderberry series, and valley oak series. These six series are briefly described below:

BLACK WILLOW SERIES: In the black willow series black willow is the sole or dominant woody plant that forms a forest or shrubland. In this series black willow can be a tree or a shrub depending on frequency or severity of disturbance, or the seral stage of the site. Other trees occasionally found in the canopy include California sycamore, Fremont's cottonwood, white alder, and Oregon ash. Other shrubs that may be present in the black willow series include other species of willow, mulefat, Mexican elderberry, and Himalaya berry. The herb layer in black willow series can vary greatly depending on substrate conditions and site hydrology (Sawyer et al. 1996).

Black willow series is typically found at sites that are seasonally flooded or saturated with freshwater along low-gradient depositions along rivers, streams, or sloughs. Black willow series intergrades with tidal brackish and freshwater marsh habitats and with narrowleaf willow series, white alder series, and buttonbush series.

NARROWLEAF WILLOW SERIES: In the narrowleaf willow series narrowleaf willow is the sole or overwhelmingly dominant shrub in the canopy. Other trees or shrubs infrequently found in the canopy include other species of willow, Fremont's cottonwood, and white alder. The herb layer in narrowleaf willow series is usually sparse or absent because of the frequent scouring from flood events and the dense shade provided by the shrubs (Sawyer et al. 1996).

Narrowleaf willow series often occurs at sites along the margins of rivers that are continuously disturbed by sediment deposition. Older stands narrowleaf willow series are typically found on sites that are former sandbars that have been isolated from the main channel of a waterway either through channel migration or as a result of flood control. Narrowleaf willow series intergrades with tidal brackish and freshwater marsh habitats in some areas and with black willow series, white alder series, and buttonbush series.

WHITE ALDER SERIES: In the white alder series white alder is the sole or dominant tree in the canopy. Other trees that may be present include California sycamore, Oregon ash, or California box-elder. Depending on the level of flooding in this series the shrub layer can be dense to sparse. The ground, or herb, layer in white alder series can be variable, however, it is typically sparse in the Central Valley (Sawyer et al. 1996).

White alder series occurs along the banks of rivers typically in areas that experience high energy intermittent flooding. White alder series typically is best developed along the low-flow margins of rivers and streams. White alder series intergrades with black willow series, narrowleaf willow series, and valley oak series.

BUTTONBUSH SERIES: In the buttonbush series buttonbush is the dominant shrub in the canopy with occasional shrubs of red osier dogwood, narrowleaf willow, or other willows also present. Buttonbush series typically forms extensive dense canopies at the water's edge and typically has a sparse ground layer (Sawyer et al. 1996).

Buttonbush series occurs along intermittently flooded and seasonally saturated freshwater sites along rivers or sloughs. Buttonbush series intergrades with black willow series, narrowleaf willow series, and tidal brackish and freshwater marsh habitat plant communities.

MEXICAN ELDERBERRY SERIES: Mexican elderberry is often the dominant shrub in the canopy of Mexican elderberry series. Other shrubs that may occur in this series include California wild grape, narrowleaf willow, Oregon ash, and coyote brush. Occasional Fremont's cottonwood or valley oak trees may also be present. Mexican elderberry is a species that also frequently occurs in valley oak series. The ground layer in Mexican elderberry series is variable but often consists of non-native grasses and herbs (Sawyer et al. 1996).

Mexican elderberry series typically occurs on high floodplains or low terraces of rivers and streams. These sites experience infrequent flooding but do have seasonally high water tables. Mexican elderberry is the host plant for the Valley elderberry longhorn beetle, a federally listed threatened species. Mexican elderberry series intergrades with valley oak series and older stands of narrowleaf willow series that occur on abandoned floodplains.

VALLEY OAK SERIES: In Valley oak series valley oak is the sole or dominant tree in the canopy. In valley oak series that occurs on the high floodplains and low terraces of rivers other tree species that may be present include California sycamore, Fremont's cottonwood, and Oregon ash. The shrub layer in valley oak series is typically sparse. Common shrubs include poison oak, Mexican elderberry, and occasional willows in wetter sites. Lianas of California wild grape growing into the canopy are common in this series. The ground layer in this series is typically grassy and is often dominated by native perennial grasses where extensive ground disturbance has not occurred.

Valley oak series typically occurs on the high floodplains and low terraces of rivers and streams. These sites are infrequently or frequently flooded for relatively short durations. Valley oak series intergrades with Mexican elderberry series and infrequently with older stands of narrowleaf willow series.

In general, tidal riparian vegetation is healthiest where ecosystem processes are in the most unaffected natural state. These unaffected sites are also the most resilient to human and natural disturbance. Ecosystem processes that are integral components of tidal riparian vegetation include sediment transport, deposition, and scour. These components support the succession and regeneration of riparian vegetation promoting its continued existence and ensuring continued habitat benefits for the aquatic environment. Riparian vegetation serves many important ecological functions. Riparian vegetation absorbs nutrients and produces primary (plant) and secondary (invertebrate) biomass at very high rates. This biomass feeds numerous fish and wildlife species. Birds and small mammals nest and take cover in the protective foliage of trees and shrubs. Trees also shade and cool floodplains and channels. Water velocities are slowed by riparian vegetation, allowing sediment to settle and create new landforms. Riparian foliage also stabilizes channels and banks, thereby rendering the characteristic geomorphology of estuaries, rivers, and streams.

Primary stressors affecting tidal riparian vegetation include:

- channel straightening and clearing
- levee construction and bank hardening to protect bridge abutments and diversion structures (e.g. with rip-rap);
- instream gravel mining and riparian zone grazing;
- flow modifications affecting sediment transport and riparian plant germination;
- removal, burning, and fragmentation of mature riparian vegetation; and
- loss of sediment and bedload from watershed sources upstream of dams.

Other stressors that affect tidal riparian vegetation include (listed in increasing importance and magnitude):

- human set fires along riparian corridors;
- new expansion of orchards and vineyards into the riparian floodplain;
- displacement by invasive non-native trees and shrubs (e.g. giant reed and black fig);
- unusually high summer stage in rivers that supply increasing demand for downstream water diversions;
- groundwater lowered below the root zone; and
- expanded clearing of channel vegetation in response to recent flood events that called into question the capacity of levee-confined rivers and streams.

Most stressors have an indirect but lasting effect on riparian vegetation. These stressors can affect the ability of riparian vegetation to recover following disturbance and can reduce the overall quality of the habitat. Collectively, these stressors have substantially reduced the quality and resilience of tidal riparian vegetation, thereby diminishing their effectiveness in providing for the life cycle requirements of fishes of the Delta and Sacramento and San Joaquin Rivers and their tributaries.

VISION

The vision for tidal riparian vegetation is to protect and increase its area and quality. Achieving this vision will assist in the recovery of special-status fish, wildlife, and plant populations and provide high-quality habitat for other fish, wildlife, and plants dependent on the Bay-Delta. The vision includes restoring native tidal riparian plant communities on both the less frequently flooded higher floodplain elevations and lower frequently flooded floodplain and streambanks.

The simple preservation of remaining natural riparian vegetation will not ensure the diversity, and resilience of these habitats. Many remnant natural sites no longer have all the physical processes necessary to ensure their continued existence and habitat value. Additionally, remaining natural riparian areas are in many cases highly fragmented and disturbed reducing their overall habitat value. Most riparian vegetation restoration projects in the Central Valley have been implemented on a relatively small scale, primarily as mitigation for project impacts or as infill of existing protected preserves.

Where natural physical processes are intact, or created through active land and water management, suitable conditions for the restoration (e.g. natural colonization or active restoration) of riparian vegetation will exist. Even partial restoration or simulation of natural physical processes will amplify ecosystem processes and resultant habitat quality. Rivers and Delta estuaries where natural fluvial processes and landforms are relatively intact need to be identified and highlighted as potential reserves of riparian vegetation.

Successful restoration of riparian vegetation depends on the recovery or simulation of natural fluvial processes and landforms. Revegetating and artificially altering stream channels will be considered only where overwhelming limitations prevent natural recovery of these physical processes and ecosystem functions.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to achieve the vision for tidal riparian habitat communities may involve coordination with other programs. These include:

- U.S. Army Corps of Engineers' proposed reevaluation of the Sacramento River flood control project and ongoing bank protection project, including more comprehensive floodplain management and river ecosystem restoration opportunities;
- proposed riparian habitat restoration and floodplain management and riparian restoration studies for the San Joaquin River, including potential new flood bypass systems and expanded river floodplains on lands recently acquired by State and federal agencies and land trusts;
- ongoing Sacramento Valley conservation planning by The Nature Conservancy and other private nonprofit conservation organizations;
- ongoing coordination efforts and programs of the Wildlife Conservation Board, including the Riparian Habitat Joint Venture;
- all county-sponsored instream mining and reclamation ordinances and river and stream management plans;
- and the California Department of Conservation reclamation planning assistance programs under the Surface Mining and Reclamation Act.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Tidal riparian vegetation is linked to the ecological health of many ERPP Ecological Management Zones and Units. This type of vegetation is important to many fish, wildlife, and plant species and communities. It is adversely affected by many stressors that include levee construction and maintenance, flood flow patterns, summer flow patterns, gravel mining, fragmentation of existing stands of vegetation, competition and displacement by invasive non-native species, land use conversion, flood control activities, and lowered groundwater levels.

OBJECTIVE, TARGETS, AND ACTIONS

The Strategic Objective is to enhance and/or conserve native biotic communities in the Bay-Delta estuary and its watershed.

SPECIES TARGETS: The target for all plant communities is to maintain the present distribution and abundance and ensure self-sustaining communities in the long-term.

LONG-TERM OBJECTIVES: Protect and restore, on a self-sustaining basis throughout the Delta, large blocks of tidal riparian habitat as a mosaic with other aquatic and wetland habitat types to a point where all at-risk species such as the valley elderberry longhorn beetle, riparian brush rabbit, and yellow-billed cuckoo that depend on this habitat are no longer at risk.

SHORT-TERM OBJECTIVES: Conserve the best examples of riparian habitats in the Delta. Begin to restore large areas of tidal riparian habitat.

RATIONALE: Restoring tidal riparian habitat in combination with other aquatic, wetland, and upland habitat types will help restore and maintain the ecological health of aquatic, terrestrial, and plant resources in the Delta and other areas of the Central Valley. Foodweb processes will be supported and the effects of contaminants reduced. Tidal riparian habitat will provide high quality foraging and nesting habitat for migratory and wintering songbirds, neotropical migrants such as the Swainson's hawk, riparian brush rabbit, and yellow-billed cuckoo. Restoration of tidal riparian habitat will occur as a by product of restoring floodplain processes in a manner that improves spawning habitat for fish species such as splittail while avoiding concurrent increases in non-native predatory fish. Each habitat, including tidal riparian habitat, supports a different assemblage of organisms and quite likely many of the invertebrates and plants are still unrecognized as endemic forms. Thus systematic protection of examples of the entire array of habitats in the region provides some assurance that rare and unusual aquatic organisms will also be protected, preventing contentious endangered species listings.

STAGE 1 EXPECTATIONS: Several large tidal riparian habitat projects will have been initiated in the Delta. At least two of the projects will be associated with floodplain process restoration projects. At least two projects will be associated with restoring tidal riparian habitat in areas at the edges of the Delta where lands are not heavily subsided land elevations are appropriate to support actions to restore tidal riparian habitat.

RESTORATION ACTIONS

Recovery and simulation of natural physical processes and landforms will be accomplished using the following integrated steps:

- locating setback levees to expand potential riparian floodplain;
- expanding the storage, detention, and bypass capacity of the Sacramento and San Joaquin River flood control project to allow natural expansion of riparian vegetation within levees and the Sutter and Yolo Bypasses; and
- designating, acquiring title or easements for, and deliberately managing river riparian corridors throughout the Central Valley.

The following actions would restore or enhance sediment supply to rivers and streams:

- reduce bank hardening by creating meander zones and widening floodplains;
- analyze alternative approaches for water diversions and associated intake and screening facilities on the mainstem river to avoid hardening the bank in some sections of the river;
- remove small, nonessential dams on gravel-rich streams;
- eliminate mining in streams and on low floodplains near channels;
- widen bridges to broaden out-of-bank flow and eliminate the need to riprap vulnerable bridge abutments; and
- breach or remove nonessential levees restricting former tidelands that would capture sediment needed to create tidal mudflats and estuary landforms.

Opportunities for reducing riparian vegetation stressors include:

- phasing out instream gravel mining;
- designating and acquiring "stream erosion zones" to reduce the use of bank riprap and allow greater normal recolonization;
- designing biotechnical slope protection measures that allow riparian vegetation to be established within levees;
- phasing out or reducing livestock grazing in riparian zones;
- establishing conservation easements for purchase of land or using other incentives to reduce or eliminate cropland conversion or riparian forest;

- identifying levee-confined channels and banks where routine vegetation removal by local reclamation districts can be safely discontinued; and
- establishing weed control programs to suppress the expansion of tamarisk, giant reed, locust, black fig, and other invasive non-native plants degrading habitat quality and native flora.

Reservoir operations will be evaluated to determine whether winter and spring releases can be augmented with flood simulation spikes every 1-10 years. Simulated flood spikes would mobilize bed and bank deposits to redistribute, sort, and clean spawning gravels and scour deep pools between riffles.

Restoring and enhancing riparian vegetation should be accomplished by eliminating the stressors and recovering or simulating the physical processes and fluvial landforms described above. Vegetation restored in this manner will be more resilient to future disturbances; require little or no long-term maintenance; be self-sustaining; and be more compatible with flood control requirements.

However, vegetation fragmentation and severe limitations of the physical environment will not allow ecosystem processes and functions to fully recover on many segments of valley streams and Delta estuaries. In these solutions, some large-scale stream channel sculpting, gravel additions, and riparian replanting may be necessary. For example, the lower Sacramento River has abandoned river floodplains and sediment is in short supply. Naturally reactivating these habitats would be nearly impossible. Restoring these habitats would require human intervention. Revegetation projects should be contemplated only where native trees and grasses many no longer germinate naturally but have a high probability of unaided survival and vigorous growth following 1-5 years of artificial irrigation.

Reference

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

◆ MAINTAIN HARVESTED SPECIES

INTRODUCTION

The Strategic Plan for Ecosystem Restoration presents 6 goals to guide the implementation of restoration actions during the 20-30 year program. Strategic Goal 3 focuses on species which provide sustainable recreational and commercial harvest not already covered by Goal 1:

> *Goal 3: Maintain and /or enhance populations of selected species for sustainable commercial and recreational harvest consistent with the other ERP strategic goals.*

Somewhere between 40 and 50 species of fish and invertebrates are harvested in significant numbers in the CALFED region, as are a number of species of birds (waterfowl, mourning doves, ring-necked pheasants). The ERP has the potential to affect the harvest of many of these species, improving most of them in the long run.

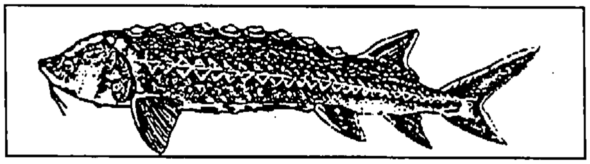
MAINTAIN HARVESTED SPECIES ("H"): For those species designated "H" the CALFED Program will undertake actions to maintain the species at levels which support viable harvest rates. The goal "maintain harvested species" was assigned to species which are harvested for recreational or commercial purposes. A key to maintaining harvestable surplus levels is recognizing the need to recover, contribute to recovery, or maintain species evaluated in the MSCS. Thus, species interactions such as competition and predation and habitat needs for space and flow need to be balanced in favor of species designated for recovery, contribute to recovery and maintain. Those three designations apply only to native species and assemblages while the "maintain harvested species" designation includes some native species and non-native species. Thus, actions implemented to maintain harvested species would be expected, *at a minimum*, to not contribute to the need to list an unlisted species, degrade the status of an already listed species, or impair in any way efforts to recover, contribute to recovery, or maintain native species.

Some species, such as chinook salmon and steelhead trout, are covered by more than one strategic objective. For example, both chinook and steelhead are at-risk species and harvested species and thus covered by the objective to achieve, first, recovery and then large self-sustaining population, and by the objective to enhance fisheries for chinook, steelhead, white sturgeon, Pacific herring, and native cyprinid fishes.

The "maintain harvested species" addressed in this section include:

- chinook salmon *
- steelhead trout *
- white sturgeon
- striped bass
- American shad
- non-native warmwater gamefish
- Pacific herring
- native cyprinid fishes
- grass shrimp
- signal crayfish
- waterfowl *
- upland game.

*Designates species that have previously been discussed. Chinook salmon and steelhead trout were discussed in the section on species designated for recovery and waterfowl were discussed in the section on species communities and assemblages.



INTRODUCTION

White sturgeon rear in the Sacramento-San Joaquin estuary and spawn in the Sacramento and San Joaquin rivers and their major tributaries. Sturgeon may leave the Bay-Delta and move along the coast to as far as Alaska. Populations of white sturgeon are found in many of the larger rivers from California north to British Columbia.

The white sturgeon is an important native anadromous sport fish with high recreational and ecological value.

Major factors that limit sturgeon populations in the Bay-Delta are adequate streamflows for attracting adults to spawning areas in rivers and transporting young to nursery areas, illegal and legal harvest, and entrainment into water diversions.

RESOURCE DESCRIPTION

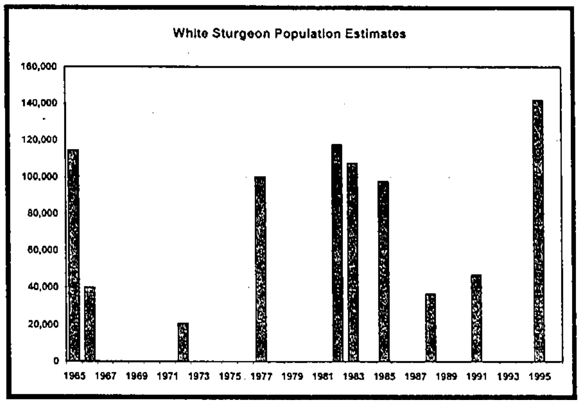
White sturgeon are native to Central Valley rivers and the Bay-Delta and represent an important component of the historic native fish fauna. Throughout recorded history, white sturgeon have been the dominant sturgeon populations in the Bay-Delta system, whereas in smaller systems such as the Eel River, green sturgeon dominate. White sturgeon support a valuable sport fishery in the Bay and Delta.

Sturgeon are long-lived species. Change in abundance of older fish may reflect the harvest of adults and habitat conditions that occurred decades ago during the larval and early juvenile life stages.

White sturgeon inhabit both saltwater and fresh water and tolerate a wide range of salinity concentrations. Spawning occurs in larger rivers upstream of the Delta. Low river flow during late winter and spring may reduce attraction of sturgeon to specific rivers and reduce spawning success. Stream channelization and flood control measures on large rivers (e.g., levee construction) may affect sturgeon use and spawning success.

Losses of sturgeon young into water diversions reduces sturgeon productivity. However, relative to other species, the percentage of the sturgeon population caught in diversions is low.

Food availability, toxic substances, and competition and predation are among the factors influencing the abundance of sturgeon. Sturgeon are long lived (e.g., some live over 50 years) and may concentrate pollutants in body tissue from eating contaminated prey over long periods. Harvesting by sport fishers also affects abundance of the adult populations. Illegal harvest (poaching) also reduces the adult population.



Recently, white sturgeon have been feeding on Asian clams in Suisun Bay, which may indicate a very important ecological role that could feed back through foodweb productivity of the Bay-Delta. Sturgeon predation may limit clam abundance and therefore potentially decrease the loss of plankton to clam feeding. The clams also accumulate contaminants, which may pose a long-term problem for sturgeon feeding heavily on clams.

VISION

The vision for white sturgeon is to maintain and restore population distribution and abundance to historical levels.

Restoration would support a sport fishery for white sturgeon and contribute to overall species richness and diversity and reduce conflict between the need for protection for this species and other beneficial uses of water in the Bay-Delta.

White sturgeon would benefit from improved ecosystem processes, including adequate streamflow to attract adults to spawning habitat, transport larvae and early juveniles to productive rearing habitat, and maintain productivity and suitability of spawning and rearing habitat (including production of food). Ecosystem processes that need improvement include streamflows, stream and channel configurations, and migration barriers (e.g., dams). Additional streamflow during late winter and spring would attract sturgeon to rivers and maintain spawning flow requirements.

White sturgeon would benefit from restoring spawning and rearing habitat. Habitat restoration may be achieved by adding and modifying physical habitat and increasing freshwater flow during critical periods. Juvenile sturgeon frequent Delta sloughs and may benefit from increases in slough habitat. Spawning habitat includes upstream river reaches that contain appropriate substrate (e.g., gravel, rock). Rearing habitat includes areas in the Sacramento and San Joaquin rivers and the Delta that provide protective, food-rich habitats such as the shallow shoals and bays of the Bay-Delta.

Reducing stressors is a component of restoring white sturgeon populations. Reducing losses to diversions from the Sacramento-San Joaquin Delta estuary would increase survival of young sturgeon. White sturgeon would also benefit from actions to reduce pollutant input to streams and rivers in the Sacramento-San Joaquin River basin.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore white sturgeon in the Central Valley would involve cooperation and support from other programs underway to restore sturgeon and other important fish.

- The Central Valley Project Improvement Act (CVPIA) (PL 102-575) calls for implementing changes in flows and project facilities and operations by 2002 that lead to doubling of the sturgeon populations.
- The Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1988 requires DFG to restore historical numbers of sturgeon in the Central Valley.
- The Four Pumps (SWP) and Tracy (CVP) Fish Agreements provide funds and actions to DFG for sturgeon restoration.
- The Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes (USFWS) identifies recovery actions for white and green sturgeon.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of white sturgeon populations are integrally linked with restoration of river floodplain and stream meander habitat, improvements in Central Valley streamflows, improvements in habitat, and reductions in losses to water diversions and illegal harvest.

OBJECTIVE, TARGETS, AND ACTIONS

> The Strategic Objective is to enhance fisheries for salmonids, white sturgeon, Pacific herring, and native cyprinid fishes.

SPECIES TARGET: Meet Native Fish Recovery Plan goals (U.S. Fish and Wildlife Service 1996), which include 100,000 white sturgeon and 2,000 green sturgeon greater than 100 centimeters long as measured in the DFG mark-recapture program.

LONG-TERM OBJECTIVE: Increase white sturgeon numbers (and harvest) by improving habitat conditions for spawning and rearing throughout the Sacramento-San Joaquin estuary and tributaries.

SHORT-TERM OBJECTIVE: Continue to manage white sturgeon for the sustainable sport fishery, without artificial propagation.

RATIONALE: White sturgeon represent an unusual situation: a success story in the management of the fishery for a native species. Numbers of sturgeon today are probably nearly as high as they were in the nineteenth century before they were devastated by commercial fisheries. The longevity and high fecundity of the sturgeon, combined with good management practices of the California Department of Fish and Game, have allowed it to sustain a substantial fishery since the 1950s, without a major decline in numbers. Numbers of white sturgeon could presumably be increased if the San Joaquin River once again contained suitable habitat for spawning and rearing.

STAGE 1 EXPECTATIONS: White sturgeon will continue to support a significant sport fishery in the estuary and will not have experienced a significant decline in abundance.

RESTORATION ACTIONS

General targets for sturgeon populations are:

- Restore population to levels of the 1960s,
- Improve flow in Sacramento River in spring,
- Reduce the rate of illegal harvest,
- Reduce the percentage lost of sturgeon to water diversions to that of the 1960s,

The general approach for programmatic actions are:

- Improve the aquatic foodweb,
- Improve spring flows in Sacramento River and major tributaries,
- Restore natural meander belts and add gravel substrates in upstream spawning areas,
- Increase Delta outflow in spring of dry and normal years,
- Improve water quality of Bay-Delta,
- Provide greater enforcement to reduce poaching,
- Reduce losses of eggs, larvae, and juvenile sturgeon at water diversions,
- Upgrade fish protection facilities at diversion facilities in the Delta,
- Restore tidally influenced Delta and estuarine habitat such as tidal perennial aquatic habitat and sloughs.

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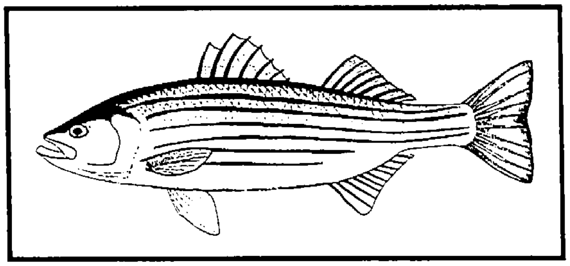


INTRODUCTION

The striped bass is an important non-native anadromous sport fish with high recreation value. It also plays an important role as a top predator in the Bay-Delta and its watershed.

Major factors that limit striped bass contribution to the health of the Delta are streamflow, water diversions, spawning and rearing habitat, legal and illegal harvest, predation and competition from non-native fishes, and reduce survival from contaminants in the water.

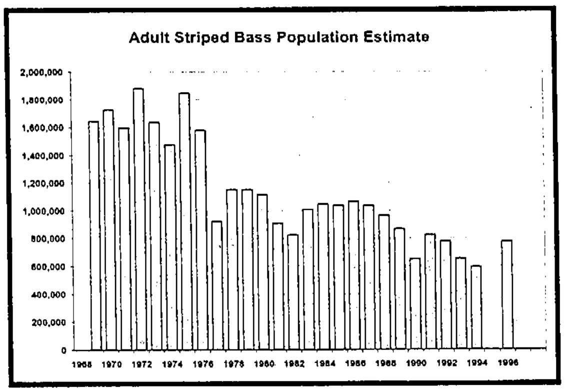
RESOURCE DESCRIPTION

Striped bass were introduced into the Bay-Delta from the east coast of the United States in 1879. For the past century, they have been an important sport fish, commercial fish, and top predator within the Bay-Delta and upstream rivers. They adapted well to the complex habitat conditions of the estuary and remain the premier sport fish of the Bay and Delta. Anglers seek out striped bass along the coast, in the Bay and Delta, and in the lower portions of the Sacramento and San Joaquin Rivers and their tributaries. Striped bass are also an important recreational resource in the waterways of the State and federal water projects south of the Delta.

In the Sacramento River, striped bass are commonly found from Princeton downstream to the Delta and in the lower Feather and American Rivers. In the San Joaquin basin, they are found in the lower Stanislaus, Tuolumne, and San Joaquin rivers. Striped bass spawn primarily in the Sacramento River between Colusa and Sacramento and in the San Joaquin River portion of the Delta.

Juvenile rearing habitat include sloughs, river channels, and bays of the western Delta and Suisun Bay. In wet years young fish rearing habitat extends into San Pablo Bay and adjacent tidal sloughs and marshes. Yearling striped bass are found throughout the Bay and Delta. Adult striped bass are widely distributed from the ocean to the rivers.

The number of adult striped bass and young produced each year have declined dramatically over the past several decades. The total adult population has declined from about 3 million fish in the 1960s to 1.5 million in the early 1970s. More recent estimates are 500,000 to 700,000 adult fish. A greater decline has occurred in older fish, possibly the consequences of greater numbers of older fish migrating to coastal waters, or higher mortality of individual adults from contaminants in the water.



The decline in the adult population of striped bass has been accompanied by a decline in the production of young. The young bass abundance index for summer, when they are 1.5 inches long, has declined dramatically, especially during the recent drought of the late 1980s and early 1990s, and has not recovered. Factors related to and believed to contribute to this decline include the following:

- Low spring flows in the Sacramento River are believed to reduce survival of eggs and larvae by creating poor water quality conditions, reducing plankton food supply, and increasing vulnerability to water diversions.
- Low freshwater flows through the Delta and Suisun Bay may limit the production of food

organisms during critical early life stages of striped bass.

- Low Delta outflow may limit transport of eggs, larvae, and juvenile striped bass into quality nursery grounds of Suisun Bay and away from water diversions in the Delta.
- Higher transport of Sacramento River water across the Delta toward the south Delta pumping plants moves more striped bass young into areas where they are more susceptible to entrainment into agricultural diversions or water project export pumps.

The number of juveniles lost at south Delta export facilities was in the tens of millions in some years during the 1960s to mid-1970s, and again in the middle to late 1980s. The estimated loss in 1974 exceeded 100 million juveniles. Although subsequent export losses have decreased, the rate of loss per unit of population has greatly increased as population abundance has declined.

The number of adult spawners has dropped to such low levels in recent years that there may no longer be sufficient eggs spawned to bring about quick recovery in the population. Good juvenile production even when flows and habitat are excellent for survival is limited by reduced adult spawning populations.

In addition to the low survival of young fish and their low entry into the adult spawning population, mortality rates of adults have increased despite reduced harvest rates in the sport fishery. The higher mortality rates are particularly evident in older adults, and may be a result of effects of toxins, poaching, marine mammal predation, or combinations of these and other factors.

Other factors possibly contributing to the decline and low abundance of striped bass include toxins that reduce survival of young bass or their food supply, competition or predation by recently established, non-native fishes, such as gobies, or poor food production caused by the influx of Asia clams. Both the gobies and Asia clams were introduced from ballast water released from ships from Asia.

Food habit studies conducted by numerous investigators indicate that chinook salmon are not an important component in the diet of striped bass, although, at times, young salmon, primarily fall-run, have constituted a substantial part (U.S. Bureau of Reclamation 1995). Generally, this has occurred in the SacramentoRiver upstream of the estuary and has been localized at water management structures, bridge abutments, and other predator habitats. It also occurs at structures that cause disorientation of juveniles such as RBDD. In the Delta, it is a known problem in CCF and at sites where large numbers of artificially produced chinook salmon are released.

The studies reveal that, except at localized sites and structures, striped bass are less likely to eat salmon in Suisun Bay and the Delta than in the rivers above the Delta. The greater vulnerability of salmon in the river may be a result of the greater clarity and the smaller width of the river. In many areas, bank protection activities, such as maintaining levees and riprapping, have removed SRA habitat and eliminated escape cover needed by young fish.

The U.S. Bureau of Reclamation (1995) reported that the entire striped bass population consumes about 1.4% of the winter-run chinook salmon smolts migration from the Sacramento River. The Bureau also reported that the year-round overlap in the distribution of striped bass and delta smelt resulted in an estimated annual consumption of 195,000 delta smelt, and the striped bass had essentially no impact on splittail.

VISION

The vision for striped bass is to restore populations to levels of abundance consistent with the Fish and Game Commission striped bass policy.

This will support a sport fishery in the Bay, Delta, and tributary rivers, and to reduce the conflict between protection of striped bass and other beneficial uses of water in the Bay-Delta.

Over the past two decades, a major focus of striped bass recovery efforts has been Delta outflow enhancement and restrictions on spring and early summer water exports. The recent 1995 Water Quality Control Plan provided interim provisions for improving spring Delta outflows and limiting exports, but did not address summer outflows or effects of water exports in summer or fall. This vision anticipates further improvements in the following:

- spring Delta inflows and outflows in drier years when more flow is needed for successful spawning,
- Bay-Delta foodweb production,
- transporting egg and larval striped bass to nursery grounds in Suisun Bay,
- reducing the effects of water exports from the Delta, especially exports that reverse the natural flow patterns in the Delta.

Although deterioration of habitat may not be a major factor in the decline of striped bass, it could be an important detriment to their recovery. Protecting, improving, and restoring a substantial amount of shallow-water habitat in the Bay and Delta may improve the food supply for striped bass, as well as provide more area for rearing juvenile striped bass. An improved food supply and increased rearing area may help overcome other factors that have little potential for change (e.g., predation and competition from non-native species). Increases in tidal wetlands will provide tidal channels that are important rearing habitat for juvenile striped bass. Improvement and restoration of shallow waters and riparian vegetation along levees and channel islands in the Delta may provide further important habitat for young striped bass. Habitat improvements are expected to also increase the abundance of shrimp and small fish that are important prey of young and adult striped bass and may lead to higher striped bass survival rates.

Reducing the extent and effect of stressors on striped bass will also be important to their recovery. Reducing losses of young striped bass at water diversions in the Delta and Bay, particularly the very high losses at the south Delta pumping plants of the State and federal water projects, will be most important. Improvements are needed to upgrade the two fish protection facilities to reduce the loss of young bass to entrainment into the pumping plants, and to reduce indirect losses to predators associated with the fish protection facilities. Pumping plant operations could also be reduced during periods of high losses.

Longer term actions may involve relocating the pumping plant intakes, screening or reducing the number of small water diversions to agricultural lands in the Delta, and continuing to find ways to reduce entrainment losses into cooling water diversions at two power plant complexes in the Delta. Limiting further introductions of non-native species and reducing the input of contaminants into Central Valley waterways may also be important to striped bass recovery. In the short-term, recovery may depend on supplementing natural reproduction with hatchery and pen-reared striped bass, and possibly reducing illegal and legal harvest. Management actions for striped bass need to be carefully evaluated and structured to avoid adverse affects on native species.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore striped bass in the Central Valley would involve cooperation and support from other programs underway to restore striped bass and other important fish.

- The Central Valley Project Improvement Act (CVPIA) calls for implementing changes in flows and project facilities and operations by 2002 that lead to doubling of the striped bass population.
- The Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1988 requires the DFG to restore striped bass in the Central Valley.
- The State Water Resources Control Board will implement the Water Quality Control Plan for the San Francisco/Sacramento-San Joaquin Delta estuary that will include provisions to limit entrainment in diversions and protect habitat conditions for Sacramento splittail, chinook salmon, striped bass, and other species.
- Fish and Game Commission Striped Bass Policy: (I) the Department of Fish and Game shall work toward stabilizing and then restoring the presently declining striped bass fishery of the Sacramento-San Joaquin Estuary. This goal is consistent with Commission policy that the Department shall emphasize programs that ensure, enhance, and prevent loss of sport fishing opportunities. (II) The Department shall ensure

that actions to increase striped bass abundance are consistent with the Department's long-term mission and public trust responsibilities including those related to threatened and endangered species and other species of special concern. Recognizing issues associated with potential incidental take of these species, an appropriate interim objective is to restore the striped bass population to the 1980 population level of 1.1 million adults within the next 5-10 years. (III) the long-term striped bass restoration goal, as identified in the Department's 1989 Striped Bass Restoration Plan, is 3 million adults. (IV) The Department shall work toward these goals through any appropriate means. Such means may include actions to help maintain, restore, and improve habitat; pen-rearing of fish salvaged from water project screens; and artificial propagation. (*Adopted 4/5/96*) (Fish and Game Code 1997).

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Because striped bass are predators, they could affect efforts to recover populations of a number of native fishes of the Central Valley including chinook salmon, steelhead, delta smelt, longfin smelt, and Sacramento splittail. Consequently, it will be necessary to consult and cooperate with the National Marine Fisheries Service and U.S. Fish and Wildlife Service under the federal Endangered Species Act (ESA) and DFG under the California ESA.

OBJECTIVE, TARGETS, AND ACTIONS

The Strategic Objective is to maintain, to the extent consistent with ERP goals, fisheries for striped bass, American shad, signal crayfish, grass shrimp, and nonnative warmwater gamefishes.

SPECIES TARGET: Restore the adult population (greater than 18 inches total length) to 1.1 million fish within the next 10 years. In addition, all measures will be taken to assure that striped bass restoration efforts do not interfere with the recovery of threatened and endangered species and other species of special concern covered under public trust responsibilities.

LONG-TERM OBJECTIVE: Restore the adult population (greater than 18 inches total length) to 3 million fish through such actions as improving, maintaining, and restoring habitat, pen-rearing of fish salvaged at water project screens, and artificial propagation. In addition, all measures will be taken to assure that striped bass restoration efforts do not interfere with the recovery of threatened and endangered species and other species of special concern covered under public trust responsibilities.

SHORT-TERM OBJECTIVE: Restore the adult population (greater than 18 inches total length) to 1.1 million fish within the next 10 years. In addition, all measures will be taken to assure that striped bass restoration efforts do not interfere with the recovery of threatened and endangered species and other species of special concern covered under public trust responsibilities.

RATIONALE: The striped bass is a non-native species that is a favorite sport fish in the estuary. It is also the most abundant and voracious piscivorous fish in the system and it has the potential to limit the recovery of native species, such as chinook salmon and steelhead. Therefore, the management for striped bass must juggle the objectives of providing opportunities for harvest while not jeopardizing recovery of native species. An appropriate policy may be to allow striped bass to increase in numbers as estuarine conditions permit but not to take any extraordinary measures to enhance its populations, especially artificial propagation. Artificially reared bass have the potential to depress not only native fish populations but also populations of wild striped bass, because larger juveniles (of hatchery origin) may prey on smaller juveniles (of wild origin). If increases in bass numbers appear to adversely affect recovery of native species, additional management measures may be required to keep bass numbers below the level that pose a threat to native species.

STAGE 1 EXPECTATIONS: Continue investigations into the causes of striped bass decline throughout the Sacramento-San Joaquin Estuary. In addition, all efforts shall be undertaken to ensure that programs are developed that ensure, enhance, and prevent the loss of sport fishing opportunities.

RESTORATION ACTIONS

General targets for striped bass are:

- restore population to levels of the 1960s,
- maintain flow in the Sacramento River at Sacramento at 13,000 cfs in the spring,
- improve health of average individual striped bass in population,
- reduce the rate of illegal harvest of striped bass, and
- reduce the percentage of young striped bass lost to entrainment at water diversions.

General programmatic actions which will help to meet the targets for striped bass include:

- protect and restore shallow water, tidal slough, and wetlands habitats,
- improve aquatic foodweb,
- maintain 13,000 cfs flow in lower Sacramento River in the spring months of all but driest years,
- increase Delta outflow in spring of dry and below normal years,
- reduce the introductions of non-native aquatic organisms into the Bay-Delta,
- improve water quality of the Bay-Delta,
- provide greater enforcement to reduce illegal harvest,
- reduce losses of eggs, larvae, and juvenile striped bass at water diversions,
- upgrade fish protection facilities at south Delta pumping plants and power generation plants in the Delta, and
- supplement striped bass population with pen-reared and hatchery-reared striped bass, as needed, until natural production is adequate to sustain the population at target level.

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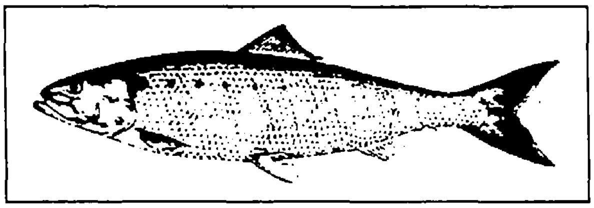


INTRODUCTION

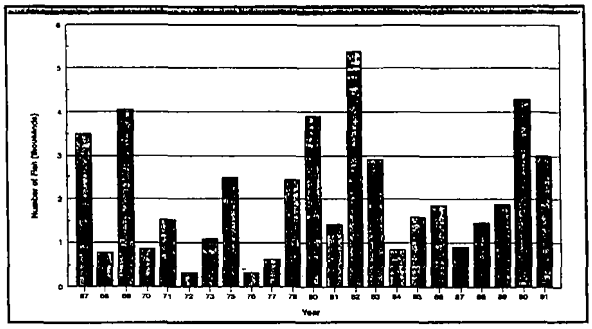
American shad is an important non-native anadromous sport fish with high recreational value. It migrates in spring from the ocean into the Bay-Delta and upstream to spawn in Central Valley rivers. Newly hatched young spend their first summer in the rivers and Delta before migrating downstream to the ocean in fall.

Major factors that limit the contribution of the American shad to the health of the Delta are streamflow, aquatic habitat, and food supply.

RESOURCE DESCRIPTION

The American shad was introduced into Central Valley rivers from the east coast in the 1870s and 1880s. It adapted well to the complex habitat conditions of the rivers and estuary. It continues to be an important sport fish in the Sacramento, Feather, Yuba, and American rivers and has extended its range as far north as the Columbia River. Adults (age 3-5) migrate into the rivers from the ocean to spawn from late April through June. Some may remain in the rivers through August before returning to the Bay-Delta and ocean. Many die during the spawning run, but about 30% of the runs are made up of repeat spawners. In the Sacramento River system, American shad are commonly found from Red Bluff downstream to the Delta and in the lower Feather, Yuba, and American rivers. American shad populations are small in the San Joaquin basin compared with those in the Sacramento basin.

When the adult population was measured in 1976 and 1977, the total Central Valley run was estimated at 3 million and 2.8 million, respectively. The California Department of Fish and Game (DFG) has conducted annual fall midwater trawl surveys in the Delta since 1967 to monitor trends in the population's health. Juvenile shad catch has generally been higher in wetter years (1967, 1969, 1975, 1978, 1980, 1982, and 1983) and lower in dry years (1968, 1972, 1976, 1977, 1984, and 1987). The production index was relatively high, however, in two recent dry years (1990 and 1991).



Index of Juvenile American Shad Abundance in Fall Midwater Trawl Survey

Ocean, estuary, and river conditions affect overall shad abundance. Growth and survival in the ocean may be affected by El Niño (ocean warming). Water temperatures and flows are important habitat factors in the spawning rivers of the Central Valley. River flows trigger the shad to move into rivers and affect their selection of spawning locations among and within the rivers. Water temperatures determine the onset of spawning (59-68°F). High water temperatures (above 68°F) may reduce adult survival. Factors believed to affect American shad production in the Central Valley include the following:

- Low flows in spring may delay or hinder shad from moving into the rivers to spawn. During their upstream migration through the Delta, adult shad may delay spawning or may die because of the higher water temperatures resulting from low flows. Low flows also may reduce downstream transport of eggs and larvae to productive nursery areas.
- Transport of Sacramento River water south across the Delta and toward the south Delta pumping plants may carry more American shad young into the southern Delta and away from their primary migration path to the ocean. Under low Delta outflow, shad young may be more susceptible to loss at agricultural diversions

and water project export pumps. Annual losses of juveniles at south Delta export facilities reach into the millions.

- Poor water quality and low spring flows may limit production of American shad in the San Joaquin River and its tributaries.
- Diversion dams on valley rivers limit American shad from moving into potential spawning reaches. Examples include the Red Bluff Diversion Dam on the Sacramento River, Daguerre Dam on the Yuba River, and Woodbridge Dam on the Mokelumne River. Shad are generally unable to use the fish ladders provided at these diversion dams.
- Pollutants may affect the production and run size of American shad by reducing survival of young and their food supply.

Harvest rates of adult shad in the sport fishery are low and have little impact on production of American shad.

> **VISION**
>
> The vision for American shad is to maintain a naturally spawning population, consistent with restoring native species, that supports a sport fishery similar to the fishery that existed in the 1960s and 1970s.

Achieving this vision will reduce the conflict between protection of this species and other beneficial uses of water in the Bay-Delta.

A major focus of Central Valley fish recovery efforts over the past two decades has been on flow enhancement in streams and rivers. Natural river flows in dry and normal water-year types has been reduced, particularly in spring, by water development in the Central Valley. The 1995 December Delta Accord provided interim provisions for improving spring flows. Further improvements are anticipated under the Central Valley Project Improvement Act (CVPIA).

The restoration of American shad vision requires further improvements in drier years when more flow is needed to attract American shad to upstream spawning areas in the rivers and major tributaries, including the American, Feather, and Yuba rivers, and to transport egg and larval shad to nursery grounds in the lower rivers and Delta.

Habitat improvements could contribute to increases in American shad runs. Protecting, improving, and restoring shallow-water habitat in rivers and the Delta may improve the food supply for American shad and provide better rearing habitat. Improved food supply and rearing habitat may help to overcome other factors that are unlikely to change (e.g., the presence of competing non-native species).

Reducing the extent and effect of stressors will further benefit American shad runs. Most important will be reducing loss of young American shad at water diversions in rivers and the Delta, especially large losses at the south Delta pumping plants of the State and federal water projects. The two fish protection facilities should be upgraded to reduce entrainment of young American shad in the pumping plants and the concentrations of predators associated with the fish protection facilities. Screening or reducing the number of the many small water diversions to agricultural lands in the Delta may also provide benefits. Limiting further introduction of non-native species and reducing the input of toxic pollutants into Central Valley waterways will also provide benefits.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to maintain American shad runs in Central Valley rivers would involve cooperation and support from other established programs underway to restore American shad and other important fish.

- CVPIA (PL 102-575) calls for doubling the American shad population by 2002 through changes in flows and project facilities and operations.
- The Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1988 DFG is required under State legislation to restore American shad in the Central Valley.
- The Lower American River Task Force and Water Forum will improve flows and habitat in the lower American River that will benefit American shad.

- The State Water Resources Control Board will implement the Water Quality Control Plan for the San Francisco/Sacramento-San Joaquin Delta estuary that will include provisions to limit entrainment in diversions and protect habitat conditions for Sacramento splittail, chinook salmon, striped bass, and other species.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Actions to restore populations of salmon, steelhead, striped bass, and Delta native fishes are likely to benefit the runs of American shad.

OBJECTIVE, TARGETS, AND ACTIONS

> The Strategic Objective is to maintain, to the extent consistent with ERP goals, fisheries for striped bass, American shad, signal crayfish, grass shrimp, and nonnative warmwater gamefishes.

SPECIES TARGET: The target for American shad is to maintain production of young as measured in the fall midwater trawl survey and targets of the Anadromous Fish Restoration Program (US Fish and Wildlife Service 1997, in preparation). Specifically, the index of young American shad production should increase, especially in dry water years.

LONG-TERM OBJECTIVE: Allow American shad numbers (and harvest) to increase gradually as conditions in the restored estuary and streams favor its reproduction and survival. Use harvest and other management measures to ensure that increases in American shad populations do not jeopardize programs to sustain native species.

SHORT-TERM OBJECTIVE: Maintain the fishery for American shad at its present levels but without special intervention (e.g. special flow releases).

RATIONALE: The American shad is a non-native species that is an important sport fish in the estuary and its spawning streams, although less seems to be known about its life history in the estuary than any other major game fish. It is a common planktivore and occasional piscivore in the system and it may have the potential to limit the recovery of native species, such as chinook salmon. Therefore, the management for American shad must juggle the objectives of providing opportunities for harvest without jeopardizing recovery of native species. An appropriate policy may be to allow American shad to increase in numbers as estuarine conditions permit but not to take any extraordinary measures to enhance its populations, especially flow releases specifically to favor shad reproduction. If increases in shad numbers appear to adversely affect recovery of native species, additional management measures may be required to keep shad numbers below the level that pose a threat to native species.

STAGE 1 EXPECTATIONS: No special efforts to increase American shad numbers will have been made and benefits to shad will have been derived from restoration actions directed to other species such as chinook salmon. Their impact on juvenile salmon (predation) in the Sacramento River will have been investigated.

RESTORATION ACTIONS

The general target for American shad is to improve production of young, particularly in dry years as measured in the DFG fall mid-water trawl survey.

Programmatic actions that would help improve American shad populations in Central Valley rivers include the following:

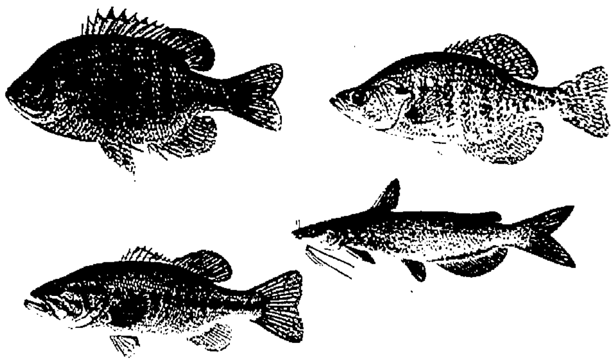
- Provide additional Sacramento, Feather, Yuba, and American river flows in spring of dry and normal water years to attract adult spawners and transport young downstream to productive nursery habitat.
- Remove barriers to American shad migrations in the Sacramento, Yuba, and Mokelumne rivers.
- Reduce adverse effects of water diversions on American shad in fall.
- Allow the first natural pulse of flow in the fall to pass through the Delta to the Bay to help juvenile American shad migrate to the ocean.
- Upgrade existing fish protection facilities at south Delta pumping plants of the Central Valley Project and the State Water Project.

- Reduce the number, screen or upgrade screening, or relocate diversions that entrain American shad in the rivers and Bay-Delta.

REFERENCE

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

◆ Non-native Warmwater Gamefish



Introduction

Throughout the Sacramento-San Joaquin Delta warmwater gamefish are an important component of resource health. Not only do these species fill an important biological component, they are also of economic importance. The group of warmwater gamefish is represented by largemouth bass, white crappie, bluegill, redear, green sunfish, white and channel catfish, brown and black bullhead and striped bass to name a few. The warmwater gamefish group is best represented by both the largemouth bass (*Micropterus salmoides*) and white catfish (*Ameiurus catus*). Within the Delta over forty largemouth bass fishing tournaments are held yearly. Currently, largemouth bass populations support a 30 percent catch and release fishery in the Delta, while the white catfish has a harvest rate of around 10% to 15%.

Factors that may limit the warmwater gamefishes ability to contribute to a healthy Delta ecosystem is the degradation and loss of existing aquatic habitat as a result of channel dredging, levee stabilization, and increased channel velocities.

Resource Description

The largemouth bass was first introduced into California waters in 1870s and has since spread to suitable habitats throughout the State. The largemouth bass prefers warm, slow moving waters with low turbidity. Within the Delta the largemouth bass tends to inhabit sloughs and backwaters with large quantities of aquatic cover and submerged objects. The overall stability and health of the largemouth bass population in the Delta is at an all time high. The healthier population (related to size of the fish) of fish is due to the introduction of the "Florida strain" to the gene pool.

Spawning for largemouth bass occurs in the second or third year of life when water temperatures reach 14 to 16 degrees C in April and continues through June. Nests are shallow substrate depressions located in about one to two meters of water near submerged objects. Eggs are adhesive and hatch within two to five days after being fertilized. The nest and eggs are actively protected by the male until sac-fry emerge from nest in about five to eight days.

The white catfish was first introduced into the San Joaquin River in the mid-1870s and has since been introduced into all of the major water systems of the State (except the Colorado and Klamath systems). The white catfish prefers slow moving waters in channels devoid of heavy aquatic vegetation and is typically found in waters greater than two meters deep. The overall interest in white catfish as a gamefish is due to the fact that it is quite numerous within the Sacramento-San Joaquin Delta.

Spawning age and size for white catfish is highly variable and occurs from April through June. Nest sites are typically located in cave-like structures, like muskrat burrows, log jams, and undercut banks. Spawning activity is also triggered by water temperatures when they approach 21 to 29 degrees C, with optimum spawning occurring at 27 to 28 degrees C. The nest is actively guarded by the male. The eggs hatch in about six to ten days with the young actively swimming about two days after hatching.

Losses to Delta diversions (e.g., hundreds of small agricultural diversions, Central Valley Project and State Water Project export pumps, and Pacific Gas & Electric power generation facilities) may reduce resident species abundance through direct entrainment or indirect effects on the prey of resident fish. Large numbers of some resident species (e.g., white catfish, threadfin shad) are entrained in Delta diversions. Other resident species (e.g., largemouth bass) spend their lives in habitat that is in close proximity to where they were spawned and are not particularly susceptible to entrainment in Delta.

Food availability, toxic substances, and competition and predation are among the factors influencing abundance of resident species. In addition, harvest of many resident species for food and bait by sport anglers may affect abundance.

VISION

The vision for warmwater gamefish is to maintain self-sustaining populations in order to provide opportunities for consumptive use such as fishing.

Increasing the variability in aquatic habitat types would provide additional spawning, nesting, rearing, and escape cover for all species of fish, both game and non-game species. Population levels and harvest/catch rates for all gamefish species will need to be monitored to determine restoration success.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to maintain and enhance the population of warmwater gamefish in the Sacramento-San Joaquin Delta would also involve cooperation and support from other established programs.

- The Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes.
- California Fish and Game Commission will continue to regulate and develop fishing regulations based on recommendations by the California Department of Fish and Game.
- Central Valley Project Improvement Act: This act is required to double the natural population of Central Valley anadromous fish stocks.
- Salmon, Steelhead Trout, and Anadromous Fisheries Act: The California Department of Fish and Game is required under State legislation to double the number of anadromous fish in the Central Valley.
- Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (December 1995) and Water Rights Decision 1485 (1978).

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration and maintenance of warmwater gamefish populations and habitats will benefit from other CALFED actions to increase flows, enhance levees, establishing riparian corridors, and increase the productivity of the food web.

OBJECTIVE, TARGETS, AND ACTIONS

The Strategic Objective is to maintain, to the extent consistent with ERP goals, fisheries for striped bass, American shad, signal crayfish, grass shrimp, and nonnative warmwater gamefishes.

SPECIES TARGET: Increase our knowledge about warmwater sport fishes in the Delta, Suisun Marsh, riverine backwaters, and elsewhere to find out their interactions with native fishes, limiting factors, and their contaminant loads (for both fish and human health).

LONG-TERM OBJECTIVE: Non-native warmwater game fishes will continue to be abundant enough in many parts of the estuary and river systems to support a substantial sport fishery.

SHORT-TERM OBJECTIVE: Increase our knowledge about warmwater sport fishes in the Delta, Suisun Marsh, riverine backwaters, and elsewhere to find out their interactions with native fishes, limiting factors, and their contaminant loads (for both fish and human health).

RATIONALE: White catfish, channel catfish, brown and black bullhead, largemouth bass, and various sunfishes are among the most common fishes caught in the sport fishery in the Delta, Suisun Marsh, riverine backwaters, reservoirs, and other lowland waters. Although this fishery is poorly documented, it is probably the largest sport fishery in central California in terms of people engaged in it and in terms of numbers of fish caught. There is no sign of overexploitation of the fishes, although some (e.g., white catfish) have remarkably slow growth rates, indicating vulnerability to overexploitation. The fishes and the fishers are always going to be part of the lowland environment and deserve support of the management agencies. However, habitat improvements that favor native fishes, especially improvements that increase flows or decrease summer temperatures, may not favor these game fishes. The effects of the various CALFED actions on these fish and fisheries need to be understood, as do the interactions among the non-native fishes and the native fish CALFED is trying to protect.

STAGE 1 EXPECTATIONS: Studies will have been conducted to find out how major CALFED actions are likely to affect the warmwater fish and fisheries and how the fishes affect the recovery of native at-risk species. In particular, the potential of the non-native fishes to use and dominate newly created warmwater habitat will have been thoroughly investigated.

RESTORATION ACTIONS

Warmwater gamefish would benefit from the following actions and restorations: activities:

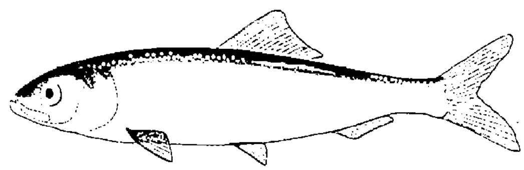
- acquire and enhance aquatic habitat,
- creation of tidally influenced fresh-water woodlands,
- creation of set-back levees to increase shallow-water habitat along existing channels,
- eliminate water hyacinth and other noxious aquatic plants from the Delta,
- update existing fish protection facilities at the South Delta pumping plants,
- installing screens on unscreened diversions, and
- preventing further introductions of non-native aquatic organisms.

REFERENCES

Moyle, P. B. 1976. Inland Fishes of California. University of California Press, Berkeley. pps 242-244, 313-316.

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

◆ PACIFIC HERRING



INTRODUCTION

California's largest population of Pacific herring uses San Francisco Bay as a spawning and nursery grounds. This population supports a multi-million dollar a year commercial fishery for roe which is exported to Japan. The herring fishery is the best monitored fishery in California and over-exploitation of the commercial fishery is not expected to occur. Herring are also an important component of the Bay's food web for other fish, birds, mammals, and invertebrates.

The primary factor affecting the year-class strength of Pacific herring is the Bay and ocean nutrient productivity.

RESOURCE DESCRIPTION

Pacific herring inhabit areas along the Pacific coast of the North American continent. Typically adult herring reside in the ocean and return to the Bay during the November through March spawning season. However, juveniles (young of the year) have been noted in the estuary year round. Spawning activities primarily occur in the intertidal and shallow subtidal zones on a variety of substrates, including pilings, rocks, jetties, eelgrass, and seaweed.

Spawning occurs from October through April in San Francisco Bay with peak activity occurring in January. The eggs are adhesive and stick to structures or substrates and hatch in about ten days, depending on temperature.

VISION

The vision for the Pacific herring is to maintain a self-sustaining populations in order to support commercial fishing.

The Pacific herring is also an integral part of the Bay food web. A major focus of efforts to maintain the fishery would be to assure that shallow intertidal zones with aquatic vegetation are protected and enhanced. CALFED will also need to assure that salinity regimes of the Bay and surrounding areas are maintained during spawning and juvenile periods. Some of the activities scheduled for implementation during Stage 1 Actions will benefit the Pacific herring.

Current efforts by the Department of Fish and Game to monitor the herring population and commercial fishing activities will be sufficient to assure the continued existence of Pacific herring.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

- Central Valley Project Improvement Act: This act is required to double the natural population of Central Valley anadromous fish stocks.
- Salmon, Steelhead Trout, and Anadromous Fisheries Act: The California Department of Fish and Game is required under State legislation to double the number of anadromous fish in the Central Valley.
- Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (December 1995) and Water Rights Decision 1485 (1978).
- California Fish and Game Commission will continue to regulate and develop fishing regulations based on recommendations by the California Department of Fish and Game.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Maintenance of Pacific herring populations is linked with the addition and restoration of tidal habitats, Delta outflow, and the aquatic food web within and upstream of San Francisco Bay.

OBJECTIVE, TARGETS, AND ACTIONS

> The Strategic Objective is to enhance fisheries for salmonids, white sturgeon, Pacific herring, and native cyprinid fishes.

SPECIES TARGET: Increase abundance of marine/estuarine fish and large invertebrates, particularly in dry years.

LONG-TERM OBJECTIVE: Maintain a high level of harvest management that will allow for sustainable fisheries for Pacific herring and their roe.

SHORT-TERM OBJECTIVE: Continue, with caution, the present limited-entry fishery and determine the major factors that limit both the fishery and herring spawning in San Francisco Bay.

RATIONALE: Pacific herring support the most valuable commercial fishery in San Francisco Bay. This seasonal, limited-entry fishery focuses on spawning fish, for the fish themselves, their roe, and kazunoko kombu (herring eggs on eel grass). It seems to be an example of successful fishery management because it has been able to sustain itself through a series of years with highly variable ocean and bay conditions. An important connection to the ERP is that highest survival of herring embryos (which are attached to eel grass and other substrates) occurs during years of high outflow during the spawning period; the developing fish seem to require a relatively low-salinity environment. There is also some indication that populations have been lower since the invasion of the Asiatic clam into the estuary, with the subsequent reduction in planktonic food organisms. Given the frequent collapse of commercial fisheries (including those for herring) in the modern world, it is best to manage this fishery very cautiously to make sure it can continue indefinitely.

STAGE 1 EXPECTATIONS: In the next 7-10 years the fishery will have continued at roughly present levels and investigations continued to determine factors limiting herring abundance and spawning success, especially as tied to Bay-Delta physical processes.

RESTORATION ACTIONS

Pacific herring would benefit from the following restoration activities and actions:

- Limit further introductions of non-native species especially from ship ballast water.
- Restoration of tidal and shallow-water habitat in the Suisun Marsh and San Francisco Bay
- More uniform salinity regimes in the San Francisco Bay during both drought and wet water years.

REFERENCES

Department of Fish and Game. 1998. Final Environmental Documentation for Pacific Herring Commercial Fishing Regulations.

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

Wang, Johnson, C.S. 1986. Fishes of the Sacramento-San Joaquin Estuary and Adjacent Waters, California: A Guide to the Early Life Histories. IESP Technical Report 9. pps 3-4 through 3-7.

INTRODUCTION

The term "grass shrimp" refers collectively to two genus of shrimp (*Crangon and Palaemon*) that are present in the San Francisco Bay. These grass shrimp are commercially fished in the Bay and sold as bait. Early this century, commercial trawls landed around three million pounds of shrimp for a dried shrimp market. Recently, catches of shrimp have been between 100,00 to 200,000 pounds of shrimp per year. The general life cycle of these shrimp is to hatch larval shrimp in highly saline areas and the juveniles migrate to less saline areas to mature. These shrimp are relatively short lived and mature in about one year.

A factor that may limit the grass shrimp's ability to contribute to a healthy ecosystem is a reduction in freshwater outflow.

RESOURCE DESCRIPTION

The genus *Crangon* is comprised of three native species (*C. franciscorum*, *C. nigricauda*, and *C. nigromaculata*) while the genus *Palaemon* is a single introduced species (*P. macrodactylus*). Unlike the *P. macrodactylus*, which remains in the Bay throughout its life cycle, *Crangon spp.* utilize the Bay as a nursery area and move into less saline waters to mature. *C. franciscorum* juveniles are most abundant in April through May in brackish warm waters. *C. nigricauda* juveniles peak in late-spring to early summer in higher saline waters. *C. nigromaculata* juveniles occur from May through November with all ages occurring in cool shallow coastal waters. *P. macrodactylus* larvae hatch from April to August and juveniles are abundant from June to September.

VISION

The vision for grass shrimp is to maintain self-sustaining populations in order to support existing commercial fisheries.

A major focus of efforts will be to assure that average March through May outflow from the Sacramento and San Joaquin rivers is above 30,000 cfs. Many of the actions described in the Stage 1 Actions may not benefit these species. However, other CALFED actions will benefit these species such as levee improvements that will prevent the influx of more saline waters into the western Delta.

Efforts will need to be implemented that look at the interaction among members of the benthic community. Specifically the interaction between grass shrimp and the recently introduced mitten crab (*Eriocheir sinensis*) will need to be examined.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to maintain a sustained population of grass shrimp in the Sacramento and San Joaquin rivers and Delta would also involve cooperation and support from other established programs.

- Water Quality Control Program for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (May 1995).
- California Fish and Game Commission will continue to regulate and develop fishing regulation based on recommendations by the California Department of Fish and Game.
- Suisun Marsh Preservation Agreement between the Department of Fish and Game, Department of Water Resources, U.S. Bureau of Reclamation, and Suisun Resource Conservation District.

- San Francisco Bay Conservation and Development Commission

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Maintenance of grass shrimp populations will be benefitted by other efforts to restore populations of chinook salmon, steelhead, delta smelt, sturgeon, and outflow requirements in the Delta.

OBJECTIVE, TARGETS, AND ACTIONS

> The Strategic Objective is to maintain, to the extent consistent with ERP goals, fisheries for striped bass, American shad, signal crayfish, grass shrimp, and nonnative warmwater gamefishes.

SPECIES TARGET: Maintain grass shrimp populations at present levels as a minimum to support the existing commercial fisheries. Determine factors regulating their populations in order to discover if the fisheries conflict with other ecosystem restoration objectives.

LONG-TERM OBJECTIVE: Allow grass shrimp (Crangon spp., Paleomon) numbers (and harvest) to increase as conditions in the restored estuary favor their reproduction and survival.

SHORT-TERM OBJECTIVES: Maintain grass shrimp populations at present levels as a minimum to support the existing commercial fisheries. Determine factors regulating their populations in order to discover if the fisheries conflict with other ecosystem restoration objectives.

RATIONALE: Grass shrimp are a mixture of native and introduced species that support a small commercial fishery in San Francisco Bay, largely for bait. The relative abundance of the various species as well as their total abundance appears to be tied in part to outflow patterns. It is likely that these abundant shrimp are important in Bay-Delta food webs leading to many other species of interest. The role of these shrimp in the Bay-Delta system and the effects of the fishery on that role need to be investigated.

STAGE 1 EXPECTATIONS: An investigation of the ecological role and requirements of the shrimp species and the effects of the fishery will have been conducted, to find out if any special management for either is needed.

RESTORATION ACTIONS

The target for grass shrimp is to increase the population of grass shrimp above existing levels and eventually increase the commercial fishery within San Francisco and surrounding bays.

Grass shrimp would benefit from the following restoration activities and actions:

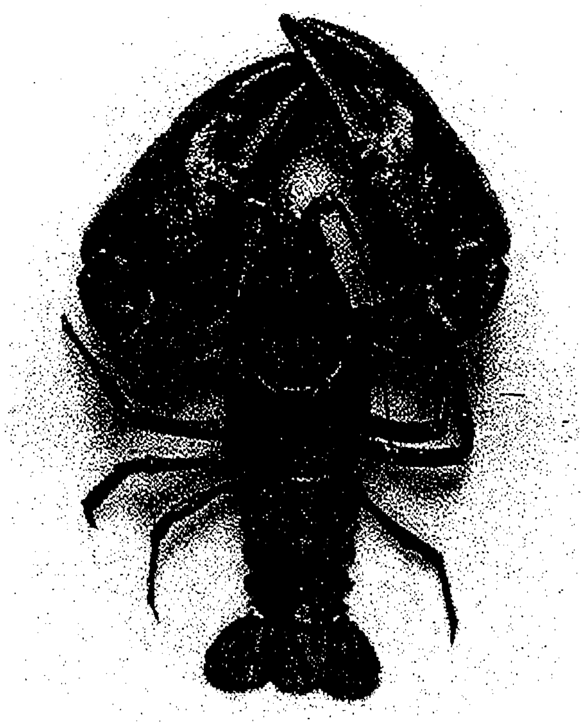
- Determine the interaction and potential effects between mitten crabs and grass shrimp on the commercial fishery.
- Improved and sustain Delta outflow during the March through May period.

REFERENCES

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

WRINT-DFG-Exhibit # 6. 1992. 1992 Water Quality/Water Rights Proceedings in the San Francisco Bay/Sacramento - San Joaquin Delta Estuary Dependent Species.

◆ SIGNAL CRAYFISH



INTRODUCTION

The signal crayfish is an important non-native resident invertebrate of the Central Valley and Delta. It occupies a wide range of habitats from swift large rivers to sluggish backwaters. It currently supports a recreational and an active commercial fishery that in 1977 resulted in over 500,000 pounds of crayfish being harvested. The population appears to be stable since the introduction of fishing regulations that limits the commercial take of any crayfish under 9.2 centimeters total length.

Factors that may limit the signal crayfish's ability to contribute to a healthy Central Valley ecosystem are river and stream flow, aquatic habitat, and competition from recently introduced species (mitten crab).

RESOURCE DESCRIPTION

The signal crayfish was first described in 1852 by the U.S. Exploring Expedition during their west coast expeditions. The signal crayfish was introduced into California waters from Oregon and has spread throughout Central Valley waterways. Crayfish have been known to estivate for periods of time when fields are dried and then re-flooded at a later date. This process makes them extremely adaptable to drought conditions. Habitat use has been described to not exceed over 3 meters in depth and water conditions from clear cool fast moving water to slow stagnate backwaters. Signal crayfish have also been noted in slightly brackish waters of the western Delta.

Spawning occurs in the fall with the females carrying the eggs over winter and releasing the young of the year in early spring.

VISION

The vision for the signal crayfish is to maintain self-sustaining population of crayfish in order to support recreational and commercial fishing.

A major focus of efforts to maintain the fishery would be to assure that the Sacramento and San Joaquin river flows during the late summer and early fall remain above an established level for that period. Many of the efforts implemented under the Stage 1 Actions to increase tidally influenced and other aquatic habitats will benefit crayfish populations. Increases in shallow-water habitat will provide additional burrowing and foraging areas for the crayfish. Increases in crayfish numbers will provide an increased forage base for sturgeon (green and white), smallmouth bass, and terrestrial species.

Efforts will need to be implemented that look at the interaction among members of the benthic community. Specifically the interaction between crayfish and the recently introduced mitten crab (*Eriocheir sinensis*) will need to be examined.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to maintain a sustained population of signal crayfish in the Sacramento and San Joaquin rivers and Delta would also involve cooperation and support from other established programs.

- Water Quality Control Program for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (May 1995).
- California Fish and Game Commission will continue to regulate and develop fishing regulation based on recommendations by the California Department of Fish and Game.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Maintenance of the crayfish population will be benefitted by other efforts to restore populations of chinook salmon, steelhead, delta smelt, sturgeon, and riparian habitats throughout the ERPP service area.

OBJECTIVE, TARGETS, AND ACTIONS

> The Strategic Objective is to maintain, to the extent consistent with ERP goals, fisheries for striped bass, American shad, signal crayfish, grass shrimp, and nonnative warmwater gamefishes.

SPECIES TARGET: Maintain signal crayfish populations at present levels, in order to support the existing fisheries.

LONG-TERM OBJECTIVE: Allow signal crayfish numbers (and harvest) to increase gradually as conditions in the restored estuary favor its reproduction and survival. Use harvest and other management measures to ensure that increases in crayfish populations do not jeopardize programs to sustain native species.

SHORT-TERM OBJECTIVE: Maintain signal crayfish populations at present levels, in order to support the existing fisheries.

RATIONALE: The signal crayfish is an introduced species that supports a small commercial fishery, as well as a recreational fishery, in the Delta. It has been established in the Delta for nearly a century and appears to be integrated into the Bay-Delta system, appearing as a major food item for otters and some fish. The signal crayfish has fairly high water quality requirements so its populations will presumably increase as water quality in the freshwater portions of the Delta improves. Its role in the ecosystem and the effects of the fishery on that role need to be investigated.

STAGE 1 EXPECTATIONS: An investigation of the ecological requirements of the crayfish and the effects of the fishery will have been conducted, to find out if any special management for either is needed.

RESTORATION ACTIONS

The target for signal crayfish is to maintain existing levels and eventually increase both the commercial and recreational fisheries within the Sacramento-San Joaquin Delta.

Signal crayfish would benefit from the following restoration activities and actions:

All Ecological Management Zones:

- Determine the interaction and potential effects between mitten crabs and signal crayfish on both the commercial and recreational fisheries.
- Habitat improvements and increases to both riparian and tidally influenced zones.
- Improved and sustained flows in the major rivers and streams of the Central Valley

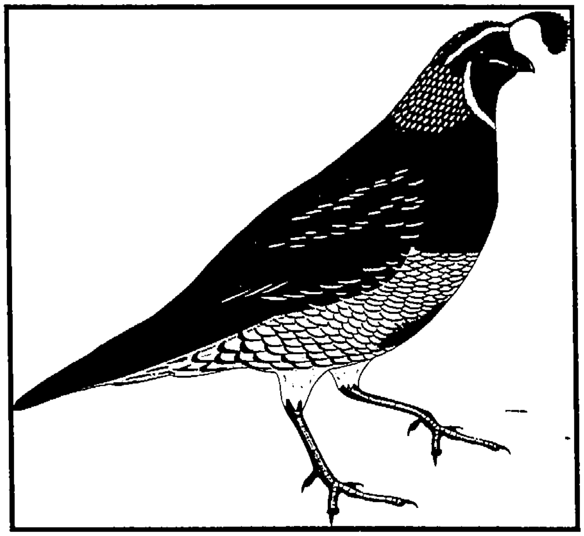
REFERENCES

Riegal, J.A. 1959. The systematics and Distribution of Crayfishes in California. In: California Fish and Game; Volume 45, Number 1, pages 29-49.

Huner, Jay V. 1978. Exploitation of Freshwater Crayfishes in North America. In: Fisheries; Volume 3, Number 6, pages 2-5.

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

◆ UPLAND GAME



INTRODUCTION

Upland game species are of high interest to recreational hunters in the Bay-Delta and contribute to California's economy through the sale of hunting-related equipment and hunting-related expenditures. Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of conversion of native upland habitats for agricultural, industrial, and urban uses, and land use practices that degrade habitats used by these species.

RESOURCE DESCRIPTION

The upland game guild includes those species defined in the California Department of Fish and Game (DFG) hunting regulations as resident and migratory upland game birds and small game. Of the three groups of upland game species that define the guild (Coastal and Central Valley, Mountain Upland, and Eastern Upland), only the coastal and Central Valley group (see table) is addressed in this vision. The montane upland game group includes species that typically inhabit the upper elevations of the Coast Ranges, Cascade Range, and Sierra Nevada. The eastern upland game group includes those species inhabiting the eastern slopes of the Sierra Nevada and eastern high deserts within California.

Upland game species commonly occur in upland habitat types, including agricultural cropland, riparian habitats, and oak woodlands. The ring-necked pheasant and wild turkey are non-native species that have successfully established in the Central Valley and are popular game for hunting. These species occur from the Central Valley floor to the foothills. Native species' population densities, with the exception of the American crow, are currently lower than they were before lands in the Bay-Delta were reclaimed. Native species are an integral part of our heritage, providing recreation and food for thousands of people. Their populations are good indicators of the health and viability of the vegetative communities on which they rely.

Throughout California, upland game habitat has been degraded or lost as a result of some types of land uses, such as logging, land conversion, water projects, intensive farming, overgrazing, and urban encroachment. Wildfires and floods also destroy many acres of nesting and escape cover.

VISION

The vision is to maintain healthy populations of upland game species at levels that can support both consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses, through protection and improvement of habitats and reduction in stressors.

Protecting and restoring existing and additional suitable riparian habitats and improving management of agricultural lands and reducing the effect of stressors that can suppress breeding success will be critical to maintaining healthy upland game populations in the Bay-Delta. The key to improving populations of upland game will be in providing increased nesting habitat and escape cover. The ERPP's proposed habitat restoration in the Sacramento-San Joaquin Delta and Suisun Marsh/North San Francisco Bay Ecological Management Zones will increase habitat quality and quantity. Restoration will also help maintain healthy populations of upland game species.

Restoring upland game habitat over a range of elevations above Bay-Delta mean-high-tide water levels would allow a greater diversity of plant species to establish. Grassland, woodland, and shrub habitats will be developed, maintained, protected, and restored in those areas that are out of the inundation zones of high water. This will provide an area that will serve as a transition zone which will greatly increase the natural processes necessary for restoring native habitat and plant communities.

Upland game species would also benefit from management strategies that would improve habitat quality. Management strategies should include protecting and maintaining important existing habitat areas and encouraging establishment and maintenance of agricultural and upland habitats used by these species. Such strategies could be implemented through cooperative agreements with land management agencies, landowner incentive programs, or conservation easements with or purchase from willing sellers.

Restoration of ecosystem processes and habitats that allow natural floodplains, meander corridors, seasonal pools, and riparian vegetation to develop will provide habitat for upland game species elsewhere in the Central Valley.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Groups that are involved in efforts to restore upland game include:

- California Department of Fish and Game wildlife program branch,
- California Department of Fish and Game's Game Bird Heritage Program,
- Pheasants Forever,
- Turkey Federation, and
- Quail Unlimited.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Protection and restoration of upland game species is integrally linked with restoration of riparian, grassland, and agricultural habitats, as well as improvements in upper watershed health.

OBJECTIVE, TARGETS, AND ACTIONS

The Strategic Objective is to enhance, to the extent consistent with ERP goals, populations of waterfowl and upland game for harvest by hunting and for non-consumptive recreation.

SPECIES TARGET: Increase the populations and distribution of upland game.

LONG-TERM OBJECTIVE: Maintain self-sustaining populations of upland game birds at levels to meet or exceed population levels present during the 1970s.

SHORT-TERM OBJECTIVE: Protect and maintain important existing habitat areas and encourage the maintenance of agricultural and upland habitats used by these species.

RATIONALE: Upland game are supported by diverse agricultural and upland habitats. The key to maintaining these species is by maintaining the habitats upon which they depend.

STAGE 1 EXPECTATIONS: Important upland game habitats will have been identified as well as conditions that reduce habitat quality. Existing habitats will have been protected and, where feasible, agricultural practices will have been adjusted to improve upland game populations.

RESTORATION ACTIONS

The following general targets will assist in meeting the restoration objective:

- Restore grassland, shrub, and woodland habitats,
- Increase upland game populations, and
- Improve hunting opportunities.

The following general programmatic actions will assist in meeting the targets:

- Protect and restore upland habitats.

- Improve land use and agricultural land management to enhance upland game.
- Improve forest and riparian land management for upland game.
- Reduce potential for wildfire in floodplain, riparian forest, grasslands, and forest lands.

REFERENCE

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

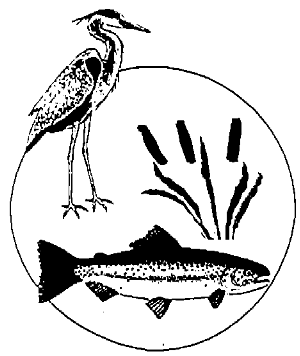
Upland Game Species and the Groups in Which They Appear			
Species	Coastal and Central Valley Group	Montane Upland Game Group	Eastern Upland Game Group
Ring-necked pheasant	✔		
California quail	✔		✔
Wild turkey	✔	✔	
Common snipe	✔	✔	✔
Dove	✔	✔	✔
American crow	✔	✔	✔
Tree squirrels	✔	✔	✔
Cottontail/brush rabbit	✔	✔	✔
Black-tailed hare	✔	✔	✔
Band-tailed pigeon	✔	✔	✔
Chukar*		✔	✔
Mountain quail*		✔	✔
Sage grouse*			✔
Blue/ruffed grouse*		✔	
Ptarmigan*		✔	

*These species are not addressed by this vision.

◆ VISION FOR REDUCING OR ELIMINATING STRESSORS

INTRODUCTION

This section presents visions for stressors that adversely affect important ecosystem elements. Stressors are natural and unnatural events or activities that adversely affect ecosystem processes, habitats, and species. Environmental stressors include water diversions, water contaminants, levee confinement, stream channelization and bank armoring, mining and dredging in streams and estuaries, excessive harvest of fish and wildlife, introduced predator and competitor species, and invasive plants in aquatic and riparian zones. Some major stressors affecting the ecosystem are permanent features on the landscape, such as large dams and reservoirs that block transport of the natural supply of woody debris and sediment in rivers or alter unimpaired flows. Reducing the adverse effects of stressors is a major component in the Ecosystem Restoration Program Plan (ERPP). Stressors addressed have a strong effect on an ecological process, habitat, or a species that is dependent on the Bay-Delta and can be feasiblely and sufficiently reduced to improve the health of the Bay-Delta ecosystem. Table 19 identifies important stressors and the related ERPP Strategic Objective. Strategic Objectives are fixed and will not change through time. Table 20 presents the basis for their selection as an ecosystem stressor.



These visions describe the locations where the stressor has a substantial adverse effect in the ERPP area, and how each stressor affects ecological processes, habitats, and/or species. Restoration needs to reduce the adverse effects of stressors are also identified. The Ecosystem Restoration Program Plan, Volume II: Ecological Management Zone Visions contains more detailed objectives, targets, and programmatic actions for each stressor as it relates to a specific ecological management zone. Table 21 identifies which ecological management zones address which stressors.

Table 19. Strategic Objectives for Stressors.

Stressor	Strategic Objective
Water Diversions	Achieve, first, recovery and then large self-sustaining populations of at-risk native species dependent on the Delta, Suisun Bay, and Suisun Marsh. Enhance and/or conserve native biotic communities in the Bay-Delta estuary and its watershed. Establish hydrologic regimes in streams, including sufficient flow timing, magnitude, duration, and high flow frequency, to maintain channel and sediment conditions supporting the recovery and restoration of native aquatic and riparian species and biotic communities. Establish and maintain hydrologic and hydrodynamic regimes for the Bay and Delta that support the recovery and restoration of native species and biotic communities, support the restoration and maintenance of functional natural habitats, and maintain harvestable species.

Table 19. Strategic Objectives for Stressors (continued).

Stressor	Strategic Objective
Dams and Other Structures	Create and/or maintain flow and temperature regimes in rivers that support the recovery and restoration of native aquatic species. Establish hydrologic regimes in streams, including sufficient flow timing, magnitude, duration, and high flow frequency, to maintain channel and sediment conditions supporting the recovery and restoration of native aquatic and riparian species and biotic communities. Reestablish floodplain inundation and channel-floodplain connectivity of sufficient frequency, timing, duration, and magnitude to support the restoration and maintenance of functional natural floodplain, riparian, and riverine habitats. Restore coarse sediment supplies to sediment-starved rivers downstream of reservoirs to support the restoration and maintenance of functional natural riverine habitats.
Levees, Bridges, and Bank Protection	Reestablish floodplain inundation and channel-floodplain connectivity of sufficient frequency, timing, duration, and magnitude to support the restoration and maintenance of functional natural floodplain, riparian, and riverine habitats.
Dredging and Sediment Disposal	Rehabilitate natural processes to create and maintain complex channel morphology, in-channel islands, and shallow water habitat in the Delta and Suisun Marsh.
Gravel Mining	Restore coarse sediment supply to sediment-starved rivers downstream of reservoirs to support the restoration and maintenance of functional natural riverine, riparian, and floodplain habitats.
Invasive Aquatic Organisms	Eliminate further introductions of new species from the ballast water of ships into the Bay-Delta estuary. Eliminate further introductions of new species from imported marine and freshwater baits into the Bay-Delta estuary and its watershed. Halt the unauthorized introduction and spread of potentially harmful non-native introduced fish and other aquatic organisms in the Bay-Delta and Central Valley. Halt the release of non-native introduced fish and other aquatic organisms from private aquaculture operations and the aquarium and pet trades into the Bay-Delta estuary, its watershed, and other central California waters. Limit the spread or, when possible and appropriate, eradicate populations of nonnative invasive species through focused management efforts.
Invasive Aquatic Plants	Halt the introduction of invasive aquatic and terrestrial plants into the Bay-Delta estuary, its watershed, and other central California waters. Limit the spread or, when possible and appropriate, eradicate populations of non-native invasive species through focused management efforts.

Table 19. Strategic Objectives for Stressors (continued).

Stressor	Strategic Objective
Invasive Riparian and Salt Marsh Plants	Halt the introduction of invasive aquatic and terrestrial plants into the Bay-Delta estuary, its watershed, and other central California waters. Limit the spread or, when possible and appropriate, eradicate populations of non-native invasive species through focused management efforts.
Zebra Mussel	Prevent the invasion of the zebra mussel into California.
Non-Native Wildlife	Reduce the impact of non-native mammals on native birds, mammals, and other organisms. Limit the spread or, when possible and appropriate, eradicate populations of nonnative invasive species through focused management efforts.
Predation and Competition	Ensure that chinook salmon, steelhead, trout, and striped bass hatchery, rearing, and planting programs do not have detrimental effects on wild populations of native fish species and ERP actions.
Contaminants	Reduce the loadings and concentrations of toxic contaminants in all aquatic environments in the Bay-Delta estuary and watershed to levels that do not adversely affect aquatic organisms, wildlife, and human health. Reduce loading of oxygen-depleting substances from human activities into aquatic ecosystems in the Bay-Delta estuary and watershed to levels that do not cause adverse ecological effects. Reduce fine sediment loadings from human activities into rivers and streams to levels that do not cause adverse ecological effects.
Fish and Wildlife Harvest	Enhance, to the extent consistent with ERP goals, populations of waterfowl and upland game for harvest by hunting and for non-consumptive recreation. Maintain, to the extent consistent with ERP goals, fisheries for striped bass, American shad, signal crayfish, grass shrimp, and nonnative warmwater gamefishes. Enhance fisheries for salmonids, white sturgeon, Pacific herring, and native cyprinid fishes.
Artificial Fish Propagation	Ensure that chinook salmon, steelhead, trout, and striped bass hatchery, rearing, and planting programs do not have detrimental effects on wild populations of native fish species and ERP actions.
Stranding	Reestablish floodplain inundation and channel-floodplain connectivity of sufficient frequency, timing, duration, and magnitude to support the restoration and maintenance of functional natural floodplain, riparian, and riverine habitats.
Disturbance	Contribute to the recovery of at-risk native species in the Bay-Delta estuary and its watershed.

Table 20. Basis for Selection of Stressor Ecosystem Elements.

Stressors	Basis for Selection as an Ecosystem Element
Water Diversions	Diversions cause loss of water, nutrients, sediment, and organisms (entrainment). The transfer of water across the Delta through existing channels may also detour migrating resident, estuarine, and resident fish species from their primary routes. The diversion rate also contributes to reduced water residence time which reduces primary (plant) and secondary (animal) production and standing biomass.
Dams and Other Structures	Dams block fish movement, alter water quality, remove fish and wildlife habitat, and alter hydrological and sediment processes. Other human-made structures may block fish movement or provide habitat or opportunities for detrimental predatory fish and wildlife.
Levees, Bridges, and Bank Protection	Levee, bridge, and bank protection structures inhibit overland flow and erosion and depositional processes that develop and maintain floodplains, and allow stream channels to meander. Levees prevent floodflows from entering historic floodplains, and eliminate or alter the character of floodplain ecosystem processes and habitats. Channelizing floodflows also increases scour or incision and reduces or halts channel meander and oxbow formation. Bridges have a similar, though generally more localized effect.
Dredging and Sediment Disposal	Dredging in Bay-Delta waters may damage aquatic habitat or harm aquatic animals and plants. Channel dredging also contributes to levee instability and steepens channel banks which increases shoreline habitat erosion.
Gravel Mining	Mining sand and gravels from rivers and floodplains may affect natural sediment supply, gravel movement, and sediment deposition. Sand, gravel, and sediment distribution influences the quality of wildlife habitat, abundance of aquatic predators, water quality and fish and wildlife populations. Excessive instream mining could result in riparian corridor instability.
Invasive Aquatic Plants	Invasive aquatic plants may have an adverse effect on native aquatic plants, constrain habitat quality of water ways, require control measures, and impair water conveyance systems and use of fish protective devices such as fish screens.
Invasive Aquatic Organisms	Invasive aquatic organisms may have an adverse effect on the foodweb and on native species resulting from competition for food and habitat and direct predation.
Invasive Riparian and Marsh Plants	Restoration of native riparian and marsh plants and plant communities can be hindered by introduced species which may out-compete or displace native plant species. Non-native plant species may have little value to wildlife and other riparian dependent species.

Table 20. Basis for Selection of Stressor Ecosystem Elements (continued).

Stressors	Basis for Selection as an Ecosystem Element
Zebra Mussel	The zebra mussel has caused enormous damage to water supply infrastructure and natural ecosystems in the eastern United States. It is likely that zebra mussel will appear in California's Central Valley through any one of several means. Therefore, it is highly desirable to have in place a strategy to swiftly contain a localized invasion.
Non-native Wildlife	Introductions of non-native species may adversely affect the survival of native wildlife. Non-native wildlife has greatly altered ecological processes, functions, habitats, species diversity, and abundance of native plants, fish, and wildlife.
Predation and Competition	Unnatural levels of predation and competition may adversely affect populations of fish and wildlife.
Contaminants	Contaminants affect water quality and the survival of fish, waterfowl, and the aquatic foodweb.
Fish and Wildlife Harvest	Fish and wildlife harvest may affect abundance of species or viability of local populations.
Artificial Fish Propagation	Fish hatcheries and other artificial propagation programs (e.g., pen-rearing salvaged striped bass) may adversely affect populations of "wild" fish. Direct effects might be predation on wild fish or competition from artificially-produced fish. Indirect effects may occur from adverse changes in wild population genetics from interbreeding with hatchery fish. Disease may also be transferred from hatchery fish to wild fish.
Stranding	Stranding of juvenile fish and other aquatic organisms was probably a natural environmental event in the historical Central Valley. Today, many stranding events are caused by flood bypasses, construction of levee toe drains, and other anthropomorphic events. Modification to lowland areas and providing escape routes back to larger bodies of water and flowing streams will reduce the mortality related to stranding.
Disturbance	Boating, habitat disturbance, and other negative anthropogenic activities may adversely affect wildlife habitat and species abundance and distributions.

Table 21. Ecological Management Zones in Which Targets and Programmatic Actions to Reduce Stressors Are Proposed

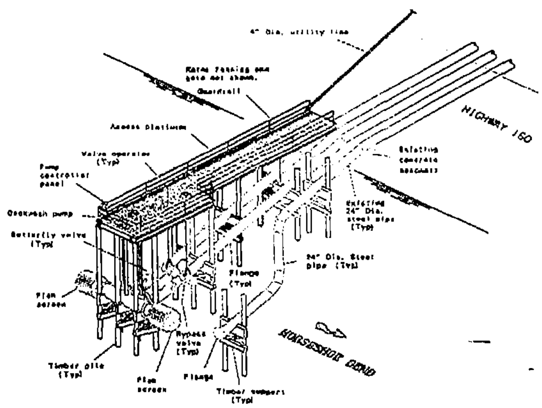
[Note: Refer to Volume II: Ecological Management Zone Visions for information regarding specific targets and actions.]

Stressors	Ecological Management Zone[1]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Water Diversions	●	●	●	●			●	●	●	●	●	●	●	
Dams and Other Structures			●	●			●	●			●		●	
Levees, Bridges, and Bank Protection	●		●						●			●		
Dredging and Sediment Disposal	●													
Gravel Mining				●	●					●				
Non-native Species	●	●	●	●					●	●	●			
Zebra Mussel	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Predation and Competition	●	●	●							●	●		●	
Contaminants	●	●	●			●			●	●	●	●		●
Fish and Wildlife Harvest	●	●	●	●			●	●	●		●		●	
Artificial Fish Propagation			●	●			●	●	●		●		●	
Stranding	●	●	●				●	●	●	●			●	
Disturbance	●	●												

Ecological Management Zones

[1] 1 = Sacramento-San Joaquin Delta
2 = Suisun Marsh/North San Francisco Bay
3 = Sacramento River
4 = North Sacramento Valley
5 = Cottonwood Creek
6 = Colusa Basin
7 = Butte Basin
8 = Feather River/Sutter Basin
9 = American River Basin
10 = Yolo Basin
11 = Eastside Delta Tributaries
12 = San Joaquin River
13 = East San Joaquin Basin
14 = West San Joaquin Basin

◆ WATER DIVERSIONS



INTRODUCTION

Water diversions are found throughout Central Valley rivers and their tributaries, the Bay and Delta. Water is diverted for irrigated agriculture, municipal and industrial use, and managed wetlands.

Water diversions in the Bay-Delta watershed directly and indirectly affect fish, aquatic organisms, sediments, salinity, streamflow, habitat, foodweb productivity, and species abundance and distribution. The rate of diversion from the Delta affects residence time of water which, in turn, affects primary (plant) and secondary (animal) production.

Factors that relate to the influence that diversions have on the health of the Bay-Delta ecosystem health include diversion rate, the season in which water is diverted, the diversion location, fish species, fish life stage periodicity, and whether the diversion is equipped with adequate fish protection facilities.

In most cases, entrained organisms do not survive. Some diversions have screens that exclude most juvenile and adult fish; however, eggs and larval fish, invertebrates, planktonic plants, organic debris and dissolved nutrients are lost to diversions.

STRESSOR DESCRIPTION

Water diversion in the Bay-Delta and its watershed may vary by water year type and month of the year, and has a wide variety of effects on streamflow, aquatic organisms, habitat, and ecosystem processes. In some cases, diversions on a tributary stream remove so much flow during summer and fall that little or no flow remains in the stream.

Along the mainstem Sacramento River the following diversions exist:

- The Red Bluff Diversion Dam (RBDD) diverts Sacramento River water into the Tehama-Colusa Canal and the Corning Canal.
- The Anderson-Cottonwood Irrigation District (ACID) Diversion Dam diverts water into the ACID canal.
- The Glenn-Colusa Irrigation District's (GCID's) Hamilton City Pumping Plant. With a diversion capacity of 3,000 cubic feet per second (cfs) it is the largest diversion on the Sacramento River.
- Several hundred smaller diversions exist along the Sacramento River, more than 2,000 diversions exist in the Delta, and about 150 diversions exist in the San Joaquin.

The largest diversions have fish screens and require frequent, routine maintenance to provide consistent levels of fish protection. The effectiveness of screens is dependent on may factors, including maintenance, design, and site-specific physical conditions. A well-designed fish screen based on proved technology is effective in reducing entrainment and impingement losses of many species of juvenile fish. Screen retrofits can be fairly inexpensive, especially on smaller-sized diversions.

In the south Delta, the two largest diversions are operated by the State Water Project (SWP) and federal Central Valley Project (CVP). These two large diversions have louvers that guide juvenile fish into bypasses and holding facilities, where salvaged fish are collected and transported back to the Bay and Delta. Many fish are salvaged. Nevertheless, many more are lost to handling, predation and to bypass inefficiency during collection and holding at the fish facilities, or during fish transport. Programs to upgrade these fish protection facilities are ongoing.

Two large fossil fuel power plants are operated in the Bay-Delta, one at Antioch and one at Pittsburg. Each has large, screened intake systems. The screens, however, use 1950s technology and do not effectively screen larvae or small juvenile fish. Although the power plants return the water to the Delta, many entrained larvae and juveniles are killed by mechanical damage or heat stress. Survival rates have been measured only for striped bass and under many conditions, approximately 80% passing through the plant survive.

The Contra Costa Water District has several diversions in the Bay-Delta. They sporadically operate a diversion at Mallard Slough in Suisun Bay. New screens are in place at the new Los Vaqueros diversion on Old River. New screens are being constructed at the Contra Costa Water District Rock Slough intake.

In Suisun Bay and Suisun Marsh, far fewer agricultural diversions exist because of brackish waters. However, many State and privately managed wetlands divert water seasonally from Suisun Marsh sloughs. The larger diversions at Roaring River, Grizzly Slough, and Island Slough are screened. The smaller diversions are unscreened gates, siphons, or pumps. Recently, the Suisun Resource Conservation District (SRCD) and California Department of Fish and Game (DFG) began a program to screen some diversions with self-cleaning, fine-mesh screens.

ISSUES AND OPPORTUNITIES

ENTRAINMENT OF FISH AT PUMPS. The entrainment of fish and other biota in the CVP and SWP pumps and agricultural water diversions in the Delta and tributaries stimulate conflicts among stakeholders. However, it is not clear to what extent entrainment affects the population size of any one species of fish or invertebrate (Diversion Effects on Fish Team 1998). More information on the effects of entrainment will be pivotal in choosing a water conveyance method, because it will help determine to what extent an "isolated facility" can be expected to alleviate any problems. Reducing this uncertainty is also essential to ensure the most efficient allocation of restoration funds because proposed solutions to this problem include potentially tens of millions of dollars spent constructing fish screens and new intake facilities throughout the Bay-Delta system, not all of which may be as effective as intended at reducing population declines (Strategic Plan 2000).

VISION

The vision for water diversions is to reduce the adverse effects of water diversions, including entrainment of all life stages of aquatic species, by installing fish screens, consolidating or moving diversions to less sensitive locations, removing diversions, or reducing the volume of water diverted.

Achieving this vision will assist in the recovery of State- and federally listed fish species, improve important sport fisheries, and improve the Bay-Delta aquatic foodweb.

This vision concentrates on the direct effects of aquatic organism entrainment. Cumulatively, water diversions remove large numbers of young salmon, steelhead, delta smelt, splittail, striped bass, and many other fishes and invertebrates from the rivers, Delta, and Bay.

Approaches to achieving this vision include reducing their adverse effects by removing or relocating high impact diversions. Altering the timing of some diversions would help to reduce losses of aquatic organisms. Installing positive-barrier fish screens would help to reduce losses.

On many Sacramento and San Joaquin rivers and their tributaries, diversions entrain juvenile salmon and steelhead in spawning and rearing areas, and on their migrations downstream toward the ocean. Adequate positive barrier fish screens will protect juvenile salmon and steelhead from being entrained. Positive barrier fish screens can be employed at most of the tributary diversion sites.

Screen upgrades continue to improve screening efficiency for the large diversions along the Sacramento River, such as those of ACID, RBDD, and GCID. The Red Bluff Research Program is studying alternatives, including pumping from the river and returning entrained salmon and steelhead to the river through a bypass system. Positive-barrier screens that move fish through a bypass are also being considered for large diversions such as GCID.

The Delta Fish Facilities Technical Team is focusing on reducing entrainment losses at the south Delta pumping plants through the use of positive barrier fish screens. Salvage facilities at SWP and CVP diversions do not provide adequate fish protection, especially for small, fragile species like delta smelt.

The technical team is currently considering two parallel approaches. The first is to upgrade the screening systems of the existing facilities. The second is to provide an alternative intake location, such as in the north Delta, where entrainment losses would be less and fewer fish would be drawn into the Central and South Delta.

The preferred approach includes construction of a new screened intake at Clifton Court Forebay with protective screening criteria and construction of either a new screened diversion at Tracy with protective screening criteria; and/or an expansion of the new diversion at Clifton Court Forebay to meet the Tracy Pumping Plant export capacity. This approach is designed to improve water supply reliability, protect and improve Delta water quality, improve ecosystem heath, and reduce risk of supply disruption due to catastrophic breaching of Delta levees.

Using self-cleaning cylindrical screens on small Bay-Delta siphons and pump diversions appears feasible. In Suisun Bay and Suisun Marsh, use of either positive-barrier flat screens or conical screens on slough intakes (e.g., Roaring River diversion) has proven effective.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Working with individual diverters would achieve the vision to provide them with alternative sources of water, moving their intakes, revising their diversion schedules, or funding installation of screened intakes.

Efforts to reduce impacts of unscreened diversions in the Bay-Delta and its watershed will involve cooperation among several agencies' screening programs including DFG's Unscreened Diversion Program, Anadromous Fish Screen Program of the CVPIA, and NRCS's Fish Screen Program. Recently, Reclamation Districts 108 and 1004, and Princeton-Cordua-Glenn/Provident Irrigation District and other large diverters are either installing new screens or have begun the engineering needed to install screens. Hundreds of smaller diversions along the river consist of siphons or pumps; most of these are unscreened. The CVPIA Anadromous Fish Screen Program will contribute to the screening of many of these diversions on a cost-share basis. Cooperation will also be sought with agencies having responsibility or authority for dealing with screening diversions, including DFG, DWR, Reclamation, State Water Resources Control Board, NRCS, NMFS, and the U.S. Army Corps of Engineers.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Water diversions are closely linked to other ecosystem elements including processes, habitats, and species. For example, the diversion of large quantities of water in the Delta also results in the diversion of sediments, nutrients, and many lower level organisms in the Bay-Delta aquatic food chain. The management of water in the ERPP study area, particularly the delivery of water to the Delta for export, has altered natural flow patterns and ecological processes that maintain habitats in upstream rivers and tributaries and in the Delta. Entrainment also causes direct and indirect mortality to juvenile fish, eggs and larvae.

OBJECTIVES, TARGETS, ACTIONS, AND MEASURES

Achieve, first, recovery and then large self-sustaining populations of at-risk native species dependent on the Delta, Suisun Bay, and Suisun Marsh.

Enhance and/or conserve native biotic communities in the Bay-Delta estuary and its watershed.

LONG-TERM OBJECTIVE: Eliminate or reduce adverse impacts of the diversion of water to a level of little significance.

SHORT-TERM OBJECTIVE: Construct and screen a new SWP intake to Clifton Court Forebay. Construct a new screened intake at the CVP intake and/or expand the new diversion at Clifton Court to meet Tracy Pumping Plant need. Screen the largest of the remaining unscreened diversions then begin screening the smaller diversions. Develop a science and data based analysis/evaluation process by which to set priorities for screening.

RATIONALE: Storage and diversion of water from Central Valley rivers and streams and from the Delta has produced significant detrimental effects on the ecosystem, including functions such as spawning, rearing, and migration, the processes that create and maintain habitat, habitat, and species that depend on the aquatic habitats. The relocation, consolidation and installation of positive barrier fish screens does not reduce the amount of water extracted, but such actions are encouraged as they will reduce the mortality resulting from the direct entrainment of young fish. The intent of the restoration program is to eliminate loss of fish resulting from the unscreened diversion of water to a level that no longer impairs efforts to rebuild fish populations to healthy levels. Likewise, the potential future relocation of the SWP and CVP intakes and installation of positive barrier fish screens does not reduce the amount of water extracted, but will reduce the mortality resulting from the direct entrainment of young fish and contribute to restoring the ecological functions of the Delta such as food web support, and spawning and rearing habitat.

STAGE 1 EXPECTATIONS: During Stage 1 of the implementation program, all diversions greater than 250 cfs will have been screened, the majority of diversions between 100 and 250 cfs will have been screened, and a process will be in place to set priorities and screen diversion smaller that 100 cfs. During this period, fish populations will exhibit a positive response and increase in abundance.

Establish hydrologic regimes in streams, including sufficient flow timing, magnitude, duration and high flow frequency, to maintain channel and sediment conditions supporting the recovery and restoration of native aquatic and riparian species and biotic communities.

Establish and maintain hydrological and hydrodynamic regimes for the Bay and Delta that support the recovery and restoration of native species and biotic communities, support the restoration and maintenance of functional natural habitats, and maintains harvestable species.

LONG-TERM OBJECTIVE: For regulated rivers in the region, establish scientifically based high-flow events necessary to maintain dynamic channel processes, channel complexity, bed sediment quality, and natural riparian habitats where feasible.

SHORT-TERM OBJECTIVE: Through management of the reservoir pool or deliberate reservoir releases, provide a series of experimental high-flow events in regulated rivers to observe flow effects on bed mobility, bed sediment quality, channel migration, invertebrate assemblages, fish abundance, and riparian habitats over a period of years. Use the findings of these studies to reestablish natural stream processes where feasible, including restoration of periodic inundation of remaining undeveloped floodplains.

RATIONALE: Native aquatic and riparian organisms in the Central Valley evolved under a flow regime with pronounced seasonal and year-to-year variability. Frequent (annual or longer term) high flows mobilized gravel beds, drove channel migration, inundated floodplains, maintained sediment quality for native fishes and invertebrates, and maintained complex channel and floodplain habitats. By deliberately releasing such flows from reservoirs, at least some of these physical and ecological functions can probably be recreated. A program of such high-flow releases, in conjunction with natural high-flow events, lends itself well to adaptive management because the flows can easily be adjusted to the level needed to achieve specific objectives. However, it should be recognized that channel adjustments may lag behind hydrologic changes by years or decades, requiring long-term monitoring. Also, on most rivers, reservoirs are not large enough to eliminate extremely large, infrequent events so these will continue to affect channel form at irregular, often long, intervals; artificial high-flow events may be needed to maintain desirable channel configurations created during the natural events. This objective focuses on flows that are likely to be higher than those needed to maintain most native fish species but that are important for maintaining in-channel and riparian habitats for fish as well as other species (e.g., invertebrates, birds, mammals). Experimental flow releases also will have to be carefully monitored for negative effects, such as encouraging the invasion of unwanted non-native species.

STAGE 1 EXPECTATIONS: Studies should be conducted on five to 10 regulated rivers in the Central Valley to determine the effects of high-flow releases. Natural floodplains should be identified that can be inundated with minimal disruption of human activity. Where positive benefits are shown, flow recommendations should be developed and instituted where feasible.

RESTORATION ACTIONS

The general target is to reduce the adverse effects of water diversion so that the diversion of water, in conjunction with other restoration actions, does not impair other restoration efforts needed to restore ecological health to the Bay-Delta system.

The following activities would help to achieve this vision:

- Widen the area of concern of the Anadromous Fish Screen Program's multiagency policy level and management team for unscreened diversions which is composed of representatives from the National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), U.S. Bureau of Reclamation (Reclamation), DFG, California Department of Water Resources (DWR), and U.S. Natural Resources Conservation Service (NRCS) districts.
- Finish the development of the priority system to install positive-barrier fish screens on all diversions of more than 100 cfs in the upper Sacramento River and all diversions in tributary streams with salmon and steelhead populations by providing funding support to DFG and CVPIA screening programs.
- Construct and test a pilot screening facility in the south Delta adjacent to the Tracy Fish Facility to test a 500 cfs positive-barrier fish screen and collection system.
- Construct new screened intakes at Clifton Court and the Tracy Fish Facility; and/or expand the diversion at Clifton Court to accommodate the needs of the Tracy Pumping Plant and fish-holding facility.
- Support completion of research at the Red Bluff Research Program.
- Assess the effectiveness of test cylindrical screens at DWR siphon diversions on Sherman Island.
- Screen small diversions in Suisun Marsh, focusing on Montezuma and Suisun Sloughs.
- Continue research on fish behavior relative to screening (University of California, Davis Treadmill Study).
- Continue research on fish screening and related facilities design and operations.
- Coordinate research and testing of the various screening programs among resource agencies.
- Develop a long-term screening program plan in cooperation with DFG, USFWS, NMFS, irrigators, and other stakeholders.
- Screen small siphon and pump diversions in the Delta, mainstem rivers, and lower tributaries.
- Develop an incentive plan to encourage local diverters to consolidate smaller diversions where possible to increase the cost-effectiveness of screening.
- Consider an upgrade to existing screens at PG&E's Pittsburg power plant and Contra Costa Water District's Mallard Slough diversion with positive-barrier fish screens.
- Provide alternative sources of water to diversions, where possible, in lower portions of tributaries

and agricultural lands and managed wetlands along rivers and in the Delta and Suisun Marsh.

MSCS Conservation Measures

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Consistent with CALFED objectives, operate diversions to minimize adverse affects of diversion on longfin smelt during the peak spawning period (January - March).
- Protect the Sacramento and San Joaquin river and tributary channels from flow disruptions (e.g., water diversion that result in entrainment and inchannel barriers or tidal gates) for the period February 1, to August 31.
- Reduce the loss of young splittail to entrainment into south Delta pumping plants.
- To the extent practicable, reduce the loss of splittail at 1800 unscreened diversions in the Delta.
- Design and construct a new intake screen system at the entrance to Clifton Court Forebay that minimizes potential involvement of splittail and connect intakes of Tracy Pumping Plant to Clifton Court Forebay.

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The Resources Agency. 1989. Upper Sacramento River fisheries and riparian habitat management plan. Sacramento, CA.

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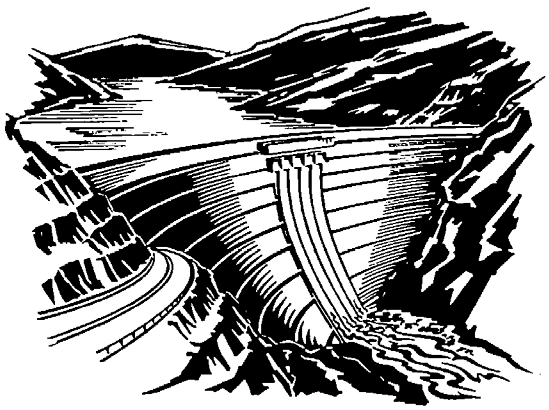

INTRODUCTION

Dams and other human-made structures come in various forms, from the largest dam (Shasta), to small weirs on tributary streams. Dams stop downstream water flow and capture sediment derived from erosion in the upper watersheds. The captured water backs up to create a reservoir. Seven major dams restrict streamflows from entering the Bay-Delta.

Diversion dams exist throughout the watershed of the Sacramento-San Joaquin rivers and Bay-Delta. Larger weirs are located along the Sacramento River at the Yolo, Sutter, and Sacramento bypasses. Small weirs can be found on most upper watershed tributaries.

Dams and other human-made structures act as stressors on ecosystem processes, important habitats, and species in aquatic ecosystems. For example, dams and their associated reservoirs block fish migration, alter water quality, remove fish and wildlife habitat, and alter hydrological and sediment processes. The construction, operation, and maintenance of these structures in the Central Valley have contributed to the decline of many species.

STRESSOR DESCRIPTION

Dams in any form block or hinder upstream and downstream migrations of anadromous fish and hinder downstream transport of sediment. Larger dams completely block anadromous fish migration. These large dams resulted in the loss, and in some cases extinction, of local salmon and steelhead populations (Mills et al. 1996).

Many moderately sized diversion dams, such as Red Bluff Diversion Dam (RBDD) and Anderson-Cottonwood Irrigation District (ACID) Diversion Dam, contain fish ladders to allow fish passage. Some dams, such as Capay Dam on Cache Creek and Solano Dam on Putah Creek, do not.

Small diversion dams are generally constructed to seasonally divert water for irrigation. Although many have been fitted with ladders to allow fish passage, many are technologically outdated and only marginally effective. Often, salmon and steelhead can negotiate the fish ladders, but other species, such as American shad, green sturgeon, and white sturgeon, cannot. In some cases, fish ladders delay adult salmon and steelhead from reaching upstream spawning grounds or downstream migrating juvenile salmon and steelhead.

In high-flow years, water flows from the river into the bypasses and downstream to return to the river or Delta. In such cases, adult salmon and steelhead may migrate upstream through the bypasses and become blocked below the weirs opposite the river. A similar situation occurs in the Sacramento Ship Channel. Blockage and delay of steelhead and winter-run salmon are of particular concern because the fish usually migrate upstream during the winter and spring high-flow periods.

Larger irrigation returns in wetter years have relatively high flows that may attract anadromous fish. Fish attracted to these returns may become lost or delayed. The Colusa Basin drain, which enters the Sacramento River near Knights Landing, is an example of an irrigation return that is known to attract adult salmon.

ISSUES AND OPPORTUNITIES

OPPORTUNITIES FOR RIVERS: Mimic natural flow regimes through innovative methods to manage reservoir releases. There is underutilized potential to modify reservoir operations rules to create more dynamic, natural high-flow regimes in regulated rivers without seriously impinging on the water storage purposes for which the reservoir was constructed. Water release operating rules could be changed to ensure greater variability of flow, provide adequate spring flows for riparian vegetation establishment, simulate effects of natural floods in scouring riverbeds and creating point bars, and increase the frequency and duration of overflow onto adjacent floodplains. In some cases, downstream infrastructure of river floodways may require upgrading to safely accommodate a more desirable natural variability and peak discharge magnitude associated with moderate floodflows (e.g., strengthen or set levees back) (Strategic Plan 2000).

Remove barriers to anadromous fish migration where feasible. Significant progress has been made in recent years to improve salmon passage on several spawning streams (e.g., Butte Creek, Battle Creek) by removing barriers, consolidating diversion weirs, or constructing state-of-the-art fish passage structures. Existing and potential spawning areas in the ERP focus area that are not obstructed by major reservoir dams, but are currently obstructed by other barriers, should be identified and action taken to restore anadromous fish spawning upstream (Strategic Plan 2000).

VISION

The vision for dams and other structures is to reduce their adverse effects by improving fish passage and enhancing downstream fish habitat.

Reducing these adverse effects will assist in the recovery of State- and federally listed fish species and contribute to sustainable sport and commercial fisheries.

To accomplish this vision, the Ecosystem Restoration Program (ERP) proposes to address a variety of problems caused by these structures which effect natural processes (e.g., sediment transport), habitats (e.g., riverine and riparian aquatic habitat), and species (e.g., winter-run chinook salmon and steelhead).

For rivers with large dams that block anadromous fish migration, ERPP proposes to improve flow and habitat conditions below these dams. Flow and habitat improvements would enhance salmon and steelhead populations in the lower river reaches. The feasibility of restoring anadromous fish above some of these dams may be considered in the future. Cooperation will be required from local irrigation districts and landowners to rectify these problems.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to reduce the effects of human-made structures on the aquatic ecosystem would involve cooperation and support from other established programs underway to protect and improve conditions for anadromous fish and native resident fishes in the Bay-Delta and its watershed. The recovery plan for the Sacramento/San Joaquin Delta native fishes will be considered in the development of proposed actions (USFWS 1996). CVPIA will implement actions that will reduce adverse effects caused by structures (USFWS 1997). California's Salmon, Steelhead Trout, and Anadromous Fisheries Program Act includes actions to reduce adverse effects of structures (Reynolds et al 1993). The Four Pumps Agreement Program continues to develop projects to reduce effects of structures. Endangered Species Act requirements (biological opinions and habitat conservation plans) will ensure maintenance of existing habitat conditions and implementation of recovery actions (NMFS 1997).

The blockage of migrating anadromous fish in mainstem rivers and tributary streams is a major concern of the Central Valley Project Improvement Act's (CVPIA's) Anadromous Fish Restoration Program (AFRP) and California Department of Fish and Game's (DFG's) Salmon and Steelhead Restoration Program.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Dams and other humanmade structures are found throughout the ERPP Study Area and its ecological management zones. Large water storage and flood control dams are present on the large rivers and streams and many smaller streams. Water storage and diversion structures impair ecological processes such as Central Valley streamflow, natural sediment supply, stream meander, natural floodplain and flood processes, and Central Valley stream temperatures. This group of stressors also impairs a variety of habitats needed to support fish, wildlife, and plant communities. The most adversely affected habitat is riparian and riverine aquatic habitat. Virtually all fish, wildlife and plant community populations which are dependent on seasonal and perennial aquatic habitats have been reduced. This is particularly true for anadromous fish populations which no longer have access to their former oversummering, spawning, and rearing areas above the major dams.

OBJECTIVES, TARGETS, ACTIONS, AND MEASURES

One Strategic Objective for dams and other structures is to establish hydrologic regimes in regulated streams, including sufficient flow timing, magnitude, duration, and high flow frequency, to maintain channel and sediment conditions supporting the recovery and restoration of native aquatic and riparian species and biotic communities.

LONG-TERM OBJECTIVE: For regulated rivers in the region, establish scientifically based high-flow events necessary to maintain dynamic channel processes, channel complexity, bed sediment quality, and natural riparian habitats where feasible.

SHORT-TERM OBJECTIVE: Through management of the reservoir pool or deliberate reservoir releases, provide a series of experimental high-flow events in regulated rivers to observe flow effects on bed mobility, bed sediment quality, channel migration, invertebrate assemblages, fish abundance, and riparian habitats over a period of years. Use the findings of these studies to reestablish natural stream processes where feasible, including restoration of periodic inundation of remaining undeveloped floodplains.

RATIONALE: Native aquatic and riparian organisms in the Central Valley evolved under a flow regime with pronounced seasonal and year-to-year variability. Frequent (annual or longer term) high flows mobilized gravel beds, drove channel migration, inundated floodplains, maintained sediment quality for native fishes and invertebrates, and maintained complex channel and floodplain habitats. By deliberately releasing such flows from reservoirs, at least some of these physical and ecological functions can probably be recreated. A program of such high-flow releases, in conjunction with natural high-flow events, lends itself well to adaptive management because the flows can easily be adjusted to the level needed to achieve specific objectives. However, it should be recognized that channel adjustments may lag behind hydrologic changes by years or decades, requiring long-term monitoring. Also, on most rivers, reservoirs are not large enough to eliminate extremely large, infrequent events so these will continue to affect channel form at irregular, often long, intervals; artificial high-flow events may be needed to maintain desirable channel configurations created during the natural events.

This objective is similar to the previous one but differs in its focus on flows that are likely to be higher than those needed to maintain most native fish species but that are important for maintaining in-channel and riparian habitats for fish as well as other species (e.g., invertebrates, birds, mammals). Experimental flow releases also will have to be carefully monitored for negative effects, such as encouraging the invasion of unwanted non-native species.

STAGE 1 EXPECTATIONS: Studies should be conducted on five to 10 regulated rivers in the Central Valley to determine the effects of high-flow releases. Natural floodplains should be identified that can be inundated with minimal disruption of human activity. Where positive benefits are shown, flow recommendations should be developed and instituted where feasible.

Another Strategic Objective is to create and/or maintain flow and temperature regimes in rivers that support the recovery and restoration of native aquatic species.

LONG-TERM OBJECTIVE: Native fish and invertebrate assemblages will be restored to regulated streams where feasible, using methods developed during the short-term objective phase.

SHORT-TERM OBJECTIVE: Provide adequate flows, temperatures, and other conditions to double the number of miles (as of 1998) of regulated streams that are dominated (>75% by numbers and biomass) by assemblages with four or more native fish species.

RATIONALE: Virtually all streams in the region are regulated to some degree, and the regulated flow regimes frequently favor non-native fishes. The native fish assemblages (including those with anadromous fishes) are increasingly uncommon. Recent studies in Putah Creek, the Stanislaus River, and the Tuolumne River demonstrate that native fish assemblages can be restored to sections of streams if flow (and temperature) regimes are manipulated in ways that favor their spawning and survival, usually by having flow regimes that mimic natural patterns in winter and spring but that increase flows during summer and fall months (to make up for loss of upstream summer habitats). Native invertebrates and riparian plants may also respond positively to these flow regimes. Achievement of this objective will require additional systematic manipulations of flows below dams (or the re-regulation of existing flow regimes) to determine the optimal flow and habitat conditions for native organisms, as part of the short-term goal. Part of the studies should be to determine if the objective can be achieved without "new" water, by just altering the timing of releases or by developing conjunctive use agreements that allow more water to flow down the stream channel. Ways to restore native fish communities that do not involve changed flows should be developed (where feasible) to be used in place of or synergistically with changed flows. These findings can then be applied opportunistically to achieve the long-term goal of restoring native fish communities.

STAGE 1 EXPECTATIONS: Surveys will have been completed to determine the status of native fishes in all regulated streams of the Central Valley and flow recommendations made to restore native fishes where feasible. During negotiations for relicensing of dams, agency personnel should request flow regimes favorable for native fishes.

Another Strategic Objective is to restore coarse sediment supplies to sediment-starved rivers downstream of reservoirs to support the restoration and maintenance of functional natural riverine, riparian, and floodplain habitats.

LONG-TERM OBJECTIVE: Implement a comprehensive sediment management plan for the Bay-Delta system that will minimize problems of reservoir sedimentation and sediment starvation, shift aggregate extraction from rivers to alternate sources, and restore continuity of sediment transport through the system to the extent feasible.

SHORT-TERM OBJECTIVE: Develop methods and procedures to end gravel deficits below dams and mining operations; prioritize for correcting existing streams with major deficit problems and initiate action on at least 10 streams.

RATIONALE: One of the major negative effects of dams is the capture of coarse sediments that naturally would pass on to downstream areas. As a result, the downstream reaches can become sediment starved, producing "armoring" of streambeds in many (but not all) rivers to the point where they provide greatly reduced habitat for fish and aquatic organisms and are largely unsuitable for spawning salmon and other anadromous fish.

This objective can be accomplished by a wide variety of means, but most obviously through artificial importation of gravel and sand. Other possible actions include: (1) explore the feasibility of passing sediment through small reservoirs; (2) remove nonessential or low-value dams; (3) eliminate instream gravel mining on channels downstream of reservoirs, and limit extraction on unregulated channels to 50% of estimated bedload supply or less (or to levels determined not to negatively impact fish and other ecological resources); (4) develop incentives to discourage mining of gravel from river channels and adjacent floodplain sites; and (5) develop programs for comprehensive sediment management in each watershed, accounting for sediment trapped by reservoirs, availability of sediment from tributaries down stream of reservoirs, loss of reservoir capacity, release of sediment-starved water downstream, channel incision and related effects, and the need for sources of construction aggregate.

STAGE 1 EXPECTATIONS: Sediment-starved channels in the Bay-Delta system will have been identified; strategies to mitigate sediment starvation, such as shifting mining of gravel from river channels to alternate sources, adding gravel below dams, and removing nonessential dams will have been developed; demonstration projects will have been implemented (and monitored) to mitigate sediment starvation in at least six rivers.

> Another Strategic Objective is to re-establish floodplain inundation and channel-floodplain connectivity of sufficient frequency, timing, duration, and magnitude to support the restoration and maintenance of functional natural floodplain, riparian and, riverine habitats.

LONG-TERM OBJECTIVE: Reestablish active inundation of floodplains with area targets and inundation frequencies (1-5 years) to be set for each major alluvial river (where feasible) based on probable pre-1850 floodplain inundation regimes and on existing opportunities to modify existing land uses.

SHORT-TERM OBJECTIVE: Reestablish active inundation of at least half of all remaining un-urbanized floodplains in the Central Valley, where feasible.

RATIONALE: Frequent (often annual) floodplain inundation was an important attribute of the original aquatic systems in the Central Valley and was important for maintaining diverse riverine and riparian habitats. Important interactions between channel and floodplain include overflow onto the floodplain, which (1) reduces the cutting down of the channel, (2) acts as a "pressure relief valve", permitting a larger range of sediment grain sizes to remain on the channel bed, (3) increases the complexity and diversity of instream and riparian habitats, and (4) stores floodwater (thereby decreasing flooding downstream). The floodplain also provides shading, food organisms, and large woody debris to the channel. Floodplain forests serve as filters to improve the quality of water reaching the stream channel by both surface flow and groundwater. The actions necessary to reestablish active inundation will probably require major land purchases or easements, and financial incentives to move existing floodplain uses elsewhere, as has been done in the Midwest since 1993. Obviously, artificial inundation events will have to be planned to take into account other needs for stored water, including increased summer flows.

STAGE 1 EXPECTATIONS: All existing un-urbanized floodplains in the Central Valley will have been identified and a priority list for floodplain restoration projects developed. Strategies for the restoration of natural channel and floodplain dynamics will have been developed and implemented in at least two large demonstration projects. Results of initial floodplain reactivation projects will be used to increase understanding of channel-floodplain interactions and the potential for restoration of processes.

RESTORATION ACTIONS

The general target for dams and other human-made structures is to reduce or eliminate their adverse influence on ecological processes, habitats, and dependent species.

The following actions would help to restore healthy populations of Central Valley fish:

- Upgrade existing ladder systems to improve fish passage where needed.
- Construct fish ladders, where appropriate, to minimize blockages of upstream migrating anadromous fish behind weirs.
- Provide adequate fish passage, including fish ladders and appropriate attraction flows to the ladders, for small- to moderate-sized diversion dams.
- Where feasible and consistent with other uses, reconstruct diversions or remove dams to allow fish passage.

MSCS CONSERVATION MEASURES

The following conservation measures are included in the Multi-Species Conservation Strategy (2000) which provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Coordinate protection, enhancement, and restoration of occupied and historic Central Valley habitats used by listed species with other federal, state, and local programs (e.g., the SB 1086 Program, the Anadromous Fish Restoration Program, U.S. Fish and Wildlife Service recovery plans, and the Corps' Sacramento and San Joaquin River Basins Comprehensive Study) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.

- Implement applicable management measures identified in the restoration plan for the Anadromous Fish Restoration Program and the recovery plan for the native fishes of the Sacramento/San Joaquin Delta.
- Implement management measures identified in the proposed recovery plan for the Sacramento River winter-run chinook salmon.
- To the extent consistent with CALFED objectives, manage operations at the Red Bluff diversion dam to improve fish passage, reduce the level of predation on juvenile fish, and increase fish survival.
- To the extent consistent with CALFED objectives, operate physical barriers in the Delta in a manner to assist in achieving recovery goals.
- To the extent consistent with CALFED objectives, remove diversion dams that block splittail access to lower floodplain river spawning areas.
- Consistent with CALFED objectives, modify operation of the barrier at the Head of Old River to minimize the potential for drawing splittail toward the south Delta pumping plants.
- Consistent with CALFED objectives, modify operation of the Delta Cross Channel to minimize potential to increase exposure of splittail population in the Delta to the south Delta pumping plants.
- Identify and implement measures to eliminate standing of green sturgeon in the Yolo Bypass or to return stranded fish to the Sacramento River.

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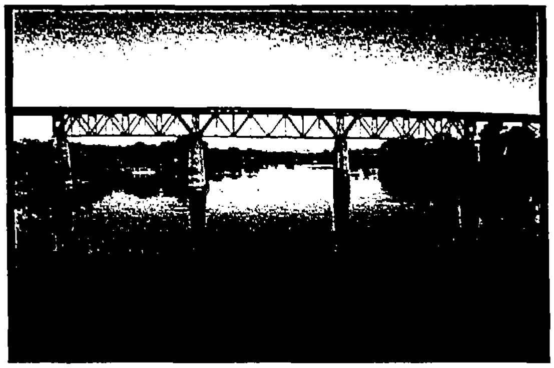
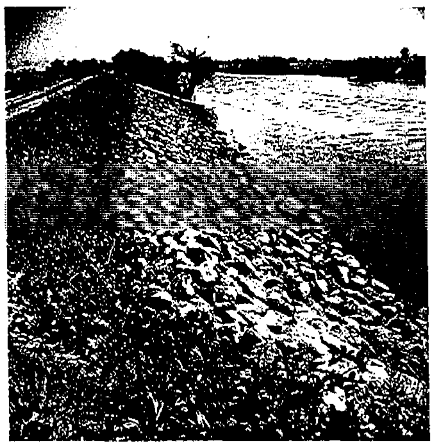
◆ LEVEES, BRIDGES, AND BANK PROTECTION





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INTRODUCTION

Three major bypass systems (Butte Basin Overflow, Yolo Bypass, and Sutter Bypass) and more than 2,000 miles of major levees confine floodflow in the Sacramento-San Joaquin Valley tributaries, rivers, and the Bay-Delta.

Levees, bridges, and bank protection structures inhibit overland flow and erosion and depositional processes that develop and maintain floodplains, and allow stream channels to meander. Levees prevent floodflows from entering historic floodplains behind levees, stopping floodplain evolution, and eliminating or altering the character of floodplain habitats. Confining floodflows to channels also increases the fluvial energy that scours or incises channel beds and reduces or halts channel meander and oxbow formation. Bridges have a similar, though generally more localized effect, on channel morphology and sediment transport.

Factors that relate to the degree of influence levees, bridges, and bank protection have on the Bay-Delta include the location and maintenance requirements of these structures.

STRESSOR DESCRIPTION

Levees were constructed in the late 19th and early 20th Century to contain the frequent flood flows. Protecting farms, towns, and cities from the devastation of floods drove levee decisions. Another driving force behind levee construction was enhancing river navigation. Thus, levees were placed near riverbanks to increase scour and prevent shoal and bar formation while making the most land available for reclamation. To further improve navigability, a fleet of "snag boats" was employed to remove fallen trees in the channel between the Delta and Red Bluff.

Each section of paired levees, constructed by State and federal projects along major rivers in the valley, is designed to carry a particular flow or flood event. Design flow is determined with the assumption that channel "roughness" (i.e., resistance to flow) will not exceed certain values. Sometimes levees fail even when floodflow is below the maximum design stage, particularly when floodflows have a long duration, such as in January 1997.

Construction materials and standards used to build the early levees would not meet present U.S. Army Corps of Engineers (Corps) structural criteria. Delta levees allowed tidally-influenced emergent marsh to be converted to productive farmland and towns.

In some cases, bank protection has been installed on channelbanks without a levee to protect the landside from erosion inside the river's active floodplain.

In some places, the width of the levees is only a little wider than the width of the channel at low flow, such as along the Sacramento River downstream of Colusa. Restricted channels typically cause deeper, faster velocities during high stage. The amount and width of potential riparian vegetation are restricted by narrow levees, and these river reaches have a low ratio of shallow-water habitats to deep, open water. Cross sections of these channels are typically trapezoidal, rather than a more natural contour with low bank angles and one or more horizontal floodplain surfaces.

Today, most of the Delta levees are higher, steeper, and therefore, pose greater potential risk of failure. This is a result of land subsidence caused primarily by the oxidation, erosion, and depletion of peat soils in the Delta. The former tule islands now resemble steep-sided bowls 5-25 feet below mean sea level.

Extensive areas in San Pablo Bay, Suisun Bay, the Delta, and the Yolo and San Joaquin basins are below mean high tide but are not subject to tidal action because of levees and flapgates. This reduces the area and water volume subject to tidal mixing and reduces the size of the Delta floodplain. Reduced residence time of Delta water and nutrients restricts the development of complex molecules and foodweb organisms. Diked tidelands also may have an artificially high concentration of salt at the surface.

Perimeter Delta floodplains and intertidal zones were formerly punctuated with many miles of low-velocity backwater channels and distributaries. Backwater channels served as nutrient, sediment, and foodweb exchange and delivery systems, as well as important rearing habitat for juvenile fish. At low tides, these branching slough systems provided several miles of mudflat and shallow shoal habitat for shorebirds, wading birds, and waterfowl. Although there are many channels on Delta islands and diked tidelands, they are isolated from the rivers and estuaries by levees. Many have been filled or drained.

Upstream of the Delta, several small and large freshwater tidal sloughs and secondary oxbow channels of the Sacramento and San Joaquin Rivers were once intertwined with main river channels. However, levee construction severed the connections. Some of these former secondary channels are still present as isolated lakes, while others have been filled or drained.

The need for extensive bank protection, primarily rock riprap, has increased because riverbanks have eroded into the narrow floodplains that typically separate levees from channelbanks, highways, railroads, or bridges. In the Delta, riprap is required to protect steep-sided levees from waves caused by wind and boat wakes in wide channels.

Most Delta levees have minimum bank vegetation, and many are covered by rock riprap. Therefore, the riparian corridor is very narrow or absent along Delta channels. In addition, the physical processes necessary to sustain floodplain habitats may be absent or diminished. Riparian vegetation is not allowed to grow on or near most levees further narrowing available habitat area. The aquatic and terrestrial habitat quality of the Delta and river corridor have declined as the percentage of riprapped levee segments increases. Tens of thousands linear feet of riprap are planned for the next phase of the Sacramento River Bank Protection Project.

Bridge spans are often much more narrow than the natural floodplain width, so bridges are usually flood stage "bottlenecks." Backwater effects during high flow may cause channel instability. Additional bank revetment and reduced vegetation are often required so flood flows may safely pass under bridges. At least 31 major bridge crossings exist on the Sacramento River, 10 each across the lower Feather and American Rivers, at least 25 on major Delta sloughs and rivers, and 18 across the lower San Joaquin River to Mossdale.

ISSUES AND OPPORTUNITIES

FLOOD MANAGEMENT AS ECOSYSTEM TOOL: The current approach is to control floods using dams, levees, bypass channels, and channel clearing. This approach is maintenance intensive, and the underlying cause of much of the habitat decline in the Bay-Delta system since 1850. Not only has flood control directly affected ecological resources, but confining flows between closely spaced levees also concentrates flow and increases flood problems downstream. With continued deterioration of flood control infrastructure, further levee failures are likely. Emergency flood repairs are stressful to local communities and resources and often result in degraded habitat conditions. An alternative approach is to manage floods, recognizing that they will occur, they cannot be controlled entirely, and have many ecological benefits. Allowing rivers access to more of their floodplains actually reduces the danger of levee failure because it provides more flood storage and relieves pressure on remaining levees. Valley-wide solutions for comprehensive flood management are essential to ensure public safety and to restore natural, ecological functioning of river channels and floodplains. Integrating ecosystem restoration with the Army Corps of Engineers' Comprehensive Study of Central Valley flood management can help redesign flood control infrastructure to accommodate more capacity for habitat while reducing the risks of flood damage (Strategic Plan 2000).

OPPORTUNITIES: Coordinate with the various levee and flood control state, local, and federal programs to establish design criteria and standards that ensure that levee rehabilitation projects incorporate features beneficial to the aquatic and riparian environments of the Delta. The majority of the approximately 50 Delta islands are hydrologically disconnected by levees from the primary channel, open-water estuarine environment. Most of these levees are likely to remain in future years and to be reinforced with rock riprap, raised and widened, or rehabilitated in other ways to prevent levee failure. Potentially beneficial projects that could be incorporated into these programs include levee setbacks and creation of broad submerged benches, as well as the construction of broader levees to support riparian vegetation. Developing contingency plans for responses to major and multiple levee failures in different parts of the Delta can also provide ecosystem benefits and minimize disturbances associated with levee repair (Strategic Plan 2000).

Mimic natural flows of sediment and large woody debris. Dams disrupt the continuity of sediment and organic-debris transport through rivers, with consequent loss of habitat, and commonly, river incision, downstream. In some cases, such as Englebright Dam on the Yuba River, the feasibility of dam removal should be evaluated as a sustainable solution to reestablishing continuity of sediment and debris transport, as well as providing access to important spawning and rearing areas. Most dams, however, cannot be removed, so methods must be sought to reestablish continuity of sediment and wood transport with the dam in place. Coarse sediment can be artificially added below dams to at least partially mitigate for sediment trapping by the dam and ameliorate the impacts of sediment-starved flows. This approach has been successfully used in Europe, using sediment from natural (landslide) and artificial sources (injected from barges). On the River Rhine, enough gravel and sand are added below the lowest dam to satisfy the present sediment transport capacity of the Rhine to prevent further incision of the bed (an average of over 200,000 cubic yards annually). On the Sacramento River, gravels have been added at a rate much below the river's transport capacity so they are vulnerable to washout at high flows. A more sustainable approach would be to add gravel (and sand) on a regular basis and at a much larger scale to better mimic natural sediment loads and therefore provide the sediment from which the river would naturally create and maintain spawning riffles. This latter approach requires a large commitment of resources and should be undertaken only in rivers where other factors (e.g., temperature regime) are favorable (or can be made favorable) for recovery of species (such as the upper Sacramento). Such opportunities will be more economical where sources of dredger tailings or reservoir Delta deposits are available nearby.

While recognizing the navigation and flood safety issues associated with large woody debris in rivers, the importance of this debris to the foodweb and structural habitat for fish should not be overlooked. There is an opportunity to investigate ways by which to pass debris safely through dams and bridges. This may require replacing some existing bridges with those less prone to trapping woody debris (Strategic Plan 2000).

VISION

The vision for levees, bridges, and bank protection is to reduce the adverse effects of these structures in order to improve riverine and floodplain habitat conditions to assist in the recovery of State- and federally listed fish species, and other fish and wildlife.

Depending on size, location, and type of habitat, setback levees can be used to create high-quality habitat nodes along low-quality, narrow sections of leveed rivers and streams. Much of the interior of central and west Delta islands are at an elevation too low for extensive levee setbacks to be feasible or desirable but should be evaluated on a case-by-case basis. Setback levees may be feasible in the east, north, and south in perimeter Delta areas, Levees set back to higher, firmer ground are more reliable and the setback zone may be available for restored habitats, or farmed part of the year.

In some cases, levees can simply be breached or removed so that the floodplain is setback to the natural shoreline. The soil could be used for restoration elsewhere. Breached-levee areas are prime candidates for restoring networks of small tidal sloughs and shallow backwater channels, increasing habitat complexity and diversity.

Some Delta islands pose overwhelming constraints to agricultural practices and levee and drainage-pump upkeep. Some are candidates for conversion to aquatic and tidal emergent wetland habitats. The Ecosystem Restoration Program Plan recommends a subsidence-control program to gradually restore island elevations.

Actions to control subsidence include:

- managing nontidal emergent and seasonal wetlands to accrete organic island soils.
- filling or raising with clean dredge materials, crop stubble, and soil material, excavated to expand floodway capacity.

Reflooded Delta islands would create a mosaic of interfaced habitat types. Depending on fill available material and island elevations, created habitats should include deep, open-water (greater than 6 feet below mean sea level), shallow-aquatic and nearshore habitats; intertidal mudflats and tule marsh; willow scrub; and mixed riparian forest. Saline areas also support halophytic plant communities such as saltgrass and pickleweed.

Several pilot projects to expand shallow, nearshore habitats along Delta channels using low benches along levees have been constructed and monitored in recent years. These designs will be refined and their application expanded. Other areas of the Delta that have more-than-adequate floodflow capacity could support more vegetation and fill in the channel. Because of the limited width of the area restored and high installation costs of this approach, this measure is considered a lower priority to levee setbacks and removal projects.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to reduce the impacts of levees, bank protection, and bridges will involve coordination with other programs. These include:

- the Upper Sacramento River Fisheries and Riparian Habitat Advisory Council (SB1086) group efforts to limit the placement of rock on banks of the river, and other river corridor management plans;
- the Corps' proposed reevaluation of the Sacramento River Flood Control Project and ongoing Bank Protection Project, including more comprehensive floodplain management and river ecosystem restoration opportunities;
- wetland restoration, under the Delta Flood Protection Act (AB360), such as Decker Island and Sherman Island habitat projects;
- proposed riparian habitat restoration and floodplain management studies, including potential new flood bypass systems and expanded river floodplains on lands recently acquired by the California Department of Parks and Recreation and U.S. Fish and Wildlife Service;
- planned and proposed restoration of diked tidelands of Suisun Marsh and San Pablo Bay and islands in the south Yolo Bypass and Delta; and
- several studies and pilot demonstration projects by the Corps, California Department of Fish and Game, California Department of Water Resources, and others to develop new alternative designs for bank revetment or biotechnical levee protection along rivers and in the Delta that allow for shoreline riparian, marsh, and shallow aquatic habitats.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Levees, bridges and bank protection adversely affect important ecological processes, habitats, and species in the ERPP Study Area. For example, bank protection limits stream channel meander, erosion, reduces opportunity for sediment deposition, and restricts opportunity to regenerate riparian and riverine aquatic habitats. In turn, fish, wildlife, and plant communities are restricted or imperiled.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

The Strategic Objective for levees, bridges, and bank protection is to reestablish floodplain inundation and channel-floodplain connectivity of sufficient frequency, timing, duration, and magnitude to support the restoration and maintenance of functional natural floodplain, riparian, and riverine habitats.

LONG-TERM OBJECTIVE: Reestablish active inundation of floodplains with area targets and inundation frequencies (1-5 years) to be set for each major alluvial river (where feasible) based on probable pre-1850 floodplain inundation regimes and on existing opportunities to modify existing land uses.

SHORT-TERM OBJECTIVE: Reestablish active inundation of at least half of all remaining unurbanized floodplains in the Central Valley, where feasible.

RATIONALE: Frequent (often annual) floodplain inundation was an important attribute of the original aquatic systems in the Central Valley and was important for maintaining diverse riverine and riparian habitats. Important interactions between channel and floodplain include overflow onto the floodplain, which (1) reduces the cutting down of the channel, (2) acts as a "pressure relief valve", permitting a larger range of sediment grain sizes to remain on the channel bed, (3) increases the complexity and diversity of instream and riparian habitats, and (4) stores floodwater (thereby decreasing flooding downstream). The floodplain also provides shading, food organisms, and large woody debris to the channel. Floodplain forests serve as filters to improve the quality of water reaching the stream channel by both surface flow and groundwater. The actions necessary to reestablish active inundation will probably require major land purchases or easements, and financial incentives to move existing floodplain uses elsewhere, as has been done in the Midwest since 1993. Obviously, artificial inundation events will have to be planned to take into account other needs for stored water, including increased summer flows.

STAGE 1 EXPECTATIONS: All existing unurbanized floodplains in the Central Valley will have been identified and a priority list for floodplain restoration projects developed. Strategies for the restoration of natural channel and floodplain dynamics will have been developed and implemented in at least two large demonstration projects. Results of initial floodplain reactivation projects will be used to increase understanding of channel-floodplain interactions and the potential for restoration of processes.

RESTORATION ACTIONS

The general target for levees, bridges, and bank protection is to reduce or eliminate adverse effects on ecological processes, habitats, and dependent species to the extent possible, and in a manner consistent with flood control.

Actions to reduce adverse effects of levees, bridges, and bank protection on the Bay-Delta ecosystem would include the following:

- Investigate the feasibility of levee setbacks along rivers.
- Investigate the feasibility of levee setbacks in the Delta.
- Convert selected Delta islands to a mosaic of deep- and shallow-water and tule-marsh habitats.
- Build innovative benches to support shoreline habitats, where levees must remain.
- Tier from on-going programs to contribute to successful implementation.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Coordinate protection, enhancement, and restoration of occupied and historic Central

Valley habitats used by listed species with other federal, state, and local programs (e.g., the SB 1086 Program, the Anadromous Fish Restoration Program, U.S. Fish and Wildlife Service recovery plans, and the Corps' Sacramento and San Joaquin River Basins Comprehensive Study) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.

- To the extent practicable, design dikes constructed in enhanced and restored saline emergent wetlands to provide optimal wetland to upland transitional habitat.
- To the extent consistent with CALFED objectives, direct ERP actions towards setting back levees in the south Delta to increase shallow water habitat.
- To the extent practicable, design setback levees in the restored Stone Lakes/Cosumnes River/White Slough habitat corridor to include a mosaic of habitats.
- Identify opportunities for implementing levee maintenance practices in the Delta that will maintain suitable levee habitat or minimize the impacts of necessary maintenance on the giant garter snake and its habitat.
- Incorporate sufficient edge habitat to support Delta mudwort in levee set back and channel island habitat restoration designs.
- Protect the Sacramento and San Joaquin river and tributary channels from physical disturbance (e.g., sand and gravel mining, dredging, and levee or bank protection and maintenance) and flow disruption (e.g., water diversion that result in entrainment and in-channel barriers or tidal gates) for the period February 1 to August 31.

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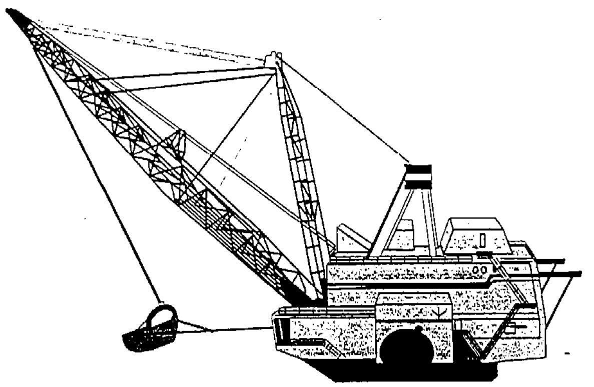
◆ Dredging and Sediment Disposal



Introduction

Dredging and sediment disposal serves a number of purposes in the Bay-Delta. Most dredging is done to maintain or deepen navigation channels, harbors, and marinas. Dredging is also required to maintain or increase flood control and water conveyance capacity and to obtain material for levee maintenance and repair. This maintenance dredging activity is required because sediments transported to the Delta tend to accumulate in deep channels and backwater areas.

Stressor Description

Approximately 2-5 million cubic yards of bottom material must be dredged from the Bay-Delta each year to maintain adequate depth for navigation channels, harbors, and marinas and to maintain flood control and water conveyance capacity. As harbors and channels are deepened to accommodate larger cargo ships, this amount is expected to increase to more than six million cubic yards per year over the next 50 years.

Dredging maintains the Stockton ship channel through the Delta along the San Joaquin River, the Sacramento deepwater ship channel, and the storage capacity in Clifton Court Forebay. Without this maintenance dredging activity, the channels and harbors would become too shallow to accommodate container ships and other heavy vessels. Lack of dredging would also increase the frequency and severity of Delta island flooding. Conveyance of freshwater from the Sacramento River to the southern Delta pumping facilities would also become less efficient.

Dredging and the disposal of dredged material are potentially harmful to the natural productivity of the Bay-Delta ecosystem. The harmful effects of dredging could be a result of the destruction or disruption of benthic communities, turbidity (muddy water) plumes, and release of organics and contaminants from sediments.

Dredge material disposal poses potential environmental problems, particularly when it contains polychlorinated biphenyls (PCBs), elevated concentrations of trace metals, or other potentially harmful constituents. The major effects of increased suspended sediment concentrations (turbidity) at sediment disposal sites are probably on fish behavior, feeding patterns, foraging efficiency, modified prey response, and habitat choice (San Francisco Estuary Project 1993).

Historically, the main disposal sites for dredged material were in the Bay near Alcatraz Island, and offshore in an area that is now within the Gulf of the Farallones National Marine Sanctuary. The Alcatraz disposal site is no longer suitable because it has become a navigation hazard. Disposal is banned in the marine sanctuary. Efforts to identify, evaluate, and prioritize alternative disposal sites are currently underway as part of the LTMS.

Dredging material is needed for agricultural stability and for use in ecosystem restoration. Fill is needed to construct setback levees, reinforce existing levees, and restore wetlands and riparian areas, channel island habitats, and other critical areas. The need for fill will be particularly acute in the lowest-lying Delta islands, some of which are 20 feet or more below sea level. One alternative for restoration efforts in subsided areas would require using fill to stop the oxidation of organic matter in peat soils. Fill material may also be required on islands that are used for continuing agricultural production.

VISION

The vision for dredging and sediment disposal in the Bay-Delta is to maintain adequate channel depth for navigation, flood control, and water conveyance while reducing the adverse effects of dredging activities on the Bay-Delta ecosystem.

Dredged material disposal would be environmentally sound and the use of nontoxic dredged material would be promoted as a resource for restoring tidal wetlands and other habitats, reversing Delta island subsidence, and improving dikes and levees.

The ERPP supports the interagency long-term management strategy (LTMS) for dredged materials in the San Francisco Bay and recommends that approximately half of the dredged material from the Bay-Delta be used to restore habitats and strengthen levees. Because one million cubic yards are equivalent to about 620 acre-feet (af), approximately one square mile (640 acres) 3 feet deep can be restored each year. The amount of high-potential tidal wetland restoration sites within the Bay is more than 10,000 acres.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

ERPP supports and seeks to extend the regional approach to dredging and sediment disposal decision making embodied in the LTMS developed by the U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, the San Francisco Bay Regional Water Quality Control Board (RWQCB), the Central Valley RWQCB, and the San Francisco Bay Conservation and Development Commission with the involvement of other agencies and stakeholder groups.

One of the objectives of the LTMS is to promote the reuse of dredged materials whenever it can be shown that there is a need for the material and placement can be done in an environmentally acceptable manner. Restoring tidal wetlands, constructing setback levees, restoring riparian areas and channel islands, and other efforts needed to restore Bay-Delta foodweb productivity and the abundance of fish, waterfowl, and wildlife populations will require fill material. Therefore, there is a great opportunity for linkage between ERPP efforts and managing dredging in the Bay-Delta to the mutual benefit of the ecosystem and the industries dependent on safe and efficient navigation in the Bay-Delta.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

The adverse effects of dredging and the disposal of dredge materials can be adjusted to contribute to restoring ecological health of the Bay-Delta. Dredge materials can be used to recreate shallow water habitats throughout the Delta. This will increase the acreage of this type of habitat and support aquatic and plant species dependent on shallow water habitat.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

The Strategic Objective for dredging and sediment disposal is Rehabilitate natural processes to create and maintain complex channel morphology, in-channel islands, and shallow water habitat in the Delta and Suisun Marsh.

LONG-TERM OBJECTIVE: To link dredging and spoil disposal with environmental restoration, reversal of subsidence, and levee maintenance.

SHORT-TERM OBJECTIVE: Reduce adverse environmental impacts and further demonstrate the beneficial reuse of dredge materials.

RATIONALE: Dredging is a necessary activity that is conducted to maintain shipping channels and channel capacity during flood flow events. Dredging can be conducted in an environmentally benign manner and clean, uncontaminated dredge spoils can be used for many uses including levee reconstruction, wetland restoration, reversal of subsidence, and the creation of shallow water habitats.

STAGE 1 EXPECTATIONS: Pilot programs that demonstrate the beneficial reuse of dredge materials for ecological purposes will have been implemented by creating wetland and shallow water habitats in the Delta and Bay.

Restoration Actions

The general target for dredging and dredge disposal is reduce the loss and degradation of habitat and to contribute sediments for the recreation of shallow water habitats.

The following actions would help to achieve this vision:

- Coordinate all actions closely with federal, State, and local agencies charged with regulating dredging activities in the Bay-Delta.
- Reduce the amount of contaminants flowing into the Bay-Delta and subsequently absorbed by Bay-Delta sediments.
- Identify alternative dredged material disposal sites including upland and ocean sites, to ensure that disposal activities are flexible and avoid undue reliance on a small number of sites.
- Maximize the reuse of dredged materials for habitat restoration and other beneficial uses and minimize the amount of disposed material that is subject to resuspension and subsequent redredging.
- Support continued research on sediment transport and deposition, sediment quality and toxicity testing, the environmental effects of suspended sediment and contaminants, and the beneficial reuse of dredged materials so that dredging and sediment disposal management will continue to improve.

MSCS Conservation Measures

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Coordinate protection, enhancement, and restoration of occupied and historic Central Valley habitats used by listed species with other federal, state, and local programs (e.g., the SB 1086 Program, the Anadromous Fish Restoration Program, U.S. Fish and Wildlife Service recovery plans, and the Corps' Sacramento and San Joaquin River Basins Comprehensive Study) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Protect the Sacramento and San Joaquin river and tributary channels from physical disturbance (e.g., sand and gravel mining, dredging, and levee or bank protection and maintenance) and flow disruption (e.g., water diversion that result in entrainment and in-channel barriers or tidal gates) for the period February 1 to August 31.
- Implement applicable management measures identified in the restoration plan for the Anadromous Fish Restoration Program and the recovery plan for the native fishes of the Sacramento/San Joaquin Delta.
- Implement management measures identified in the proposed recovery plan for the Sacramento River winter-run chinook salmon.

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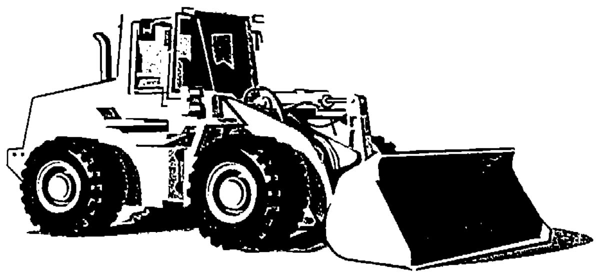
◆ GRAVEL MINING



INTRODUCTION

The natural sediment supply of Central Valley rivers and streams is composed of mineral and organic fines, sands, gravel, cobble, and woody debris (e.g., tree branches and root wads), sediments that naturally enter, transport and erode through the system. Sediment is one of the natural building blocks of the ecosystem on which many other ecological processes, functions, habitats and species depend. Gravel, for example, is important for maintaining spawning habitat of salmon and steelhead and supports many invertebrates on which young fish prey. Finer sediments and fluvial (flowing water) processes create conditions necessary to establish new riparian forests and wetlands.

Human activities have had a significant adverse effect on natural sediment processes in the Bay-Delta watershed. One of the more prominent adverse activities is the removal of sand and gravel from active stream channels. Both abandoned and active mining sites exist on virtually every stream or streamside alluvial deposit throughout the ERPP study area (Reynolds et al. 1993).

Sand and gravel mining is a valued commercial activity, but it has impaired sediment transport, gravel recruitment, and stream channel meander processes. Instream gravel extraction damages riparian vegetation, movement of groundwater, water quality, and fish and wildlife populations. In some areas, abandoned gravel pits now harbor predatory fish, serve as heat sinks that increase the ambient water temperature, or capture sediment naturally moving downstream.

STRESSOR DESCRIPTION

Development throughout the Central Valley has increased the demand for aggregate used in construction. Records of the Department of Conservation, Office of Mine Reporting and Reclamation Compliance, show that 1.53 million tons of aggregate were mined in Tehama and Shasta Counties in 1992. In Shasta County, more than half of the aggregate mined came from quarries, and was not alluvial gravel. It is also notable that in 1992, there was only one in-stream mining operation is Shasta County. County and California Department of Fish and Game permits show that up to four million tons could have been mined in the area in 1994, although the actual mined quantity may have been substantially less.

Wide-scale gravel extraction has damaged bridges, siphons, and other river-crossing structures by aggravating degradation and undermining foundations. In Glenn County, for example, the State Route 32 bridge over Stony Creek has been repaired three times at a cost of nearly $2 million. In Tehama County, the Corning Canal siphon is being exposed as the bed degrades, and repairs will cost several million dollars. The North Main Street bridge over Dibble Creek in Red Bluff has been repaired several times at a cost of more than $100,000, and the California Department of Transportation (CalTrans) has replaced the Interstate 5 bridge over Cottonwood Creek in Shasta County.

Riparian communities are affected by mining in several ways. The most obvious adverse effect is the direct removal or destruction of riparian vegetation by construction of access roads, mined areas, and storage areas. Riparian vegetation can also be lost by degradation and streambank undermining. In addition, degradation and groundwater table reductions destroy shallow-rooted riparian forest for large areas surrounding gravel mines.

Fish are directly affected by gravel removal. Anadromous fish use gravel for spawning. Salmon generally spawn in riffles with water velocities between one and 3 feet per second at a depth of between 0.5 and 3 feet. Mining activities may change riffle velocity and depth or deplete spawning-sized gravel. The Sacramento River and many of the tributaries in the Redding area have been depleted of gravel from a combination of mining and lack of gravel moving downstream from the area above Lake Shasta. In some places, the remaining substrate is too coarse for salmon spawning; in other places, bedrock is exposed over large sections of the stream.

Channel braiding caused by uniform grading during bar excavation can create conditions unsuitable for fish. Higher water temperatures are caused by lower velocities, shallower waters, and reduced vegetation cover of a braided channel. Many fish cannot survive or spawn in higher-than-normal temperatures. These effects may be avoided by maintaining a narrow and deep low-flow channel through a gravel mining area.

Instream gravel mining involves the direct removal of sand, gravel, and cobble from the channel and active floodplain of a stream. Instream mining degrades or eliminates river ecosystem functions, processes, and habitats in the following ways:

- Instream mining homogenizes the geomorphology (shape) of the river channel and its floodplain. Mining removes complex bed forms and elevated floodplains. Channels are typically widened and deepened at mining sites, creating an environment that stops downstream gravel transport. Gravel depletion can accelerate erosion and depletion of several miles of downstream gravel bars. The river will adjust to the reduced bedload by eroding valuable instream bar deposits. Therefore, instream mining causes both direct and indirect downstream loss of gravel and gravel bars.
- Historic extraction rates often exceeded the average annual yield of gravel from upstream areas. This condition further halts the downstream transport of gravel and often triggers channel incision from the upstream and downstream migration of nick points in the bed elevation as the river compensates for the loss of bedload. Instream mining may cause an increase in the downstream sediment load from fissure sediments dislodged by surface disturbance from mining or channel adjustment. Downstream sedimentation may bury spawning beds in sand and silt or suffocate fish eggs in spawning gravels. Most conditional use permits for instream mining issued in California in the last 10 to 15 years do not permit extraction rates to exceed annual yield.
- Instream mining of active channel bars and deep channel deposits is particularly disruptive to the sediment budget of alluvial streams below large dams. This is especially true where there are no major tributaries downstream of the dam to supply another source of gravel and sediment. An example of this condition is the lower American River, where instream and floodplain mining has ceased but where the only significant source of gravel and sediment is from bank and channel erosion below Nimbus Dam. Channel armoring has occurred where bars in the salmon spawning reach are primarily composed of cobbles that resist bed transport at the most common flows. The lower American River and the lower Yuba River are also depleted of fine sediment on bar deposits. There is little support for recruitment of cottonwood seedlings and saplings because these trees cannot germinate or survive in the coarse substrate during summer low-flow conditions.
- Historically, mining removed riparian vegetation, instream woody debris, and spawning redds. All vegetative cover and fluvial landforms were removed to gain access to the mining site and to clean and sort gravel for commercial use. These habitats may not have been replaced until instream mining ceases. Presently, conditional use permits issued in California usually require protection and non-disturbance of some or all riparian vegetation. In addition, many permits require concurrent reclamation, so that soil and vegetation is replaced as the mining progresses from one area to the next.
- Deep pit mines excavated in the channel and active floodplain may result in "pit capture." Deep pit mines, such as those prevalent in the tributaries to the San Joaquin River, are often separated by a wall of unexcavated river alluvium. These walls are easily eroded or overtopped by high flows. When this occurs, the river may avulse (move suddenly) from the natural channel into and through the pit, where most gravel bedload will then be captured.

When high flows recede, fish will be trapped in the instream "lakes" that are formed. Juvenile salmonids trapped in these lakes are subject to predation and high water temperatures.

- Disturbance from instream mines often leads to the invasion of undesirable non-native plants. Streams with instream mining are often sites with high rates of colonization by invasive non-native plants, such as tamarisk, eucalyptus, giant reed, and pepperweed. These species spread through displaced stem and root fragments or by prolific seed dispersal. For example, channel grading for levee construction and mining on Stony Creek, along with bank erosion, causes giant reed plants to be transported downstream and into the Sacramento River corridor. Once in the corridor, they colonize natural bars and compete with native trees and shrubs. Freshly disturbed and exposed areas at mines also offer prime invasion sites for weedy, opportunistic plant species. This situation is partially remedied by present requirements which include reclamation plans that include comprehensive revegetation with native species and eradication of non-native invasive species.

ISSUES AND OPPORTUNITIES

CHANNEL DYNAMICS, SEDIMENT TRANSPORT, AND RIPARIAN VEGETATION: There is growing recognition that dynamic river channels, free to overflow onto floodplains and migrate within a meander zone, provide the best riverine habitats. The dynamic processes of flow, sediment transport, channel erosion and deposition, periodic inundation of floodplains, establishment of riparian vegetation after floods, and ecological succession create and maintain the natural channel and bank conditions favorable to salmon and other important species. These processes also provide important inputs of food and submerged woody substrates to the channel. The most sustainable approach to restoring freshwater aquatic and riparian habitats is by restoring dynamic channel processes; however, restoration of natural channel processes is now hampered by the presence of levees and bank protection along many miles of rivers. Below reservoirs, the reductions in high flows, natural seasonal flow variability, and supply of sand and gravel have further exacerbated the constraining effect on rivers with levees and rock banks. It is therefore a priority to identify which parts of the system still have (or can have) adequate flows to inundate floodplains and sufficient energy to erode and deposit, and to identify floodplain and meander zone areas for acquisition or easements to permit natural flooding and channel migration. Sediment deficits from in-channel gravel mining should also be identified and the feasibility or efficacy of augmenting the supply of sand and gravel in reaches below dams should be evaluated (Strategic Plan).

OPPORTUNITIES: Mimic natural flows of sediment and large woody debris. Dams disrupt the continuity of sediment and organic-debris transport through rivers, with consequent loss of habitat, and commonly, river incision, downstream. In some cases, such as Englebright Dam on the Yuba River, the feasibility of dam removal should be evaluated as a sustainable solution to reestablishing continuity of sediment and debris transport, as well as opening access to important spawning and rearing areas. Most dams, however, cannot be removed, so methods must be sought to reestablish continuity of sediment and wood transport with the dam in place. Coarse sediment can be artificially added below dams to at least partially mitigate for sediment trapping by the dam and ameliorate the impacts of sediment-starved flows. This approach has been successfully used in Europe, using sediment from natural (landslide) and artificial sources (injected from barges). On the River Rhine, enough gravel and sand are added below the lowest dam to satisfy the present sediment transport capacity of the Rhine to prevent further incision of the bed (an average of over 200,000 cubic yards annually). On the Sacramento River, gravels have been added at a rate much below the river's transport capacity so they are vulnerable to washout at high flows. A more sustainable approach would be to add gravel (and sand) on a regular basis and at a much larger scale to better mimic natural sediment loads and therefore provide the sediment from which the river would naturally create and maintain spawning riffles. This latter approach requires a large commitment of resources and should be undertaken only in rivers where other factors (e.g., temperature regime) are favorable (or can be made favorable) for recovery of species (such as the upper Sacramento). Such opportunities will be more economical where sources of dredger tailings or reservoir Delta deposits are available nearby.

While recognizing the navigation and flood safety issues associated with large woody debris in rivers, the importance of this debris to the foodweb and structural habitat for fish should not be overlooked. There is an opportunity to investigate ways by which to pass debris safely through dams and bridges. This may require replacing some existing bridges with those less prone to trapping woody debris.

Identify and conserve remaining unregulated rivers and streams and take actions to restore natural processes of sediment and large woody debris flux, overbank flooding, and unimpaired channel migration. Most rivers in the Central Valley are regulated by large reservoirs and therefore require considerable investment to recreate the natural processes needed to sustain true ecosystem restoration; however, a few large unregulated rivers still exist, such as the Cosumnes River and Cottonwood Creek. Lowland alluvial rivers and streams with relatively intact natural hydrology should be identified and made a high priority for acquisition of conservation and flooding easements, setting back of levees, and other restoration actions because such actions on these rivers are likely to yield high returns in restoration of natural processes and habitats and, ultimately, fish populations.

Undertake fluviogeomorphic-ecological studies of each river before making large investments in restoration projects. River ecosystem health depends not only on the flow of water, but on the flow of sediment, nutrients, and coarse woody debris and on interactions between channels and riparian vegetation, variability in flow regime, and dynamic channel changes. It is only through interdisciplinary, watershed, and historical scale studies that the constraints and opportunities particular to each river can be understood. For example, it was only after a fluviogeomorphic study of Deer Creek that the impact of flood control actions on aquatic and riparian habitat was recognized, a recognition that has lead to a proposal for an alternative flood management approach designed to permit natural river processes to restore habitats along Lower Deer Creek.

VISION

The vision for gravel mining is to improve gravel transport and cleansing by reducing the adverse effects of instream gravel mining.

Achieving this vision would help to maintain or restore flood, floodplain, and streamflow processes that govern gravel supply to improve fish spawning and floodplain habitats.

Opportunities to achieve the vision for gravel mining include reducing or eliminating instream gravel extraction by relocating gravel mining operations to alluvial deposits outside active stream channels and riparian zones and introducing gravel in deficient areas in streams until natural processes are restored to a level that will provide sufficient quantities. The Ecosystem Restoration Program Plan (ERPP) supports channel design or levee construction projects consistent with restoring floodplains to ameliorate this problem. In certain situation, gravel mining is used as a surrogate for adequate flood control to prevent flooding, for bank protection, and to protect structures.

One strategy to achieve this vision is to identify alternative sources of gravel for fishery restoration and other uses instead of extracting gravel for these purposes from active stream channels. Potential impacts and mitigations for in-stream mining, gravel bar skimming and terrace gravel operations should be evaluated on a case-by-case basis, and could be permitted, provided that an acceptable stream management and reclamation plan is prepared, funded, and implemented. However, portland cement concrete grade aggregates are found only in in-stream and terrace deposits. Materials from other sources may not be as suitable as in-stream aggregates.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Programs sponsored by other agencies that would also help to achieve the ERPP vision for gravel mining and recruitment include:

- county-sponsored instream mining and reclamation ordinances and river and stream management plans, such as new gravel and stream management plans approved in Butte and Yolo Counties;

- the State Department of Conservation's reclamation planning assistance programs under the Surface Mining and Reclamation Act;
- Anadromous Fish Restoration Program gravel replenishment programs and plans and small dam removal and/or fish ladder rehabilitation projects (USFWS 1997);
- the San Joaquin River Parkway plan; and
- efforts by the State Department of Conservation and counties to identify alternative sources of commercial sand and gravel in reservoir deltas, floodplain terrace deposits, old dredger mining cobble deposits, and hardrock sites.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Gravel and sand extraction activities have the potential to adversely effect several important ecological processes, habitats, and the dependent species. Ecological processes include natural sediment supply and stream channel meander. Riparian and riverine aquatic habitat is the most common habitat that is adversely effected by gravel mining. Many fish, wildlife, and plant species are dependent on gravel beds, sediment, and riparian corridors. These are reduced by gravel mining. However, careful planning and mitigation of gravel operations can eliminate adverse impacts.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

The Strategic Objective is to restore coarse sediment supplies to sediment-starved rivers downstream of reservoirs to support the restoration and maintenance of functional natural riverine, riparian, and floodplain habitats.

LONG-TERM OBJECTIVE: Implement a comprehensive sediment management plan for the Bay-Delta system that will minimize problems of reservoir sedimentation and sediment starvation, shift aggregate extraction from rivers to alternate sources, and restore continuity of sediment transport through the system to the extent feasible.

SHORT-TERM OBJECTIVE: Develop methods and procedures to end gravel deficits below dams and mining operations; prioritize for correction existing streams with major deficit problems and initiate action on at least 10 streams.

RATIONALE: One of the major negative effects of dams is the capture of coarse sediments that naturally would pass on to downstream areas. As a result, the downstream reaches can become sediment starved, producing "armoring" of streambeds in many (but not all) rivers to the point where they provide greatly reduced habitat for fish and aquatic organisms and are largely unsuitable for spawning salmon and other anadromous fish. This objective can be accomplished by a wide variety of means, but most obviously through artificial importation of gravel and sand. Other possible actions include: (1) explore the feasibility of passing sediment through small reservoirs; (2) remove nonessential or low-value dams; (3) eliminate instream gravel mining on channels downstream of reservoirs, and limit extraction on unregulated channels to 50% of estimated bedload supply or less (or to levels determined not to negatively impact fish and other ecological resources); (4) develop incentives to discourage mining of gravel from river channels and adjacent floodplain sites; and (5) develop programs for comprehensive sediment management in each watershed, accounting for sediment trapped by reservoirs, availability of sediment from tributaries down stream of reservoirs, loss of reservoir capacity, release of sediment-starved water downstream, channel incision and related effects, and the need for sources of construction aggregate.

STAGE 1 EXPECTATIONS: Sediment-starved channels in the Bay-Delta system will have been identified; strategies to mitigate sediment starvation, such as shifting mining of gravel from river channels to alternate sources, adding gravel below dams, and removing nonessential dams will have been developed; demonstration projects will have been implemented (and monitored) to mitigate sediment starvation in at least six rivers.

Restoration Actions

The general target for gravel mining is work with local counties and the aggregate resource industry to relocate gravel extraction operations to areas outside the active stream channel.

Three actions to reducing the adverse effects of gravel mining include the following:

- Promote alternative gravel sources. ERPP recommends providing education and other incentives to encourage counties and mining companies to seek new off-channel sources of aggregates, including high terraces outside the active floodplain, recycled concrete, crushed cobbles from old abandoned dredge spoils, and deep pit mines away from river migration corridors. New permits for these aggregate sources can be issued in exchange for phasing out instream mines.
- Limit the extent of disturbance at instream mines. If alternative sources of aggregate are not a viable short-term solution, permits should require an undisturbed corridor of riparian vegetation and natural bar deposits adjacent to existing mines. In addition, extraction rates should be limited to the estimated yield from upstream each year. This rate will vary annually and must be verified by aerial topographic analysis or field surveys at permanent transects.
- Prevent or reduce the effects of pit capture. Deep pits should be adequately separated from the channel and measures should be taken to ensure that bank material and vegetation will resist channel migration in the direction of the pits. Alternatively, permits should require that inchannel pits be filled with overburden to the elevation of the channelbed.

MSCS Conservation Measures

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Coordinate protection, enhancement, and restoration of occupied and historic Central Valley habitats used by listed species with other federal, state, and local programs (e.g., the SB 1086 Program, the Anadromous Fish Restoration Program, U.S. Fish and Wildlife Service recovery plans, and the Corps' Sacramento and San Joaquin River Basins Comprehensive Study) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Protect the Sacramento and San Joaquin river and tributary channels from physical disturbance (e.g., sand and gravel mining, dredging, and levee or bank protection and maintenance) and flow disruption (e.g., water diversion that result in entrainment and in-channel barriers or tidal gates) for the period February 1 to August 31.

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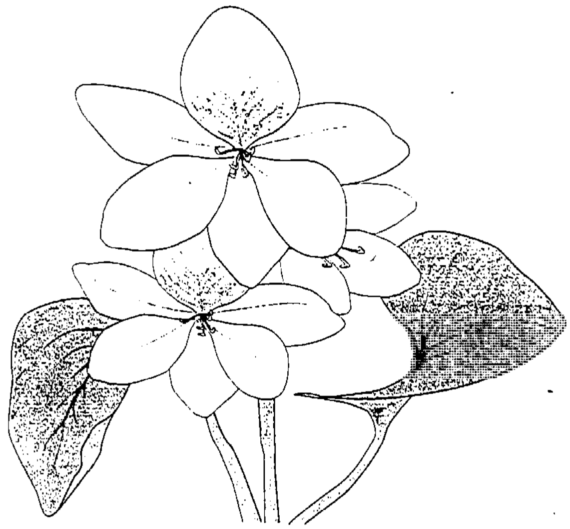
◆ INVASIVE AQUATIC PLANTS



INTRODUCTION

Weeds, or invasive plant species, are types of vegetation capable of exploiting opportunities afforded by natural or human-related disturbances in the landscape, as well as those provided by relatively undisturbed habitats. Although not all weeds are non-native, most have been introduced from other parts of the world.

Invasive aquatic plants have become sufficiently established in some locations to threaten the health of the Bay-Delta ecosystem. The aquatic plants that pose the greatest threats to aquatic ecosystems are those that directly or indirectly affect rare native species, decrease foodweb productivity, and reduce populations of desired fish and wildlife species.

Factors that relate to the degree of influence invasive aquatic plants have on the Bay-Delta include additional introductions from ship ballast and other sources and local water quality and hydrologic conditions that favor their establishment.

STRESSOR DESCRIPTION

Lacking the controls found in their native habitat (e.g., specific insects for which they are a food source or toxins produced by competing plants), these plants can flourish in a new landscape, gaining a competitive advantage over the native species. Many weeds have evolved characteristics that make them extraordinarily competitive in both natural and introduced environments, such as high seed production; mechanisms for effective seed dispersal; rapid growth rate; and adaptability to extremes in temperature, nutrients, and water availability.

A species is considered a weed problem because of its ability to adversely affect natural communities or human land use requirements. Introduced or native aquatic plant species are considered harmful when they reduce the biological diversity of existing natural communities by displacing native species or altering ecosystem processes such as nutrient cycling, hydrologic conditions, or water chemistry. They create problems for human society when they impair agricultural or aquacultural productivity, constrict waterways, diminish recreation and aesthetic values, or destroy structures.

Most aquatic weeds were introduced to California waterways unintentionally. They were brought in as pond ornamentals (e.g., water hyacinth) and aquarium plants (e.g., hydrilla), or through dispersal by boats. Aquatic weeds have been here for at least 100 years; water hyacinth was discovered in a Yolo County slough in 1904. Hydrilla, which was probably introduced through its use as an aquarium plant, has been in California for at least 20 years. Egeria, still a popular aquarium plant, has been in the ecosystem for over 30 years.

Most aquatic weeds pose a threat to the aquatic foodweb and rare aquatic or riparian species because they form dense mats that block sunlight or deplete oxygen supplies. The sheer mass of floating tissue can also impede navigation and damage water control structures. Establishment of invasive aquatic plants can harm or kill rare and valued fish, native plants, and other aquatic organisms; reduce biodiversity; impede navigation; damage water control structures; and increase mosquito habitat.

Many stream and river channels in the Delta and the Sacramento and San Joaquin Rivers and their tributaries have been channelized, confined by levees, impounded, and otherwise altered from their shapes of 150 years ago. With the conversion of adjacent riparian communities to other land uses, the ecosystem processes and functions have changed substantially. These changes stress native aquatic flora and fauna, leading to changes in species composition and population densities, and perhaps making the aquatic foodweb more vulnerable to further stressors.

Most weeds that infest the Delta and the Sacramento and San Joaquin Rivers and their tributaries are problems in specific locations, not throughout these waterways; however, locations of aquatic weeds have not been comprehensively mapped. The California Department of Food and Agriculture's Integrated Pest Control Branch records locations where aquatic weeds, such as hydrilla, pose a threat to agriculture. Locations of weeds that threaten natural areas are not recorded. Comprehensive mapping throughout the ERPP study area is needed for all weeds that threaten aquatic habitat as a first step to monitoring and controlling infestations.

Some non-native aquatic weeds that pose the most serious threats and need further research, monitoring and mapping, or control are egeria, hydrilla, water hyacinth, water pennywort, eurasian watermilfoil and parrot feather. Each of these is described below. These weeds flourish in a wide geographic area, sometimes in high densities, and are extremely dangerous because of their ability to displace native plant species, harm fish and wildlife, reduce foodweb productivity, or interfere with water conveyance and flood control systems.

EGERIA (*Egeria densa*; syn: *Elodea densa*): A native of South America, egeria is a popular aquarium plant, which most likely accounts for its introduction into California waterways. It is a submerged, rooted perennial that occupies the same littoral zone niche in slow-moving water as native pondweeds, thereby potentially excluding the pondweeds and reducing the habitat value for waterfowl that eat pondweeds. Egeria creates a structure having much more branching than pondweeds. It forms dense mats that block sunlight and reduce the amount of open water, leading to increased accretion of organic material and increased sedimentation. The dense mat structures may impede diving waterfowl from foraging, and the increased sedimentation may alter the population of benthic species and their predators.

Egeria has been in the Delta for perhaps 30 years or more but probably was not a major problem until the past 12 years, coinciding with the water hyacinth control program. Removing water hyacinth from waterways and a 6-year drought may have contributed to the expansion of coverage by egeria (Anderson pers. comm.).

Egeria currently infests approximately 3,000 acres, primarily in the Delta. The success of this infestation in the Delta is indicative of the greater success that hydrilla would have if it were not prevented from establishing there. Hydrilla, unlike egeria, has long-lived rhizomes, making it much more difficult to control. Egeria is listed as a "B"-rated noxious weed by the California Department of Food and Agriculture's Noxious Weed Program. This designation does not mandate its control and, because the species is so widespread, little attention has been paid to controlling it. Now that growing populations are increasingly obstructing water conveyance structures and natural wetlands, the California Department of Boating and Waterways is given $500,000 per year to control egeria along with water hyacinth (Anderson pers. comm.). Returning native pondweeds to an egeria-infested site would probably require active restoration once the egeria is removed.

HYDRILLA (*Hydrilla verticillata*): A submerged perennial, hydrilla was introduced to North American waterways sometime after 1956 through its use as an aquarium plant. It has since spread throughout the country, infesting waterways, irrigation canals, lakes, and ponds. It can completely fill and clog waterways, restricting flow, increasing sedimentation, and hindering navigation and public water use. Like egeria, hydrilla forms dense mats that block light, deplete oxygen, and increase sedimentation and organic deposition. In slow-moving water and oxbows, hydrilla can deplete oxygen and resources to the point of causing fish kills. Unlike egeria, however, hydrilla forms rhizomes that live 5-7 years and from which new plants can grow. Because of the persistence of rhizome viability, hydrilla will be much more difficult to remove from the Delta, if it establishes there, than egeria.

Hydrilla is an "A"-rated weed in the California Department of Food and Agriculture's Noxious Weed Program. This designation means that the plant poses a serious problem to agriculture but may be contained through control efforts. Since 1976, when it was first noticed, the California Department of Food and Agriculture has spent $20 million to eradicate hydrilla (California Exotic Pest Plant Council Biocontrol Committee 1995). Hydrilla has been found in 17 counties in California and has been eradicated from nine counties. Thus far, it has been prevented from establishing in the Delta. An example of its invasiveness can be seen in Clear Lake in northern California, where it now covers about 650 acres of the lake's 43,000-acre surface area.

WATER HYACINTH (*Eichhornia crassipes*): A floating perennial, water hyacinth is native to South America. It infests streams, ponds, backwater areas, ditches, sloughs, and waterways. It grows rapidly in the summer, floating and spreading by means of buoyant stolons and seed. Water hyacinth was introduced to the United States in 1884 when it was given to visitors as souvenirs at the Cotton States Exposition. Water hyacinth was first reported in California in a Yolo County slough in 1904. Today, it is a serious pest in the Delta, the Sacramento and San Joaquin Rivers, and many sloughs and tributaries, where it clogs waterways, obstructs commercial and recreational navigation, and impedes water conveyance.

Water hyacinth is also a serious problem for the pumping and fish-screening facilities in the south Delta. Forming a dense cover over the water surface, it blocks sunlight, reduces water flow, depletes oxygen, and inhibits gaseous interchange with the air, all of which harm other aquatic organisms. Water hyacinth increases mosquito habitat by providing larval breeding sites where mosquito predators cannot reach. In backwater areas, dense concentrations of water hyacinth can increase fish mortality. It also increases sedimentation and the accretion of organic matter. Water hyacinth reportedly competes with Mason's lilaeopsis (*Lilaeopsis masonii*), an endangered freshwater emergent plant native to California (Van Ways pers. comm.).

In 1982, the California Department of Boating and Waterways formed a task force to begin controlling water hyacinth, testing different mechanical and herbicidal control methods. In 1996, the department spent $900,000 to treat 1,750 acres of water hyacinth, mostly in the central and southern Delta (Van Ways pers. comm.). Some control efforts involve aerial spraying of herbicides, but in many areas herbicides must be applied from boats. Since water hyacinth control began, egeria populations have expanded. Egeria clogs boat propellers quickly and has made continued control of water hyacinth much more difficult. As a result, the department has now been given approval and funding to control both egeria and water hyacinth.

WATER PENNYWORT (*Hydrocotyle umbellata*): A perennial native plant, water pennywort grows along streambanks and in ponds, canals, and marshy areas. It forms stems that float and creep along wet soil. Although it takes root, plants also break off and form dense, floating rafts that drift. These rafts can cause some of the same problems seen with water hyacinth. Since water hyacinth has been controlled, the pennywort population has increased and become a weed problem in some areas. (Anderson pers. comm.).

EURASIAN WATERMILFOIL (*Myriophyllum spicatum*) and **PARROTFEATHER** (*Myriophyllum aquaticum*): Both Eurasian watermilfoil and parrotfeather are submerged perennials. Eurasian watermilfoil, as its name suggests, is native to Eurasia; parrotfeather is native to South America. Parrotfeather is sold in nurseries for aquariums and backyard ponds. Eurasian milfoil is much more abundant statewide than parrotfeather; however, no comprehensive surveys have measured the extent of these two weeds. Because Eurasian milfoil has not created a specific problem for agriculture, it has not been targeted for control. An example of a Eurasian milfoil infestation is in Lake Tahoe, where it covers about 200 surface acres, mostly in the marina area. Parrotfeather is found in seasonally wet streams, small lakes, and flood control channels. An example of its infestation is found in Parks Lake on Beale Air Force Base.

Like hydrilla and egeria, both of these plants occupy areas where native pondweeds would grow. Eurasian milfoil grows mostly submerged, whereas parrotfeather extends above the water. The growth form of parrotfeather results in substantial increases in mosquito habitat. Although both plants may present problems, they can be beneficial to aquatic habitat as well. Parrotfeather is thought to provide cover for aquatic organisms, and Eurasian milfoil stems and fruits are eaten by waterfowl (Westerdahl and Getsinger 1988).

ISSUES AND OPPORTUNITIES

Develop means to control invasive aquatic plants in the Delta. Invasive plants, such as water hyacinth and Egeria densa (Brazilian water weed), are clogging many sloughs and waterways of the Delta, not only impeding boat traffic, but also creating environments that are unfavorable for native fishes. The California Department of Boating and Waterways has an Egeria control program, but has not yet received CEQA approval for use of chemical controls. There is an immediate need to develop ways by which to control these plants that are not, in themselves, environmentally harmful. An opportunity exists for the ERP to join forces implementing ambitious eradication and control measures with agencies, organizations, and water districts concerned with the deleterious effects of these water weeds on navigation in the Delta, clogging of water intakes and fish screens, and diminished recreational uses (Strategic Plan 2000).

VISION

The vision for invasive aquatic plants is to reduce their adverse effects on native species and ecological processes, water quality and conveyance systems, and major rivers and their tributaries.

Active management of Delta streams and rivers is necessary to reduce the surface area of channels and sloughs in the Delta that are covered by water hyacinth and other invasive aquatic plant species. To effectively control aquatic weeds, existing programs will need to be expanded and funded or new programs created. Currently, locations for hydrilla and noxious weeds that pose a threat to agriculture are reported as part of the California Department of Food and Agriculture's Integrated Pest Control Program; however, weeds posing a threat to natural habitats are not mapped. An improved mapping and monitoring program that efficiently maps and monitors all targeted weeds will aid in their control, especially for rapidly spreading species. Such a program will also help to assess changes in the population levels and the effectiveness of control programs. Expanding California's noxious weed program to include weeds that pose a threat to native species or habitats would also aid in building an effective long-term aquatic weed control program.

To facilitate effective control programs for these species, all groups involved must coordinate with one another to control and restore habitat in Delta waterways. A coordinated approach to eliminate all damaging weeds, rather than only selected weed species, can reduce instances where one weed infestation replaces another, as exemplified by the increases in egeria and pennywort populations following efforts to control water hyacinth. In addition, regulatory agencies and those obligated to implement control programs must coordinate their efforts to plan and implement those programs that are appropriate to meet the specific needs of each site. Because the ecological, recreational, water quality, water conveyance, and commercial needs vary at each site, a general control strategy or regulatory policy is not possible. The specific needs of a site must be assessed and the costs and risks of different control strategies must be compared to determine the most appropriate strategy for each site. As a result, some sites will require more restrictive strategies than others.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

The California Department of Food and Agriculture's Integrated Pest Control Branch tracks and controls federally listed noxious weeds throughout the State. These are weeds that have an impact on agriculture, although most of the current infestations are restricted to natural and uncultivated areas. Listed weeds are given a letter designation: "A" weeds are tracked and targeted for control or eradication wherever they are found; "B" weeds are considered too widespread to require mandated control of them, and the decision to control them is left to the county agricultural commissioners; "C" weeds are so widespread that the agency does not endorse State- or county-funded eradication or control efforts except in nurseries and seed lots.

Of the weeds described in this vision statement, only hydrilla is listed as a noxious weed. With funding, the California Department of Food and Agriculture's Integrated Pest Control Branch could be expanded to include weeds that adversely affect natural areas and their existing infrastructure and the expertise of that branch could be used to track, map, and control weeds that pose problems in natural areas.

Two recently announced programs or policy changes may have a beneficial effect on the vision for controlling invasive non-native aquatic and riparian weeds. The first is a new weed policy developed by the U.S. Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) that regulates not only weeds that threaten agricultural or managed areas, but those affecting natural areas as well. This program will use a risk assessment to identify weeds federally listed as noxious. Among other aspects of the new policy, APHIS will have a regulatory role, detecting, assessing, and containing incipient infestations. The policy states that APHIS will act in a federal coordination role to facilitate communication and cooperation among relevant public agencies and others (Westbrooks 1995).

The second new approach was formed through a Memorandum of Understanding (MOU) signed in 1994 by 17 land-holding federal agencies. The Federal Interagency Committee for Management of Noxious and Exotic Weeds was formed, under the MOU, to enable the signing agencies to cooperatively manage noxious and non-native weeds on federal lands and to provide technical assistance on private land to achieve sustainable, healthy ecosystems that meet the needs of the society (Jackson 1995).

Many other organizations have weed issues in the Delta, all with different roles, interests, and expertise. Implementing the ERPP vision requires a coordinated effort among these groups to develop and implement weed management programs and strategies that will help meet ERPP's goals for the various resources and ecological management zones.

- The U.S. Department of Agriculture - Agricultural Research Service Aquatic Weed Control Research Laboratory in the Department of Vegetable Crops at the University of California at Davis conducts ongoing research on aquatic weed control.
- The California Weed Science Society is a 50-year-old organization serving the weed science community.
- The California Exotic Pest Plant Council is a nonprofit organization that focuses on issues regarding non-native pests and their control and educates the public on these issues.
- The U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation, California Department of Fish and Game, State Water Resources Control Board, Central Valley Regional Water Quality Control Board, California Department of Food and Agriculture, and California Department of Health Services have regulatory or programmatic roles pertaining to aquatic weed control in the Delta and the Sacramento and San Joaquin Rivers and their tributaries.

In addition to these, several public and private groups deal directly or indirectly with aquatic weeds in the Delta. Among them are:

- California Native Plant Society,
- The Nature Conservancy,
- the State and national parks systems, county and local parks departments,
- Animal and Plant Health Inspection Service ,
- U.S. Army Corps of Engineers,
- U.S. National Resources Conservation Services,
- Center for Natural Lands Management,
- resource conservation districts, mosquito abatement districts, flood control districts,
- California Association of Nurserymen,
- local land trusts,
- and private landowners.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Invasive aquatic plants adversely influence other ecosystem elements including ecological processes, habitats, and species. For example, introduced species have out competed and displaced many native species. The proliferation of exotic plants has impaired the proper functioning of fish protective devices such as fish screens and fish louvers in the Delta.

OBJECTIVES, TARGETS, AND ACTIONS

Two Strategic Objectives address invasive aquatic plants.

> The first Strategic Objective is to halt the introduction of invasive aquatic and terrestrial plants into the Bay-Delta estuary, its watershed, and other central California waters.

LONG-TERM OBJECTIVE: Halt the release and spread of aquarium organisms, exotic plants and aquatic pets in the Bay-Delta Watershed.

SHORT-TERM OBJECTIVE: Develop and institute strategies, working with the aquarium industry and interests representing the environment and other sectors that may be affected by such introductions, to halt the introduction and spread of non-native species and exotic plants from the aquarium and pet trades.

RATIONALE: Many kinds of aquatic organisms are sold in aquarium and pet stores. It is likely that some species of nuisance aquatic plants (e.g., Hydrilla) became established through aquarists dumping them in local waterways. Non-native turtles originating in pet stores are frequently present in ponds and have the potential to displace and spread diseases to native pond turtles. Although many organisms sold in aquarium stores are tropical and unlikely to survive in Central California (with some surprising exceptions), the industry is constantly searching for and bringing in new species from a variety of habitats. As indicated in the ballast water rationale, new species can have unexpected and sometimes large-scale negative impacts on aquatic ecosystems and can make restoration much more expensive and difficult. There clearly is a need to make sure that potentially harmful organisms are not available to aquarists and that new organisms are not brought in as "hitch-hikers" in shipments of aquarium fishes. There is also a need to better educate the public on the adverse impacts of invasive species and the need to not release aquatic pets into natural environments. A good model for this could be the program now in place in Hawaii, which (among other things) has a big public education component and requires all aquarium stores to have a special tank into which people can release unwanted aquatic organisms.

STAGE 1 EXPECTATIONS: Species in the aquarium and pet trades will have been identified and evaluated for their ability to establish populations in the Bay-Delta system. With the cooperation of the aquarium/pet industry and affected interests, a plan will have been developed and instituted to greatly reduce, and eventually eliminate, the introduction of unwanted aquatic organisms from these sources into natural waters.

> The second Strategic Objective is to limit the spread or, when possible and appropriate, eradicate populations of nonnative invasive species through focused management efforts.

LONG-TERM OBJECTIVE: Eliminate, or control to a level of little significance, all undesirable non-native species, where feasible.

SHORT-TERM OBJECTIVE: Eradicate or contain those species for which this can readily be done, gaining thereby the largest benefit for the least economic and environmental cost; and to monitor for the arrival of new invasive species and, where feasible, respond quickly to eradicate them.

RATIONALE: Non-native species are now part of most aquatic, riparian, and terrestrial ecosystems in California. In most instances, control is either not possible or not desirable. However, in some instances, control of invasive species is needed to protect the remaining native elements or to support human uses. Four factors should be considered in focusing control efforts. First, an introduced species is often not recognized as a problem by society until it has become widespread and abundant. At that point, control efforts are likely to be difficult, expensive, and relatively ineffective, while producing substantial environmental side effects or risks, including public health risks. Second, some organisms, by nature or circumstance, are more susceptible to control than others. Rooted plants are in general more controllable than mobile animals, and organisms restricted to smaller, isolated water bodies are in general more controllable than organisms free to roam throughout large, hydrologically connected systems. Third, although biological control is conceptually very appealing, it is rarely successful and always carries some risk of unexpected side effects, such as an introduced control agent "controlling" desirable native species. And fourth, physical or chemical control methods used in maintenance control rather than eradication require an indefinite commitment to ongoing environmental disturbance, expense, and possibly public health risks. Overall, the most efficient, cost-effective, and environmentally beneficial control programs may be those that target the most susceptible species, and species that are not yet widespread and abundant. This suggests a need to (1) assess the array of introduced species and focus on those that are most amenable to containment and eradication, rather than focusing just on those that are currently making headlines, and (2) responding rapidly to eradicate new introductions rather than waiting until they spread and become difficult or impossible to eradicate.

An example of a "rare" introduced species needing eradication that is not being dealt with is English cordgrass in the Bay. It has been described by some scientists as the most aggressive and invasive salt marsh plant in the world. It has been in the Bay, its only known California location, for 20 years without spreading, so it has not generated concern. However, in other parts of the world it has also sometimes sat around for a few decades without doing much of anything, then suddenly taken off and taken over entire estuaries in a few years. In San Francisco Bay, it is known from one site only, where it was planted, and where it exists in a single patch. It could readily be eradicated.

An example of an abundant species needing immediate attention is the water weed Egeria densa. This plant has been spreading rapidly through the Delta, where it clogs sloughs and channels with its dense growth, creating problems for navigation. From a biological perspective, it is undesirable because E. densa beds appear to exclude native fishes and favor introduced species.

STAGE 1 EXPECTATIONS: An assessment will be completed of existing introductions to identify those with the greatest potential for containment or eradication, and consider this in prioritizing control efforts. A program will have been implemented to monitor for, and respond quickly to contain and eradicate new invasions, where this is possible. A mechanism whereby new invasions can be dealt with quickly and effectively will have been developed an implemented.

RESTORATION ACTIONS

A comprehensive strategy to reduce invasive aquatic plants and their adverse effects on the Bay-Delta ecosystem would include the following items.

- Assess aquatic weeds for their level of threat, their extent, and their potential to be controlled in the long run.
- Assess potential weed control sites to determine how effective control efforts will be in improving habitat quality, the longevity of results, and the sites' likelihood of providing the types of habitats and habitat characteristics proposed for restoration.
- Develop and implement management plans to achieve specific targets for each weed and site.
- Implement habitat restoration (e.g., planting native pondweeds and other desirable aquatic and emergent wetland plants) concurrent with or following implementation of control measures, where appropriate.
- Eradicate water hyacinth from major tributaries and marinas, locks, important wetland areas, and wildlife refuges in the Sacramento-San Joaquin Delta Ecological Zone.
- Elsewhere, reduce the biomass of infested acreage to a lower maintenance level than of the present summer cover. This goal would be approached beginning in the tributaries entering the Delta, and aiming for total eradication there; then water hyacinth will be contained at maintenance levels in upstream locations.
- Provide technical expertise, serve as a clearinghouse for regional information and project results, and assist with implementation of high-priority local projects in specific ecological units or zones to increase the effectiveness of existing public and private programs to reduce the threat of invasive species.

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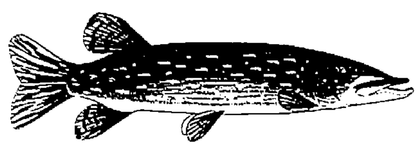
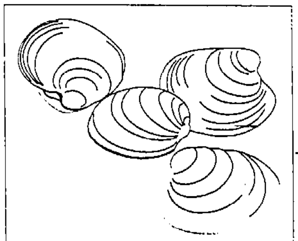
◆ INVASIVE AQUATIC ORGANISMS



Northern Pike



Asian Clams

INTRODUCTION

Most of the clams, worms and other bottom-dwelling invertebrates presently inhabiting the Bay-Delta are introduced from other estuaries. Non-native species also make up an increasing proportion of the zooplankton and fish communities of the Bay-Delta. It is estimated that a new non-native species is identified in the Bay-Delta every 15 weeks.

Many species were transported on the hulls of ships or in ship ballast water. Others arrived with the Atlantic or Japanese oysters purposely introduced into the estuary earlier in this century. Many fish, including striped bass, American shad, and largemouth bass, were introduced by federal and State resource agencies to provide sport fishing or forage fish to feed sport fish. Others, such as the northern pike, in a western Sierra reservoir, were purposely and illegally introduced.

Whether accidental or intentional, the introductions of these organisms have greatly increased the species diversity of the Bay-Delta aquatic community. However, this increase in diversity has occurred at the expense of native species, some of which have declined precipitously or even become extinct because of predation and competition from non-natives. Some introduced species are nuisances because they attach to boat hulls, bore into dock pilings, clog drainage pipes, tunnel into levees, or compete with or prey on valuable native species. Many non-native species, however, perform vital ecological functions such as serving as primary consumers of organic matter, or as a food source for Bay-Delta fish, shorebird, waterfowl, and other wildlife populations. Many non-native species have invaded the Bay-Delta successfully by filling new habitat niches that previously did not exist. Restoration of natural habitats with more natural flow regimes and hydraulic conditions throughout the Bay-Delta will hopefully favor native species. Continued study of the effects of non-native species on the abundance and distribution of native species and on the rest of the Bay-Delta ecosystem will be part of the adaptive management program guiding these restoration efforts.

STRESSOR DESCRIPTION

Invasive aquatic organisms are those non-native fish and invertebrates that have invaded the Bay-Delta at the expense of native species. Non-native aquatic invertebrates of the Bay-Delta include a wide variety of sponges, coelenterates, worms, molluscs, and crustaceans. Most are bottom- dwelling organisms as adults, but some planktonic forms have also become well established, especially in the last few years. Most were introduced accidentally from the hulls of ships passing through or abandoned or sunk in the Bay-Delta, from the release of ship ballast water, and from oysters (which usually contain dozens of nestling, symbiotic and parasitic invertebrates) brought in from Japan and the Atlantic coast for aquacultural purposes.

The first recorded introduced species, the Atlantic barnacle (*Balanus improvisus*) was observed in 1853, the single busiest year of clipper ship landings of the Gold Rush era. Since then, many species of non-native fish and invertebrates have been introduced into the estuary. The success of these introduced species is due in part to the comparatively small number of native species thought to have been present during aboriginal times and in part to environmental modifications to which non-native species were often preadapted.

The relatively low native-species diversity is thought to be a result of the relatively young age of the Bay-Delta estuary and its isolation from other Pacific Coast estuarine systems (Carlton 1979). Important environmental changes that most likely decreased native species' ability to compete with non-native species include changes in Bay-Delta morphometry, vegetation, hydraulics, and the amount and timing of Delta outflow.

It is not clear to what extent the decline in abundance of some native species is a result of environmental changes or to interactions with non-native species. It is known, however, that non-native species now figure prominently in the diets of fish species, shorebird- and invertebrate-eating waterfowl, and other wildlife species. Most non-native fish and invertebrates perform a vital role in the Bay-Delta foodweb. Certain species, however, have become so abundant in some areas or have been shown to exert a negative effect on ecosystem health or economics in other areas that their mere presence in the Bay-Delta is a source of considerable concern.

The Asian clam, *Potamocorbula amurensis,* was first observed in 1986 and has since become extremely abundant in the Bay and western Delta. This species is well adapted to the Bay-Delta saltwater conditions and exerts a heavy grazing loss on phytoplankton and zooplankton in the Bay. Precisely how the Asian clam is affecting other benthic invertebrates, the zooplankton abundance and composition, or the larval and young fish health is still not well understood, but is thought to be generally detrimental. This is especially true for native species. On the positive side, Asian clams may contribute to the foodweb as an important food source for white sturgeon (Peterson 1997).

The zebra mussel, *Dreissena polymorpha*, another clam-like species many believe will soon invade the Bay-Delta, poses a similar ominous threat.

The Asian clams came on the heels of another clam invasion. *Corbicula manillensis* was also introduced from Asia. It was first described in the Delta in 1946. This clam does not tolerate saline waters. It is now very abundant in freshwater portions of the Delta and in the lower mainstem rivers adjacent to the Delta.

Another relatively new arrival to the Bay-Delta is another species from the Orient, the Chinese mitten crab (*Eriocheir sinensis*). This crab spends most of its life in fresh water and migrates downstream to spawn in salt water. Mitten crabs were first captured in south-Bay shrimp trawls in 1993. Their distribution and abundance have increased every year since then (Hieb 1997). Although these crabs may have an adverse effect on the red swamp crayfish (another non-native species), its greatest potential negative impact on the Bay-Delta may be its effect on levees. Mitten crabs dig burrows in clay-rich soils where banks are steep and lined with vegetation. These burrows accelerate bank erosion and slumping and, over time, may pose a serious threat to Delta levee integrity. The crabs also interfere with bay shrimp fishing by fouling nets.

Introduced zooplankton species have become important elements of the Bay-Delta. *Eurytemora affinis* was probably introduced with striped bass around 1880. Until recently, it was a dominant calanoid copepod of the entrapment zone. In the last decade, however, Eurytemora has been replaced by two calanoid copepods introduced from China. This replacement was a result, in part, of Eurytemora's greater vulnerability to Asian Clam grazing.

The native mysid shrimp, *Neomysis mercedis*, began dwindling in abundance in the late 1970s primarily as a result of the declining trophic status of the Bay-Delta. Its population decline was also affected by competition with *Acanthomysis aspera*, an introduced mysid shrimp of somewhat smaller size but similar feeding habits.

Although many non-native fish species have been introduced to the Bay-Delta over the past century, only a few have been considered invasive and requiring control. The most recent example is the northern pike introduced into Davis Lake, a State Water Project reservoir on the Feather River. Two unconfirmed sightings of northern pike occurred in the Delta in early 1997. Northern pike are noted predators and could, if allowed to establish themselves, pose a significant threat to native fishes, such as chinook salmon, steelhead, and delta smelt. White bass were a similar threat in the 1980s; however, a concerted effort ensured they did not move from isolated southern San Joaquin Valley reservoirs into the San Joaquin River.

ISSUES AND OPPORTUNITIES

INTRODUCED SPECIES: Introduced species have had a significant impact throughout the Bay-Delta ecosystem, and they can pose a significant impediment to achieving restoration objectives. In order to minimize the risk of potentially massive ecological and biological disruptions associated with non-native species-disruptions that could threaten to negate the benefits of restoration efforts-it is important to initiate an early program that:

- prevents or significantly reduces additional introductions of non-native species,
- develops a better understanding of how non-native species affect ecological processes and biological interactions,
- develops effective control and eradication programs, and
- establishes habitat conditions that favor native over non-native species.

DECLINE IN PRODUCTIVITY: Productivity at the base of the foodweb has declined throughout the Delta and northern San Francisco Bay. Although some of this decline can be attributed to the introduced clam Potamocorbula amurensis, or Asia clam, not all of the decline is explained. The decline at the base of the foodweb has been accompanied by declines in several (but not all) species and trophic groups, including mysids and longfin smelt. The long-term implications of this seem to be a reduction in the capacity of the system to support higher trophic levels. This implies a limit on the extent to which Bay-Delta fish populations can be restored unless creative solutions can be found to increase foodweb productivity (Strategic Plan 2000).

OPPORTUNITIES IN THE DELTA: Reduce the introduction of ballast-water organisms from ships to 5% of 1998 levels. The shipping industry can be required to greatly reduce and eventually eliminate the introduction of organisms through ballast water using existing technology. Significant progress could also be made in reducing the introduction of non-native species from other sources as well (goal 5, objectives 2-7). This is a preventative rather than a restorative activity. Given the impacts that introduced invasive species have already had on the ecology of the Bay-Delta ecosystem, however, the eventual elimination of all additional species introductions is crucial to the ultimate success of the ERP (Strategic Plan 2000).

RESEARCH: Initiate targeted research on major restoration issues, such as: (1) how to control problem invasive species such as the Asia clam (Potamocorbula amurensis), which has a negative effect on foodweb dynamics in the estuary; (2) factors limiting the abundance of high-priority endangered species; and (3) design of habitats for shallow-water tidal marsh and bypasses. Ultimately, the limited funds available for restoration will be much more effectively spent if there is a clear understanding of the relative seriousness of the diverse problems facing the estuarine and riverine ecosystems and of the ability to solve those problems. Where the research can be linked to pilot or large-scale restoration projects, the benefits will be multiplied (Strategic Plan 2000).

VISION

The vision for invasive aquatic organisms is to reduce their adverse effects on the foodweb and on native species resulting from competition for food and habitat and direct predation.

This vision can be accomplished through enforcement of State laws regulating ballast water dumping and other measures designed to reduce the number of new, potentially harmful species introduced accidentally into the Bay-Delta estuary. Habitat changes or direct control measures may reduce their effects in specific cases.

The introduction of non-native species to the Bay-Delta has been a mixed blessing. Most have successfully integrated into the Bay-Delta aquatic community. Others, however, have hastened the extinction or greatly reduced the abundance of native species or have become an economic nuisance. Once established, non-native species cannot be effectively removed by harvesting or poisoning, except perhaps in small localized areas.

The only practical way to minimize the spread of non-native species and promote the growth of native species is to restore the habitats to more natural conditions. Restoring more natural, native aquatic communities should promote greater ecosystem stability by reducing the likelihood of catastrophic reductions in abundance of native organisms resulting from changes in environmental conditions.

Integration with Other Restoration Programs

Efforts to restore the natural environmental conditions, trophic status and native invertebrate community of the Bay-Delta will involve the cooperation and support of established programs underway to restore habitat and fish populations in the basin.

- Restoration of the plankton food supply of native fishes is a primary focus of the Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes (U.S. Fish and Wildlife Service 1995).
- The Central Valley Project Improvement Act (CVPIA) calls for the doubling of the anadromous fish populations (including striped bass, salmon, steelhead, sturgeon, and American shad) by 2002, through changes in flows and project facilities and operations. This program involves actions that may directly or indirectly benefit native invertebrates of the Bay-Delta foodweb.
- The California Department of Fish and Game is required under State legislation (The Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1988) to restore numbers of anadromous fish in the Central Valley. Actions include restoring the food supply of anadromous fish.
- Efforts will be coordinated by the State Water Resources Control Board and Regional Water Quality Control Boards to reduce the amount of toxic substances released into Central Valley waterways, which should help reduce stresses on the native and non-native invertebrate species.

Linkage with Other Ecosystem Elements

Invasive aquatic organisms adversely influence other ecosystem elements including ecological processes, habitats, and species. For example, introduced species have out competed and displaced many native species. The proliferation of these exotic organisms has altered the Bay-Delta foodweb.

Objectives, Targets, Actions, and Measures

There are many Strategic Objectives related to invasive aquatic organisms.

> The first Strategic Objective is to eliminate further introductions of new species from the ballast water of ships into the Bay-Delta estuary.

Long-Term Objective: Eliminate the dumping of all organism-contaminated ballast water and ballast sediment into the estuary.

Short-Term Objective: Eliminate the dumping of all ballast sediment into the estuary. Reduce the amount of ship ballast water contaminated with estuarine organisms from other ports that is dumped into the estuary to 5% of 1998 levels by the year 2005, and to 1% of 1998 levels by 2008.

Rationale: The introduction of non-native species in the ballast water of ships has made the estuary the most invaded estuary in the world; a new species is being added about every 14 weeks. The new species greatly increase the expense and difficulty of restoring the estuary. A new invader can effectively destroy the value of a restoration project. Aquatic invasions also have harmed public health, decimated fisheries, and impeded or blocked water deliveries. Substantial reductions in the number of organisms released via ballast water are readily achievable. Around the world, restrictions and regulations governing management of ballast water and other ballast materials are being promulgated to reduce the introduction of non-native species by this means. Strict controls on ballast water exchange should be enacted and enforced on shipping into San Francisco Bay at the earliest possible time. If prevention cannot work, the shipping industry must be made responsible for the damage caused by ballast water organisms because such introductions must be regarded as deliberate and unauthorized, rather than "accidental."

Stage 1 Expectations: Same as short-term objectives. In addition, better mechanisms to treat ballast water to eliminate unwanted organisms will have been developed. Baseline monitoring of the organisms released in ballast water should be immediately initiated so we can assess progress and monitor compliance. Studies should be completed to investigate the ecological and economic impacts of introductions into the Bay-Delta system to demonstrate that strong action is warranted.

> The second Strategic Objective is to eliminate further introductions of new species from imported marine and freshwater baits into the Bay-Delta estuary and its watershed.

LONG-TERM OBJECTIVE: Eliminate the use of imported live non-native freshwater and marine species for bait in San Francisco Bay and elsewhere in California.

SHORT-TERM OBJECTIVE: Develop and institute strategies, working with the bait industry, the fishing community, and interests representing the environment and other sectors that may be affected by such introductions, to halt the introduction and spread of organisms used as bait in fresh and brackish water.

RATIONALE: At the present time, polychaete worms are shipped live from New England and southeast Asia to the San Francisco Bay Area for use as bait in marine sport fisheries. The New England worms are packed in seaweed which contains many non-native organisms, some of which have been established in San Francisco Bay as a result. This is thus an example of small activity that has the potential for large-scale economic damage (see ballast water rationale). It should be banned by the Fish and Game Commission and the baits replaced by local organisms or by artificial bait.

Many kinds of aquatic organisms are used for bait. Bait fishes like the red shiner have been spreading rapidly and now dominate many streams, with unknown impacts on native fishes and on fisheries. They continue to be spread by anglers releasing unused bait. Other new organisms may be brought in as "hitch-hikers" in shipments of bait fishes. There is also a need to better educate the fishing public on the adverse impacts of invasive species.

STAGE 1 EXPECTATIONS: The importation of live marine baits and their associated shipping materials will have been banned, unless the industry can demonstrate that all the organisms imported cannot become established in California.

Working with the bait industry and other interested parties, a plan will have been developed and instituted to greatly reduce, and eventually eliminate, the introduction of unwanted bait organisms into natural waters.

> The third Strategic Objective is to halt the unauthorized introduction and spread of potentially harmful non-native introduced species of fish and other aquatic organisms in the Bay-Delta and Central Valley.

LONG-TERM OBJECTIVE: Prevent the establishment through deliberate introductions of any additional fish species from outside the state or from other watersheds within the state, into Central California.

SHORT-TERM OBJECTIVE: Develop a program to educate the public (especially anglers) about the dangers of moving fish and other organisms around.

RATIONALE: The California Department of Fish and Game has long had a policy of not bringing new aquatic species into California to improve fishing. However, illegal introductions continue, such as that of northern pike into Davis Reservoir. If the highly predatory pike had become established in Sacramento River and Delta, it is quite likely it would have had devastating impact on salmon and native fish populations. There is a need to develop stronger prevention strategies for illegal introductions. The conflict that developed around the necessary elimination of pike from Davis Reservoir demonstrates the need for the development of better public understanding of the need to halt invasions. Education is also needed to make the point that any movement of fish and aquatic organisms by humans to new habitats is potentially harmful, even if the species is already established nearby. Brook trout introduced into a fishless mountain lake, for example, can eliminate the population of mountain yellow-legged frog that lives there, pushing the species further towards endangered species listing.

STAGE 1 EXPECTATIONS: An aggressive public information program should be developed in regard to species introductions.

> The fourth Strategic Objective is to halt the release of non-native introduced fish and other aquatic organisms from private aquaculture operations and the aquarium and pet trades into the Bay-Delta estuary, its watershed, and other central California waters.

LONG-TERM OBJECTIVE: Halt the non-deliberate introduction into natural waters of aquatic organisms from aquaculture facilities that is often a by-product of aquaculture operations. Prevent the importation from other regions of organisms from other regions into aquaculture facilities in the Bay-Delta system unless major quarantine regulations or facilities are in place.

SHORT-TERM OBJECTIVE: Institute an independent, scientific assessment of the pathways and risks of the introduction into the environment of organisms imported from other regions by aquaculture and of any changes needed in California's current management of the industry to prevent such introductions. Develop and institute strategies, working with the aquaculture industry and interests representing the environment and other sectors that may be affected by such introductions, to halt the introduction and spread of invasive or harmful non-native species via aquaculture.

Develop and institute strategies, working with the aquarium industry and interests representing the environment and other sectors that may be affected by such introductions, to halt the introduction and spread of non-native species from the aquarium and pet trades.

RATIONALE: Stocks of fishes and invertebrates are imported from other regions for rearing in aquaculture facilities in the Bay-Delta system, and permits are occasionally approved to bring in new species for aquaculture. Numerous examples exist of organisms escaping from aquaculture facilities and becoming established outside of their range. These include, or potentially could include, fish, crayfish and other shellfish that could compete with or prey on native California fish and aquatic organisms, and on sport and commercial fish in central California waters. Of greater concern is the potential for the introduction of parasites and diseases of commercial, recreational, and native fish and shellfish. There are also many examples of such diseases introduced by aquaculture into various parts of the world, sometimes with devastating impact on commercially important species.

Many kinds of aquatic organisms are sold in aquarium and pet stores. It is likely that some species of nuisance aquatic plants (e.g., Hydrilla) became established through aquarists dumping them in local waterways. Non-native turtles originating in pet stores are frequently present in ponds and have the potential to displace and spread diseases to native pond turtles. Although many organisms sold in aquarium stores are tropical and unlikely to survive in Central California (with some surprising exceptions), the industry is constantly searching for and bringing in new species from a variety of habitats. As indicated in the ballast water rationale, new species can have unexpected and sometimes large-scale negative impacts on aquatic ecosystems and can make restoration much more expensive and difficult. There clearly is a need to make sure that potentially harmful organisms are not available to aquarists and that new organisms are not brought in as "hitch-hikers" in shipments of aquarium fishes. There is also a need to better educate the public on the adverse impacts of invasive species and the need to not release aquatic pets into natural environments. A good model for this could be the program now in place in Hawaii, which (among other things) has a big public education component and requires all aquarium stores to have a special tank into which people can release unwanted aquatic organisms.

STAGE 1 EXPECTATIONS: An independent assessment of the pathways, risks and needed management of aquaculture introductions will have been completed; management measures to eliminate by-product introductions will have been adopted and implemented.

Species in the aquarium and pet trades will have been identified and evaluated for their ability to establish populations in the Bay-Delta system. With the cooperation of the aquarium/pet industry and affected interests, a plan will have been developed and instituted to greatly reduce, and eventually eliminate, the introduction of unwanted aquatic organisms from these sources into natural waters.

> The fifth Strategic Objective is to limit the spread or, when possible and appropriate, eradicate population of non-native invasive species through focused management efforts.

LONG-TERM OBJECTIVE: Eliminate, or control to a level of little significance, all undesirable non-native species, where feasible.

SHORT-TERM OBJECTIVE: Eradicate or contain those species for which this can readily be done, gaining thereby the largest benefit for the least economic and environmental cost; and to monitor for the arrival of new invasive species and, where feasible, respond quickly to eradicate them.

RATIONALE: Non-native species are now part of most aquatic, riparian, and terrestrial ecosystems in California. In most instances, control is either not possible or not desirable. However, in some instances, control of invasive species is needed to protect the remaining native elements or to support human uses. Four factors should be considered in focusing control efforts. First, an introduced species is often not recognized as a problem by society until it has become widespread and abundant. At that point, control efforts are likely to be difficult, expensive, and relatively ineffective, while producing substantial environmental side effects or risks, including public health risks. Second, some organisms, by nature or circumstance, are more susceptible to control than others. Rooted plants are in general more controllable than mobile animals, and organisms restricted to smaller, isolated water bodies are in general more controllable than organisms free to roam throughout large, hydrologically connected systems. Third, although biological control is conceptually very appealing, it is rarely successful and always carries some risk of unexpected side effects, such as an introduced control agent "controlling" desirable native species. And fourth, physical or chemical control methods used in maintenance control rather than eradication require an indefinite commitment to ongoing environmental disturbance, expense, and possibly public health risks. Overall, the most efficient, cost-effective, and environmentally beneficial control programs may be those that target the most susceptible species, and species that are not yet widespread and abundant. This suggests a need to (1) assess the array of introduced species and focus on those that are most amenable to containment and eradication, rather than focusing just on those that are currently making headlines, and (2) responding rapidly to eradicate new introductions rather than waiting until they spread and become difficult or impossible to eradicate.

An example of a "rare" introduced species needing eradication that is not being dealt with is English cordgrass in the Bay. It has been described by some scientists as the most aggressive and invasive salt marsh plant in the world. It has been in the Bay, its only known California location, for 20 years without spreading, so it has not generated concern. However, in other parts of the world it has also sometimes sat around for a few decades without doing much of anything, then suddenly taken off and taken over entire estuaries in a few years. In San Francisco Bay, it is known from one site only, where it was planted, and where it exists in a single patch. It could readily be eradicated.

An example of an abundant species needing immediate attention is the water weed Egeria densa. This plant has been spreading rapidly through the Delta, where it clogs sloughs and channels with its dense growth, creating problems for navigation. From a biological perspective, it is undesirable because E. densa beds appear to exclude native fishes and favor introduced species.

STAGE 1 EXPECTATIONS: An assessment will be completed of existing introductions to identify those with the greatest potential for containment or eradication, and consider this in prioritizing control efforts. A program will have been implemented to monitor for, and respond quickly to contain and eradicate new invasions, where this is possible. A mechanism whereby new invasions can be dealt with quickly and effectively will have been developed an implemented.

RESTORATION ACTIONS

The general target for invasive aquatic organisms is control and reduce the incidence of introductions and to implement control programs or eradicate exotic species where possible.

Actions that would help achieve this vision include more stringent enforcement of current policies regarding the introduction of non-native species. These policies seek to prevent the introduction of known noxious species and minimize the introduction of all other species. In addition to prohibiting intentional introductions, enforcing existing laws such as International Maritime Organization's Guidelines will reduce the number of accidental introductions from ship ballast water.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Implement applicable management measures identified in the restoration plan for the Anadromous Fish Restoration Program and the recovery plan for the native fishes of the Sacramento/San Joaquin Delta.
- Implement management measures identified in the proposed recovery plan for the Sacramento River winter-run chinook salmon.

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◆ INVASIVE RIPARIAN AND MARSH PLANTS

INTRODUCTION

Invasive riparian and marsh plants have become sufficiently established in some locations to threaten the health of the Bay-Delta ecosystem. The riparian and salt marsh plants that pose the greatest threats to aquatic ecosystems are those that directly or indirectly affect rare native species, decrease foodweb productivity, and reduce populations of desired fish and wildlife species.

Factors that relate to the degree of influence invasive riparian and salt marsh plants have on the Bay-Delta include additional introductions from gardens and other sources, and ground disturbances and hydrologic regimes that create favorable conditions for their establishment.

STRESSOR DESCRIPTION

Weeds, or invasive plant species, are organisms capable of invading relatively undisturbed habitats and exploiting opportunities provided by natural or human-related disturbances in the landscape. Although not all weeds are non-native, most have been introduced from other parts of the world. In the absence of the natural biological controls found in their native habitats, such as herbivory by specific insects, weeds can flourish with fewer constraints in a new landscape, quickly gaining a competitive advantage over the native species. Many weeds have also evolved characteristics that make them extraordinarily competitive in both native and non-native environments. These specialized traits may include high seed production, both sexual and asexual reproduction, several methods of dispersal, a fast growth rate, and tolerance of a wide range of environmental conditions such as extremes in temperature, nutrients, and water availability.

A plant species becomes a weed problem when it adversely affects natural communities or land uses. Whether non-native or native, plant species are considered harmful when they reduce the biological diversity of existing natural communities by displacing native species or altering ecosystem processes such as nutrient cycling, hydrologic conditions, or the frequency of fires. They are problems to human society when they impair agricultural productivity, present fire hazards, constrict waterways, diminish recreation and aesthetic value, or destroy structures.

Since the first non-native settlers, weeds have been introduced to California and many have become established. There were at least 16 non-native plant species established by 1869, 292 by 1925, 797 by 1968, and 1,023 by 1993 (Barbour et al. 1993). Undoubtedly, non-native species introductions will continue, and correspondingly, add pressure on the native plant communities and the wildlife that depend on them.

More than 90% of the State's historic riparian habitat has been lost, primarily as a consequence of land being converted for agricultural uses (Barbour et al. 1993). What remains continues to be threatened, not only by further habitat conversions, but also by weeds. It is particularly important for the many endangered and threatened species that weeds are controlled, particularly for birds and fish that depend on native riparian plant communities.

Many riparian infestations are from species, such as Pampas grass, that spread from gardens. Others were planted intentionally along engineered or altered waterways for erosion control or in the belief that native vegetation would be too vigorous and would clog waterways (Dawson 1984). Weed infestations in riparian and salt marsh systems are magnified by both alterations to the landscape and current land use patterns. Clearing land allows weeds that thrive in disturbed areas, such as ailanthus, to invade bare areas and move into established forests. Overgrazing in riparian areas can diminish recruitment of new native trees and shrubs directly and indirectly by contributing to the establishment of a dense understory of non-native vegetation that hinders native seedling establishment. Some orchards may be a source of riparian weed infestations, as may have happened with the establishment of California black walnut, used as rootstock in English walnut orchards.

Urban development adjacent to riparian areas can lead to infestations by ornamental garden plants such as German ivy, arundo or giant reed, elm, black locust, and edible fig. Increases in summer ground and surface water from irrigation can harm some riparian vegetation, altering the species composition. It can create conditions leading to a higher rate of invasion by urban area weeds such as Bermuda grass that can compete with native seedlings, thus affecting forest regeneration. Left alone, many weeds can take over part or all of the established riparian or salt marsh communities, displacing the native vegetation and becoming the new climax successional species. Examples include arundo and tamarisk. Both were intentionally introduced and now are widespread weeds that have displaced extensive areas of native riparian vegetation throughout the western United States.

Most Central Valley and Delta riparian communities are confined to lower floodplain and river channel areas, compared to a much wider distribution over vast floodplains 150 years ago. With the conversion of riparian communities to other land uses, broad outer bands of riparian vegetation were lost or their extent greatly diminished, like those dominated by sycamores.

Today, most watercourses are confined to narrower channels with little room for changing patterns of braiding and migration. Inundation and sedimentation rates are altered from historical times in river channels and are substantially reduced in floodplain areas. In the Delta, sedimentation is also altered with the erosion of islands.

Habitat losses or alterations have resulted in a pattern of habitat fragmentation. Riparian communities are often disconnected patches along river channels, and salt marshes are either newly developed from sediment deposition or smaller patches of formerly great expanses. The alteration of ecosystem processes like sedimentation, nutrient flow, fire, and hydrologic conditions, along with reduction in cover and native plant community diversity, has resulted in degraded riparian or salt marsh habitat conditions. The riparian or salt marsh community is then vulnerable to invasions by non-native species that are better adapted to the altered conditions than the native vegetation.

Species such as arundo and tamarisk are able to quickly exploit disturbed riparian sites. They, in turn, alter the ecosystem processes further, changing the frequency of fires, increasing shade and sediment capture, armoring the streambed and banks, altering soil salinity (tamarisk), and modifying the hydrologic patterns. The native species are not adapted to the new ecosystem processes, and the introduced weeds dominate the successional community.

Weeds that pose the greatest threats to riparian and salt marsh areas are those that out compete and exclude native vegetation and diminish habitat value to wildlife and reduce biodiversity of native species. All weeds listed in the following section have this potential.

Numerous weeds threaten the establishment and succession of native riparian and salt marsh vegetation in the Delta and along the Sacramento and San Joaquin Rivers and their tributaries. Some of the most invasive, listed below, include weeds that are widespread, often extensive, and extremely dangerous because of their ability to dominate riparian or salt marsh communities and affect ecosystem processes (arundo and tamarisk). Other invaders are trees or shrubs that now dominate portions of riparian forests and can invade larger areas if not controlled (ailanthus, edible fig, northern California black walnut, eucalyptus, black locust, and Russian olive). Additional examples include some weeds that are primarily a problem in a more restricted range or ecological zone type (perennial pepperweed, German ivy, cordgrass, and purple loosestrife).

Both arundo and tamarisk are widespread weeds capable of causing enormous damage to California riparian communities. They reduce biological diversity, habitat value for wildlife, and ecosystem processes such as flooding patterns and fire frequency.

ARUNDO (*Arundo donax*), also known as giant reed or false bamboo: Native to the Mediterranean area, arundo was introduced to California in the late 1800s and used for erosion control along drainage canals. It continues to be sold and planted as an ornamental. Arundo is a highly invasive bamboo-like perennial grass that can form large, fast-growing, monospecific stands that out compete and displace native riparian vegetation while restricting water flow, increasing sedimentation, and forming large debris piles in streams and rivers. It is not considered to be of value to native wildlife. Arundo spreads by growing rhizomes (lateral roots) and disperses to new sites when stems and rhizomes break off in floodwater and take root in moist streambed soils. Grading and other construction activities can and have greatly increased areas occupied by arundo. For example, Camp Pendleton's past program for clearing native vegetation to conserve water resulted in distributing arundo throughout the cleared area. When the program was halted, the arundo population continued to expand (Reiger 1988).

The effects of arundo's ability to alter ecosystem processes may be profound. It is far more susceptible to fire than native riparian species. However, although it recovers from fires, most native vegetation does not, leading to increased postfire dominance by arundo. By increasing sedimentation after establishing in stream channels, arundo stabilizes islands, hinders braiding and shifting patterns in stream channel movement, and prevents native stream channel vegetation from establishing (Peterson pers. comm.). An example of this can be seen at Stony Creek in northern California. Because arundo has a vertical structure, it does not overhang water like native riparian vegetation. The result is less shade over water, providing less cover, increased water temperatures, and altered water chemistry, all conditions that can harm fish and other existing aquatic organisms and ultimately change the aquatic species composition

By 1993, arundo accounted for as much as 50-60% of a 1,116-acre riparian community in the Riverside west quadrangle covering a portion of the Santa Ana River in southern California (Douthit 1993). Because of this, it has been implicated in the reduction of rare native stream fish populations in the Santa Ana River (Bell 1993). Some arundo populations have been mapped in southern California (Douthit 1993), and a population has been mapped along Stony Creek in northern California; however, no comprehensive statewide mapping of arundo has been conducted. Therefore, an accurate assessment of the extent and rate of spread of the weed is unknown. It is widespread throughout the Sacramento and San Joaquin River channels and their tributaries, as well as throughout the Delta. More survey mapping is needed to determine the extent of arundo, the levels of threat posed by the weed throughout the ERPP study area, how and when best to safely control it, and a prioritized strategy for removing it.

TAMARISK (*Tamarix chinensis, T. ramossisima, T. pentandra*), also known as salt cedar: This woody shrub from Eurasia was introduced in the early 1800s as an ornamental. It has since spread or been introduced into nearly every drainage system in the southwestern United States. It occupies 1.5 million acres nationwide and 16,000 acres in California. It can alter ecosystem processes such as the frequency of fires and hydrologic conditions of streams and groundwater. Tamarisk plants evapotranspire larger quantities of groundwater than do native plants, leading to reduced groundwater supplies. It traps more sediment than native vegetation, leading to a reshaping of stream bottoms and altered flooding pattern. It adds increased fuel loads to the riparian community, which can result in more fires. Tamarisk tolerates fires; native riparian species generally do not. The result of these ecosystem process changes is the eventual exclusion or reduction in cover by native plant species and altered stream shapes and flooding patterns. Studies have shown that bird usage is lower when tamarisk, rather than native tree species, dominates the riparian zone (Meents et al. 1984, Anderson and Ohmart 1984).

Tamarisk is widespread in California rivers; however, an accurate assessment of the extent and rate of spread of the weed is unknown. Like arundo, more survey mapping is needed to determine the extent of tamarisk, the levels of threat posed by the weed, the best time to safely control it, and a prioritized strategy for removing it.

Ailanthus, edible fig, northern California black walnut, eucalyptus, and black locust are examples of invasive trees or shrubs that have achieved local dominance in riparian forests in the ERPP study area. All have the potential for population expansions.

AILANTHUS (*Ailanthus altissima*), also known as tree-of-heaven: Ailanthus was first introduced into the eastern United States in the late 1700s. By the mid-1800s, it was commonly sold by nurseries as a street and shade tree. It was introduced into California in the 1850s. Its horticultural popularity declined by the mid-1900s, and it became naturalized in mostly ruderal areas, but is often present in riparian habitats as well, especially those in agricultural or urban settings (Hunter 1995). Although it may not be as aggressive an invader as other riparian weeds, it has achieved local dominance in some sites, either displacing or preventing native riparian species from establishing. In agricultural settings, ailanthus roots can disrupt the integrity of levees and irrigation canal banks.

EDIBLE FIG (*Ficus carica*): Fig is a cultivated tree native to the Mediterranean area. Its seeds are dispersed by birds and other wildlife and by floodwaters. Present in many streams and rivers throughout California, it tends to form a shady canopy that can hinder seedling establishment by native species. It also spreads vegetatively through stump sprouting and where bent branches take root, thus forming thickets that exclude native species. An example of the fig's impacts may be seen at both the Dye Creek and Cosumnes River Preserves in northern California, where active management programs are in place to eradicate the trees.

NORTHERN CALIFORNIA BLACK WALNUT (*Juglans californica var. hindsii*): Historically, the native northern California black walnut was present only along the Sacramento River between Freeport and Rio Vista (Fuller 1978). However, Skinner and Pavlik (1994) say it historically grew in Contra Costa, Napa, Sacramento, Solano, and Yolo Counties. It is a special-status species in its native range; however, it (or a hybrid of it and the English walnut, *Juglans regia*) is now common in many Central Valley, Delta, and Bay Area riparian forests. The walnut's widespread distribution may be explained by its historical use as rootstock in English walnut orchards and possibly by active spread by Native Americans. Along the mainstem of the Sacramento River, there are dense areas of northern California black walnut saplings established under the canopy of mature valley oaks and cottonwoods. Without active management, these trees could eventually displace valley oaks and cottonwoods in many areas.

EUCALYPTUS (*Eucalyptus* spp.): Eucalyptus trees are native to Australia. They have been used commercially as fuel wood and planted horticulturally in urban settings. They are fast-growing and quickly form canopies that restrict available light from slower-growing native species. They also compete for water and form a large leaf litter layer that alters the soil chemistry and tends not to break down rapidly. The oil in the trees makes them particularly hazardous to fires, as was demonstrated in the Oakland hills and southern California fires in the summer of 1996. However, unlike native riparian plants, eucalyptus resprouts after fires. This combination of characteristics leads to dominance and expansion of the trees in riparian systems. Because the leaves are not broken down, the leaf litter can cause increased sedimentation in streams, adversely affecting invertebrate and fish populations. Eucalyptus trees growing in stream channels at maturity create flood risks because their shallow roots and large stature render them vulnerable to blow down and toppling during storm events, potentially causing debris dams during high flows. Volunteer eucalyptus stands in the channel may be found in many riparian locations, such as along Putah Creek in Yolo County.

BLACK LOCUST (*Robinia pseudoacacia*): Black locust is native to the eastern United States and is planted horticulturally in California. Once established, it spreads through seed and rhizomes to form locally dominant patches that can exclude native vegetation. Like eucalyptus, black locust resprouts after fires. Examples of its dominance may be found in sites along the Delta and lower American River and at the Cosumnes River Preserve.

Russian olive, perennial pepperweed, German ivy, cordgrass, and purple loosestrife are weeds that pose problems in a more restricted range or ecological zone type compared to the other listed weeds.

RUSSIAN OLIVE (*Elaeagnus angustifolius*): Russian olive is a cultivated shrub or tree, native to temperate Asia. It is not yet a significant problem but can become one if not controlled. It is planted in landscaping and has been planted extensively in wind breaks. It spreads into riparian areas from seed and at maturity, crowds out native species.

PERENNIAL PEPPERWEED (*Lepidium latifolium*): Perennial pepperweed is a mustard family plant, native to Eurasia, that is widespread in the United States. It was introduced to North America in the early 1800s and reportedly first introduced to Yolo County as a contaminant of sugar beet seed (Young et al. 1996). It is found in all counties in the ERPP study area. It infests freshwater riparian and wetland areas and salt-affected areas, including coastal salt marshes, often where there was past disturbance. It can also grow in areas that are only seasonally wet. The plants grow fast, up to two or more meters tall, and spread both by rhizomes and seeds, forming dense stands that exclude all other vegetation. Once stems begin growing, most herbivores will not eat the plants (Young et al. 1996). An example of a perennial pepperweed infestation may be found at Grizzly Island in the Delta.

GERMAN IVY (*Senecio milkanioides*): This vine, native to South Africa, has been planted horticulturally and has spread into primarily coastal riparian forests. German ivy can be found in Marin and Sonoma County riparian forests. It carpets large expanses of forest understory and climbs to the canopy of willow and cottonwood trees. Competing for nutrients and water and preventing sunlight from reaching seedlings, it reduces the cover of native vegetation and the riparian community structure.

CORDGRASS (*Spartina alterniflora, S. anglica, S. densiflora, S. patens*): *Spartina alterniflora*, native to eastern North America; *S. anglica, S. densiflora*, native to South America; and *S. patens*, native to the southeastern United States were intentionally introduced to San Francisco Bay areas in the 1970s (Callaway and Josselyn 1992, Daehler and Strong 1994, Spicher and Josselyn 1985, Spicher 1984). All introduced cordgrasses are a threat to the open intertidal mud and salt marsh communities in estuarine areas. The cordgrasses form tall, dense colonies in the mud with thick root systems. The result is alteration of tidal flows and increased sedimentation, as well as displacement of clams, worms, crustaceans, and shorebirds that depend on these prey species. An additional threat is to the native *S. foliosa*, which becomes overgrown by *S. alterniflora* (Callaway and Josselyn 1992) and can hybridize with it (Strong and Daehler 1996). The native *S. foliosa* community provides habitats for the clapper rail and salt marsh harvest mouse.

PURPLE LOOSESTRIFE (*Lythrum salicaria*): Native to Eurasia, this riparian herbaceous weed was introduced to North America in the early 1800s and has since invaded wetlands throughout the United States. It forms large monotypic stands, displacing native species, and can eliminate shallow open-water areas otherwise used by waterfowl and wildlife.

ISSUES AND OPPORTUNITIES

INTRODUCED SPECIES: Introduced species have had a significant impact throughout the Bay-Delta ecosystem, and they can pose a significant impediment to achieving restoration objectives. In order to minimize the risk of potentially massive ecological and biological disruptions associated with non-native species-disruptions that could threaten to negate the benefits of restoration efforts-it is important to initiate an early program that:

- prevents or significantly reduces additional introductions of non-native species,
- develops a better understanding of how non-native species affect ecological processes and biological interactions,
- develops effective control and eradication programs, and
- establishes habitat conditions that favor native over non-native species (Strategic Plan 2000).

OPPORTUNITIES: Reduce or eradicate invasive non-native shrubs and trees from riparian corridors. Of particular importance is the control of the spread of tamarisk and giant reed, two introduced species that displace native flora, offer marginal value to fish and wildlife, and cause channel instability and reduced floodway capacity. Some rivers, such as Stony Creek and Cache Creek and the lower San Joaquin River, have undergone large expansions of these non-native species, even in the past 10-15 years. A combination of large-scale eradication pilot projects and targeted research on several streams will help to temporarily reduce the rate of expansion of their range, identify the most vulnerable stream environments, and determine whether valley-wide eradication or suppression measures are warranted or feasible (Strategic Plan 2000).

VISION

The vision for invasive riparian and salt marsh plant species is to reduce their adverse effects on native species and ecological processes, water quality and water conveyance systems, and major rivers and their tributaries.

Active management is necessary to reduce invasive plant populations that compete with the establishment and succession of native riparian vegetation in the Delta and Sacramento and San Joaquin Rivers and their tributaries in order to:

- assist in the natural reestablishment of native riparian vegetation in floodplains,
- increase shaded riverine cover for fish,
- reduce stress on rare species and communities, and
- increase habitat values for riparian associated wildlife.

Reduction of populations of invasive plant species that compete with the establishment and succession of native saline and fresh emergent marsh vegetation would also assist in the natural reestablishment of these native habitats and increase habitat values for associated wildlife. Developing and enhancing programs that protect and restore our State's natural resources and biological diversity while fulfilling our flood control, water conveyance, and compatible economic development needs are necessary if efforts are to succeed on a long-term basis. Historically, governmental weed control programs have been aimed at non-native species, which has adversely affected commerce, primarily agriculture, or public services such as water delivery. Weeds in natural areas have historically not been addressed but are now areas of great and increasing concern. Expanding existing governmental and private programs or creating new, similar programs is needed to perpetually monitor, research, and control weeds that impact natural areas, and to prevent new infestations by existing weeds or new introductions. To minimize recurring infestations, programs to actively restore native habitats will require expansion into areas where infestations have been removed.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

The California Department of Food and Agriculture's Integrated Pest Control Branch has responsibility for tracking and controlling federally listed noxious weeds statewide. These are weeds that have an impact on agriculture, although most of the current infestations are restricted to natural and uncultivated areas (O'Connell pers. comm.). Listed weeds are given an "A", "B", or "C" designation. "A" weeds are tracked and targeted for control or eradication wherever they are found. "B" weeds are considered too widespread to require mandated control measures; the choice for controlling them is left to the county agricultural commissioners. "C"-rated weeds are so widespread that the agency does not endorse State- or county-funded eradication or control efforts except in nurseries and seed lots. Of the weeds described in this vision statement, only perennial pepperweed and purple loosestrife are listed as noxious agricultural weeds, both with a "B" designation. With funding, the California Department of Food and Agriculture's Integrated Pest Control Branch could be expanded to include weeds adversely affecting natural areas and their existing infrastructure and expertise used to track, map, and control weeds that are problems in natural areas.

Two recently announced programs or policy changes may bear positively on the vision for controlling aquatic, riparian, and salt marsh weeds. The first is that the U.S. Department of Animal and Plant Health Inspection Service (APHIS) developed a new weed policy that includes regulation of all types of weeds, including not only those threatening agricultural or managed areas, but natural area weeds as well. The program will use a risk assessment to list and delist noxious weeds. Among other aspects of the new policy, APHIS will institute a regulatory role of detecting, assessing, and containing incipient infestations. The policy states that APHIS will play a federal coordination role to facilitate communication and cooperation between relevant public agencies and others.

The second new approach was formed through a Memorandum of Understanding (MOU) signed by 17 land-holding federal agencies in 1994. A committee was formed called the Federal Interagency

Committee for Management of Noxious and Exotic Weeds. The purpose of the MOU and committee formation is to enable the signing agencies to cooperatively manage noxious and non-native weeds on federal lands and to provide technical assistance on private land to achieve the goal of sustainable, healthy ecosystems that meet the needs of society.

The Delta Flood Protection Program (AB 369) has data on the location and extent of invasive plants associated by levees in the Delta. The program has "habitat assistance" describing the kinds and extent of plants on the levees; Arundo is particularly noted. The eradication of Arundo by levee districts is considered as a beneficial habitat change and is reimbursable by the program.

There are many other organizations with an interest in weed issues in the ERPP study area. All have different roles, interests, and expertise. To attain ERPP's goals, a coordinated effort would be needed among the groups to develop, prioritize, and implement weed management programs and strategies that will help to achieve ecological zone and resource visions.

- The University of California Weed Science Program in the Vegetable Crops Department conducts ongoing research on weed ecology and control, including non-crop and natural area problems.
- The California Exotic Pest Plant Council is a nonprofit organization that focuses on issues regarding non-native pest plants and their control, and on public education regarding the issues.
- The California Weed Science Society is a 50-year-old organization serving the weed science community.
- The U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and the California Department of Fish and Game have regulatory roles pertaining to weed control.

Several public and private groups dealing with weeds directly or indirectly in the ERPP study area can also be included. Among these are:

- the California Native Plant Society,
- The Nature Conservancy,
- State and national parks, county and local parks,
- U.S. Bureau of Land Management,
- APHIS,
- U.S. Army Corps of Engineers,
- U.S. Natural Resource Conservation Service,
- Center for Natural Lands Management,
- resource conservation districts,
- mosquito abatement districts,
- flood control districts,
- California Association of Nurserymen,
- Team Arundo, and Team Arundo del Norte,
- local land trusts,
- and private landowners.

Linkage with Other Ecosystem Elements

Invasive riparian and salt marsh plants adversely influence other ecosystem elements such as riparian and riverine aquatic habitat, and fish, wildlife, and plant species.

Objectives, Targets, Actions, and Measures

Two Strategic Objectives address invasive riparian and marsh plants.

> The first Strategic Objective is to halt the introduction of non-native invasive aquatic and terrestrial plants into the Bay-Delta estuary, its watershed, and other central California waters.

Long-Term Objective: Halt the importation, sale, and use of aquatic and terrestrial plants that can have potentially harmful impacts on ecosystems in the Bay-Delta watershed.

Short-Term Objective: Develop and institute strategies, working with the horticulture industry and interests representing the environment and other sectors that may be affected by such introductions, to halt the introduction and spread of invasive plant species.

RATIONALE: Many areas of the Central California landscape are dominated by non-native plant species (e.g., annual grasslands, eucalyptus forests) that have displaced native species and have unexpected negative impacts. Parrot's feather, for example, is an ornamental aquatic plant that is now widespread, clogging ponds and ditches in the Bay-Delta watershed, thereby creating breeding habitat for mosquitoes. Many harmful species (e.g., water hyacinth) can easily be purchased in plant nurseries and so continue to be spread into natural systems. New species and varieties of plants from all over the world are constantly being brought into California with little evaluation of their invasive qualities. Some species (e.g., Atlantic and English cordgrass) have even been imported for marsh restoration projects! There clearly is a need to evaluate the plants imported into California from other regions and to better regulate the horticultural industry to make sure potentially invasive plants are not available for spreading by gardeners, landscapers, and people engaged in restoration or reclamation activities. There is also a need to better educate the public on the adverse impacts of invasive species and the need to not to allow garden plants to escape into natural environments.

STAGE 1 EXPECTATIONS: Plants sold in California by the horticulture industry that pose a threat to ecosystems in the Bay-Delta watershed will have been identified and evaluated for invasive potential. Special attention will be paid to plants imported into the region from other areas. Working with the horticulture industry and affected interests, a plan will have been developed and instituted to greatly reduce, and eventually eliminate, the introduction of additional invasive plant species into natural environments.

The second Strategic Objective for invasive riparian and marsh plants is to limit the spread or, when possible and appropriate, eradicate populations of non-native invasive species through focused management efforts.

LONG-TERM OBJECTIVE: Eliminate, or control to a level of little significance, all undesirable non-native species, where feasible.

SHORT-TERM OBJECTIVE: Eradicate or contain those species for which this can readily be done, gaining thereby the largest benefit for the least economic and environmental cost; and to monitor for the arrival of new invasive species and, where feasible, respond quickly to eradicate them.

RATIONALE: Non-native species are now part of most aquatic, riparian, and terrestrial ecosystems in California. In most instances, control is either not possible or not desirable. However, in some instances, control of invasive species is needed to protect the remaining native elements or to support human uses. Four factors should be considered in focusing control efforts. First, an introduced species is often not recognized as a problem by society until it has become widespread and abundant. At that point, control efforts are likely to be difficult, expensive, and relatively ineffective, while producing substantial environmental side effects or risks, including public health risks. Second, some organisms, by nature or circumstance, are more susceptible to control than others. Rooted plants are in general more controllable than mobile animals, and organisms restricted to smaller, isolated water bodies are in general more controllable than organisms free to roam throughout large, hydrologically connected systems. Third, although biological control is conceptually very appealing, it is rarely successful and always carries some risk of unexpected side effects, such as an introduced control agent "controlling" desirable native species. And fourth, physical or chemical control methods used in maintenance control rather than eradication require an indefinite commitment to ongoing environmental disturbance, expense, and possibly public health risks. Overall, the most efficient, cost-effective, and environmentally beneficial control programs may be those that target the most susceptible species, and species that are not yet widespread and abundant. This suggests a need to (1) assess the array of introduced species and focus on those that are most amenable to containment and eradication, rather than focusing just on those that are currently making headlines, and (2) responding rapidly to eradicate new introductions rather than waiting until they spread and become difficult or impossible to eradicate.

An example of a "rare" introduced species needing eradication that is not being dealt with is English cordgrass in the Bay. It has been described by some scientists as the most aggressive and invasive salt marsh plant in the world. It has been in the Bay, its only known California location, for 20 years without spreading, so it has not generated concern. However, in other parts of the world it has also sometimes sat around for a few decades without doing much of anything, then suddenly taken off and taken over entire estuaries in a few years. In San Francisco Bay, it is known from one site only, where it was planted, and where it exists in a single patch. It could readily be eradicated.

STAGE 1 EXPECTATIONS: An assessment will be completed of existing introductions to identify those with the greatest potential for containment or eradication, and consider this in prioritizing control efforts. A program will have been implemented to monitor for, and respond quickly to contain and eradicate new invasions, where this is possible. A mechanism whereby new invasions can be dealt with quickly and effectively will have been developed an implemented.

RESTORATION ACTIONS

The general target for invasive riparian and saltmarsh plants is to prevent them from becoming established in riparian and saltmarsh restoration areas, conduct distribution and abundance surveys throughout the ERPP Study Area, and develop and implement control and eradication programs for high priority problem areas.

A comprehensive strategy to reduce invasive riparian and salt marsh plant populations and their adverse effects on the Bay-Delta ecosystem would include the following items.

- Assess weeds for their levels of a threat, their extent, and their potential for long-term control.
- Assess potential weed control sites for their likelihood to provide the greatest return on control efforts in terms of improved habitat quality and other benefits, such as reducing flood risk and channel instability, longevity of results, and ability to supply the types of habitats and habitat characteristics proposed for restoration.
- Develop and implement management plans based on the assessment of weeds and sites to achieve specific targets for each weed and site.
- Wherever necessary and appropriate, implement habitat restoration simultaneous with or following control measures.
- For arundo and tamarisk, eradicate the weeds in watersheds where they have only small populations, then concentrate on eradicating satellite populations extending beyond major infestations, and finally, reduce and eventually eliminate the most extensive populations.
- Provide technical expertise, serve as a clearinghouse for regional information and project results, and assist with implementing high-priority local projects in specific ecological units or zones to increase the effectiveness of existing public and private programs to reduce the threat of invasive species.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Identify and implement feasible methods for controlling invasive non-native marsh plants.
- Control non-native invasive plants in existing salt marshes where non-native plants have degraded habitat quality and in salt marshes restored under the ERP.
- Control and reduce populations of non-native marsh species with potential effects on soft bird's-beak and potential soft bird's-beak habitat.

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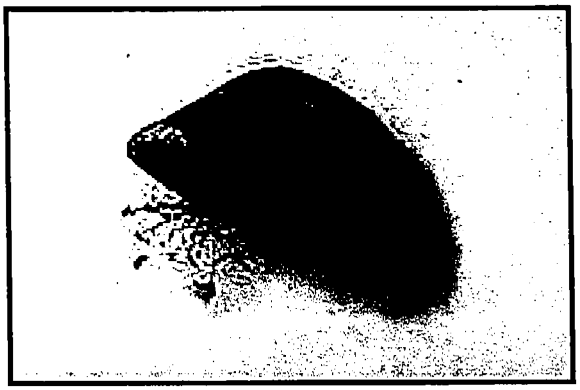
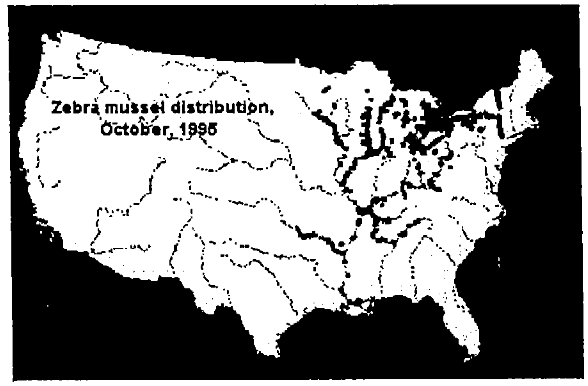


INTRODUCTION

Zebra mussels are a highly invasive exotic bivalve first discovered in the Great Lakes region in 1988 (Hebert et al. 1989). Since its introduction, the zebra mussel has caused widespread disruption of important foodweb processes in the region, altered fish species abundances, and impaired water export facilities used for municipal, industrial, and power generation purposes. The zebra mussel is not known to occur in California at this time. The introduction of zebra mussel into California's Bay-Delta watershed would be an environmental and economic catastrophe.

STRESSOR DESCRIPTION

Zebra mussels are small shellfish marked by alternating light and dark bands. They are typically 2 inches or less in size. Zebra mussels are native to the drainage basins of the Black, Caspian, and Aral seas of Eastern Europe. It is believed that ships originating from European ports carried the pest in freshwater ballast which was discharged into the Great Lakes. The first North American zebra mussel as discovered in Lake St. Clair, Michigan in June 1988. By September 1991, the mussel was found in all five of the Great Lakes, the St. Lawrence River, the Finger Lakes region of New York, and throughout the Mississippi River basin. The mussel is expected to infest most areas of North America within the next few years (New Hampshire Department of Natural Resources 1998).

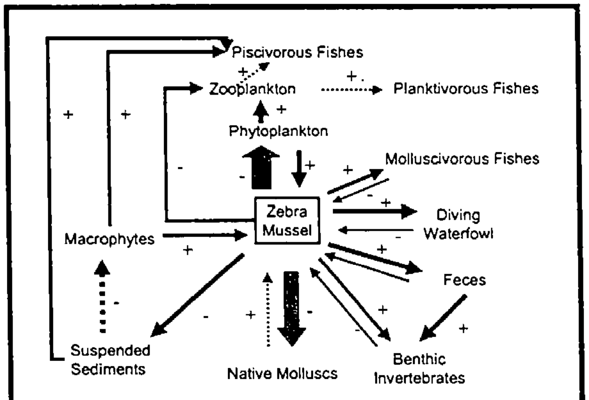


Zebra mussels are the only freshwater mussel which can secrete durable elastic strands, called byssal fibers, by which they can securely attach to nearly any surface, forming barnacle-like encrustations. Through this mechanism zebra mussels can attach to stone, wood, concrete, iron, steel, aluminum, plastic, fiberglass, and PVC. Zebra mussels typically colonize at densities greater than 30,000 individuals per square meter.

The specific origin of zebra mussels introduced into the Great Lakes is unknown but they are widespread throughout western and eastern Europe (Marsden 1996). Zebra mussels have successfully invaded a wide variety of aquatic habitats including freshwater lakes and rivers, cooling ponds, quarries, and irrigation ponds on golf courses (Strayer 1991). Recent information suggests that zebra mussel can invade brackish water or estuaries where salinities do not exceed 8 to 12 ppt.

Water quality factors that limit colonization by zebra mussel appear to include temperature, pH, and calcium content of the ambient water. The upper thermal tolerance is between 68 to 77 °F. Lower limit of calcium is 12 mg per liter and a combined threshold for pH and calcium is 7.1 and 8.5 mg per liter.

Adult zebra mussel tissues have a very high nutrient value and in the Great Lakes region are consumed in large quantities by crayfish, fish, and waterfowl (Mackie and Schloesser 1996).



Schematic of observed (solid line) and potential (dotted line) impacts of zebra mussel in freshwater communities based on European and North American studies. Taxa benefitting from zebra mussel invasion and indicated with a (+) symbol, those adversely affected by a (-) symbol. Strong interactions are denoted by thicker arrows. Zebra mussel may indirectly impact piscivorous and planktivorous fish by altering food supply or habitat quality (Adapted from MacIsaac 1996).

Zebra mussels become sexually mature in their first year of life and, depending on size, can produce 30,000 to 1,610,000 eggs per female.

Zebra mussel disperse by a variety of natural and anthropogenic means. Natural means include flowing water, birds, insects, and other animals. Human-mediated events include artificial waterways, ships, amphibious aircraft, and recreational equipments such as boats and other watercraft (Mackie and Schloesser 1996).

Live mussels have been reported found in Los Angeles attached to trailered boats. The California Department of Water Resources has also reported three more boats brought into the State since June 1996 carried zebra mussels. All three boats came from the Great Lakes region and were headed for saltwater destinations. The first of these three boats was intercepted at the Hornbrook Inspection Station near the Oregon border in June 1997 and the other two were stopped at the Truckee Inspection Station in September and December of 1996. This brought the total number of boats entering California found to be infested with zebra mussel to eleven boats since 1993.

The 1986 invasion of the Great Lakes by zebra mussel provides one of the most instructive examples of ecological modification and economic damage associated with human-mediated species introductions. (Hebert et al. 1989).

The greatest abiotic effect anticipated from an invasion by zebra mussel will be problems associated the mussel biofouling. Permanent marine structures such as pilings, bridges and docks are particularly susceptible of fouling. Water intake structures for municipal, industrial, and agricultural diversions and intake structures for power generation plants are highly vulnerable to fouling or clogging if they divert water from a source contaminated with adult or juvenile zebra mussel. Power plants components that are susceptible to biofouling include crib structures, trash bars, screen houses, steam condensers, heat exchangers, penstocks, and service water systems.

Very long or narrow pipelines are particularly vulnerable to biofouling and severely restricted flows (Claudia, R. and G.L. Mackie 1993). Mussel densities at the Monroe power plant in western Lake Erie have been reported to be as high as 750,000 individuals per square meter. These extraordinary mussel densities can be achieved in raw water intakes because of the enormous number of potential colonists entrained in the intake current, constant replenishment of nutrients and removal of mussel wastes, and absence of predators (MacIsaac 1996).

One of the most predictable outcomes of a zebra mussel invasion and a significant abiotic effect is enhanced water clarity. This also is linked to a greatly diminished phytoplankton biomass. For example, rotifer abundance in western Lake Erie declined by 74% between 1988 and the 1989-1993 period, a time coincident with the establishment of an enormous zebra mussel population beginning in 1989 (Leach 1993).

VISION

The vision for zebra mussel is to establish procedures to prevent or delay their introduction and to set up protocols to swiftly treat and eliminate any introduction.

This includes all appropriate efforts will be maintained to interdict potential sources of zebra mussels at all border check stations and other potential sources of introduction. The vision also includes an emergency response strategy to quickly contain and eradicate any suspected or proven mussel colonies.

This vision is consistent with the visions for other invasive species, particularly for invasive aquatic species and relies on measures to prevent introductions through contaminated ballast water.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

- California Department of Food and Agriculture's border inspection stations.
- Michigan Sea Grant Zebra Mussel/Aquatic Nuisance Species Program which serves as a centralized source of information exchange.
- Fish and Game Commission which can regulates the importation of live animals or aquatic plants.
- California Department of Fish and Game which issues permits for the importation of live animals and aquatic plants.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Invasive aquatic organisms adversely influence other ecosystem elements including ecological processes, habitats, and species. For example, introduced species have out competed and displaced many native species. The proliferation of these exotic organisms has altered the Bay-Delta foodweb.

OBJECTIVE, TARGETS, AND, ACTIONS

> The Strategic Objective is to prevent the invasion of the zebra mussel into California.

LONG-TERM OBJECTIVES: Develop an emergency response strategy to quickly contain and eradicate zebra mussels should they arrive in California. Continue to inspect trailered boats at the California border to intercept zebra mussels attached to boats.

SHORT-TERM OBJECTIVES: Coordinate activities with California Department of Food and Agricultural to increase monitoring activities at port of entries (boarder crossings) into California. Develop and fund protocols for inspecting vessels that enter the State from areas where zebra mussels are know to occur. Activities would also need to be under taken with adjoining states to prevent zebra mussels from becoming established in common waterways.

RATIONALE: The zebra mussel has done enormous damage to water supply infrastructure and to natural ecosystems in the eastern United States, through which they are spreading rapidly. It is likely that at some point a live population of zebra mussels will appear in California waters through any one of several means. Studies have already demonstrated that it will likely thrive in many parts of the California water system. Therefore, it is highly desirable to have in place a strategy to deal with a localized invasion, along with a commitment of resources from agencies so that rapid action is possible.

STAGE 1 EXPECTATIONS: A determination should be made as to which waters which are most likely to serve as an initial site of invasion for zebra mussels (taking into account both water quality and other environmental factors and the mechanisms likely to transport zebra mussels); a zebra mussel monitoring program for these waters should be developed; and a rapid response strategy should be developed to contain and eradicate an incipient zebra mussel invasion. In addition, the most likely source for introducing zebra mussels is boats carried by trailer from areas where zebra mussels are abundant. California already has an agricultural inspection program, and this program now includes inspection of boats for mussels.

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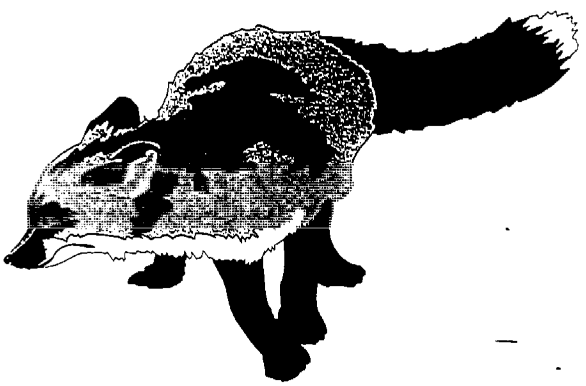

INTRODUCTION

The large-scale restoration of emergent wetlands, riparian habitat, and adjacent perennial grasslands will be the main focus of a strategy to reduce the adverse impacts of non-native wildlife on the health of the Bay-Delta ecosystem. The goal is a restored Bay-Delta and watershed where the quality, quantity, and structure of the restored habitat discourage colonization by non-native wildlife, provide a competitive advantage to native wildlife, and reduce the vulnerability of native species to nest parasitism and predation from species such as the brown-headed cowbird and starling, and from predation by species such as the red fox and Norway rat.

STRESSOR DESCRIPTION

One of the most serious environmental problems facing California is the explosive invasion of non-native pest plants and animals. Non-native plants, wildlife, fish, and aquatic invertebrates can greatly alter the ecosystem processes, functions, habitats, species diversity, and abundance of native plants, fish, and wildlife.

Many of these invasive species spread rapidly and form dense populations primarily by out-competing native species as a result of large-scale habitat changes that tend to favor non-native species and a lack of natural controls (e.g., natural predators). These non-native species usually have a competitive advantage because of their location in hospitable environments where the normal controls of disease and natural enemies are missing. As populations of non-native species grow, they can disrupt the ecosystem and population dynamics of native species. In some cases, habitat changes have eliminated connectivity of habitats that harbor the native predators that could help to limit populations of harmful non-native species.

The following common but harmful non-native species are found in the Bay-Delta area:

- The red fox was brought to California to be hunted for sport and raised for fur during the late 1800s and early 1900s. The population of this fox appears to be increasing and is now widespread in the Central Valley lowlands and the coastal counties south of Sonoma County. The range of this species also appears to be increasing, and the fox is a threat to many native endangered wildlife species such as the California clapper rail.
- The Norway rat was introduced unintentionally and was established in many areas by the mid-1800s. Increases in urban development, landfills, and riprap areas have resulted in large populations of these rats living along the bay shores. They are a threat to ground-nesting wildlife.
- The feral cat is a major predator to bird and mammal populations in the wetland areas of the Bay-Delta Estuary and wildlife areas elsewhere.
- The bullfrog is not native west of the Rockies but has been successfully introduced throughout most of California from Oregon to Mexico. Bullfrogs can establish and thrive in most permanent aquatic habitats that support emergent vegetation. Population levels in semipermanent aquatic habitats vary from year to year. Bullfrogs feed on most vertebrates and invertebrates that can be seized and swallowed.
- The red-eared slider is a turtle native to the southeastern United States and sold in pet stores throughout the west. The species has become established in the wild in some locations through

releases by pet owners. The range and status of sliders in the Delta are unknown but it is possible that this species is successfully reproducing. If so, it could compete with aquatic species in and dependent on the Delta.

Non-native wildlife species have been sighted throughout the Sacramento and San Joaquin Valleys in a variety of habitats. These include aquatic, riparian scrub, woodland, and forest habitats; valley oak woodland; grassland and agricultural land.

Reestablishing connectivity between habitats would help to reduce non-native species. For instance, restoring the connection between Bay marshlands and upland habitats that have populations of coyotes may help to reduce populations of red fox. Nest conditions in fragmented areas of riparian habitats encourage nest predation and parasitism by non-native species such as starlings and brown-headed cowbirds. Restoring large blocks or broad bands of riparian habitats will eliminate or minimize these adverse effects. Larger blocks may also encourage additional nesting by native deep-forest-nesting species that have been previously excluded.

VISION

The vision for non-native wildlife species is to implement a program to reduce the numbers of harmful non-native wildlife species (i.e., those that threaten the diversity or abundance of native species or the ecological stability of an area).

Reducing the numbers of non-native species and therefore the effects these species have on native wildlife will require a coordinated approach that includes restoring ecosystem processes and functions where applicable and possible, restoring native habitats, reducing or eliminating other stressors that suppress native species, and efforts to control non-native species.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to control non-native species, such as the red fox, are being undertaken on a small scale in the San Francisco Bay area. Most other efforts are associated with damage control in agricultural, urban, and suburban areas in the ERPP study area. Limited efforts have been focused in State and federal wildlife areas that have undertaken control programs on a small scale.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Non-native wildlife either compete with native wildlife species or prey on them. The result is diminished abundance of native species, some of which, such as the California clapper rail, are State or federally listed endangered species. Other than direct control measures, the problems caused by non-native wildlife species can be moderated by habitat restoration programs that reconnect habitats, reduce fragmentation of riparian habitat, and restore connection between lowland and upland habitats.

OBJECTIVES, TARGETS, ACTIONS, AND MEASURES

Two Strategic Objectives address non-native wildlife.

The first Strategic Objective is to reduce the impact of non-native mammals on native birds, mammals, and other organisms.

LONG-TERM OBJECTIVE: Establish mechanisms to minimize the negative effects of house cats, red fox, domestic dogs, roof rats, house mice and other non-native predators and competitors on populations of native birds and mammals, especially at-risk species.

SHORT-TERM OBJECTIVE: Develop both the means and the public support for limiting the invasion and impacts of non-native mammals into natural areas.

RATIONALE: Probably few issues are as potentially contentious to the public as programs to control the numbers of house cats (both tame and feral), red fox (introduced in the Central Valley and spread to marshes throughout the Bay-Delta system), and domestic dogs in natural areas. The fact remains that such predators can have a major impact on the ability of natural areas to support wildlife, including threatened native species such as clapper rails, salt marsh harvest mice, and salt marsh song sparrows. Likewise, non-native rats and mice can impact populations of native rodents and songbirds. Thus there is a major need to educate the public about the tradeoffs in protecting abundant and conspicuous predators that prey on native species, as well as programs to rid areas of other non-native mammals. Economical but lethal means of control (poisons, traps) are often controversial for many of these species and may also affect native species. There is thus a need to focus on prevention (e.g., containment and neutering of pets), on non-lethal means of removal (e.g., live-trapping) where feasible, and on developing support and methods for lethal control where necessary. Prevention and nonlethal methods are typically labor intensive, continuous, and more costly than limited agency budgets can endure. Therefore, there is a need to develop either better methods or bigger budgets for control if self-sustaining populations of many native birds and mammals are to be maintained.

STAGE 1 EXPECTATIONS: An aggressive public information program on the impacts of such non-native mammals in wildlife areas will have been conducted. Plans for long-term control of invasive mammals will have been developed, with alternatives clearly spelling out the impact of no or low control.

> The second Strategic Objective is to limit the spread or, when possible and appropriate, eradicate populations of non-native invasive species through focused management efforts.

LONG-TERM OBJECTIVE: Eliminate, or control to a level of little significance, all undesirable non-native species, where feasible.

SHORT-TERM OBJECTIVE: Eradicate or contain those species for which this can readily be done, gaining thereby the largest benefit for the least economic and environmental cost; and to monitor for the arrival of new invasive species and, where feasible, respond quickly to eradicate them.

RATIONALE: Non-native species are now part of most aquatic, riparian, and terrestrial ecosystems in California. In most instances, control is either not possible or not desirable. However, in some instances, control of invasive species is needed to protect the remaining native elements or to support human uses. Four factors should be considered in focusing control efforts. First, an introduced species is often not recognized as a problem by society until it has become widespread and abundant. At that point, control efforts are likely to be difficult, expensive, and relatively ineffective, while producing substantial environmental side effects or risks, including public health risks. Second, some organisms, by nature or circumstance, are more susceptible to control than others. Third, although biological control is conceptually very appealing, it is rarely successful and always carries some risk of unexpected side effects, such as an introduced control agent "controlling" desirable native species. And fourth, physical or chemical control methods used in maintenance control rather than eradication require an indefinite commitment to ongoing environmental disturbance, expense, and possibly public health risks. Overall, the most efficient, cost-effective, and environmentally beneficial control programs may be those that target the most susceptible species, and species that are not yet widespread and abundant.

STAGE 1 EXPECTATIONS: An assessment will be completed of existing introductions to identify those with the greatest potential for containment or eradication, and consider this in prioritizing control efforts. A program will have been implemented to monitor for, and respond quickly to contain and eradicate new invasions, where this is possible. A mechanism whereby new invasions can be dealt with quickly and effectively will have been developed an implemented.

RESTORATION ACTIONS

The general target for non-native wildlife is develop and implement control programs to reduce population abundance and to reestablish larger blocks of connected habitats to provide more extensive habitat and protection for native wildlife.

The Ecosystem Restoration Program Plan (ERPP) supports the following activities that would reduce adverse effects of non-native wildlife on native species:

- Reduce red fox populations in and adjacent to habitat areas suitable for California clapper rail, California black rail, salt marsh harvest mouse, and San Joaquin kit fox to reduce predation on eggs, juveniles, and adults and assist in the recovery of these native species.

- Reduce Norway rat populations in and adjacent to suitable habitat areas for California clapper rail, California black rail, and salt marsh harvest mouse to reduce predation on eggs, juveniles, and adults and assist in the recovery of these species. A combination of activities would be required to prevent the rats from establishing in important habitat areas (e.g., remove garbage and rubbish; ensure proper construction of residences and food storage structures; break down stubble in field crops, such as corn, to expose the rodents to predation during winter) and reduce populations in important habitat areas where the rats are already established (e.g., use biological controls, practice the environmental controls listed above, and use rodenticides).
- Reduce feral cat populations in and adjacent to suitable habitat for California clapper rail, California black rail, salt marsh harvest mouse, San Joaquin pocket mouse, kangaroo rat, and blunt-nosed leopard lizard habitats to reduce predation on eggs, juveniles, and adults and assist in the recovery of these species.
- Periodically drain aquatic habitats inhabited by bullfrogs to reduce the populations of these species (bullfrog larvae have an extended growing season, sometimes even overwintering, compared to native amphibians such as the California red-legged frog).
- Investigate the feasibility of increasing the harvest of bullfrogs without disturbing native species.
- Implement a "buy-back" or "take-back" program in pet stores to reduce the number of red-eared sliders released into the Delta.

MSCS Conservation Measures

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- To the extent practicable, control non-native predator populations in occupied habitat areas and salt marshes restored under the ERP.
- To the extent practicable, restore riparian habitats in patch sizes sufficient to discourage nest parasitism by brown-headed cowbirds.

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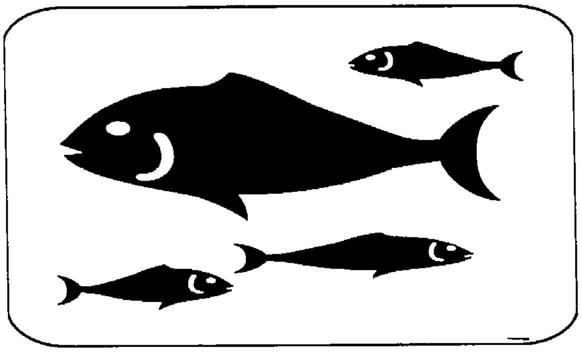
◆ PREDATION AND COMPETITION



INTRODUCTION

Predation and competition are natural ecological functions; however, unnatural levels of each can result in adverse effects to important sport and commercial fisheries and species of concern such as winter-run chinook salmon. For example, the potential adverse effects of competition between native and hatchery-reared salmonid stocks for food and other resources are a concern. Predation on important fish species and stocks is known to be a problem in the Central Valley, however, at specific sites or under specific environmental conditions.

Efforts to control the extent of unwanted predation and competition, particularly the loss of species of concern, are an important component in restoring health to the Bay-Delta system and in providing for other beneficial uses of water.

STRESSOR DESCRIPTION

CHINOOK SALMON AS A PREY SPECIES

Predation occurs throughout the river and ocean life-history stages of chinook salmon, but the magnitude and extent of predation have not been quantified. There are essentially three classes of predators on chinook salmon: birds, fishes, and marine mammals. Predatory birds include diving birds such as cormorants and gulls; terns and mergansers; wading birds such as snowy egret, great blue heron, black-crowned night heron, and green heron; and raptors such as osprey.

Predatory fish include both native and non-native species. Native predatory species include Sacramento squawfish, prickly sculpin, and steelhead. Non-native predatory species include striped bass, white catfish, channel catfish, American shad, black crappie, largemouth black bass, and bluegill.

Predation by native species is a natural phenomenon and should not have a serious effect on naturally produced chinook salmon in areas where shaded riverine aquatic (SRA) habitat and other types of escape cover are present. Chinook salmon has co-evolved with its native predators and has developed life-history strategies to avoid predation. However, predation by non-native species and increased predation resulting from artificial in-water structures and loss of instream habitat diversity may have resulted in gross imbalances in the predator-prey relationships and community structure in which chinook salmon evolved.

Artificial structures, such as dams, bridges, and diversions, create shadows and turbulence that tend to attract predator species and create an unnatural advantage for predators (Stevens 1961, Vogel et al. 1988, Decoto 1978). Specific locations where predation is of concern include Red Bluff Diversion Dam (RBDD), Glenn-Colusa Irrigation District's (GCID's) Hamilton City Pumping Plant, flood bypasses, release sites for salmon salvaged at the State and federal fish facilities, areas where rock revetment has replaced natural river bank vegetation, the Suisun Marsh Salinity Control Gates, and Clifton Court Forebay (CCF).

Predation at RBDD on juvenile chinook salmon is believed to be higher than natural levels because of the water quality and flow dynamics associated with the operation of this structure. The most important predator at RBDD is squawfish (Garcia 1989). Squawfish migrate annually upstream to RBDD from March to June, but some squawfish are present year round at the dam. Striped bass have also been captured immediately below RBDD in limited but regular numbers and have been found to have fed on juvenile salmonids (U.S. Fish and Wildlife Service unpublished data cited in Garcia 1989, Villa 1979). Striped bass were also observed by U.S. Fish and Wildlife Service (USFWS) divers below RBDD in September 1982, and five American shad captured at RBDD in June 1976 contained two to seven juvenile salmon each (Hall 1977).

Some chinook, such as juvenile winter-run chinook salmon that migrate downstream soon after emerging from the gravel in summer and early fall, will encounter RBDD when the gates are still down. They must cross Lake Red Bluff when turbidity is generally low and water temperatures are still relatively high. Because of their small size, these early emigrating winter-run juveniles may be very susceptible to predation in the lake by squawfish and cormorants (Vogel et al. 1988). In passing the dam, juveniles are subject to conditions that greatly disorient them, causing them to be highly susceptible to predation by fish or birds.

Prior to reoperation, late-migrating juvenile chinook salmon that passed RBDD in early spring most likely suffered the greatest losses because squawfish abundance was higher at that time of year and river conditions were generally favorable for predators, especially during dry years. Recent operation have reduced the aggregation of squawfish and reduced losses during the period in which the gates are up. The impacts of these losses are also more important because of the overall higher survival of these smolts (versus actively migrating fry) and their greater probability of contribution to the adult population.

There are some concerns that predation is higher in flood bypasses. In one survey of the Sutter Bypass, the most abundant species captured included chinook salmon and Sacramento squawfish (Jones & Stokes Associates 1993a).

Glenn-Colusa Irrigation District Hamilton City Pumping Plant

Evaluations at GCID Hamilton City Pumping Plant suggested that predation could be an important factor contributing to losses of juvenile salmonids at that location (Decoto 1978). In mark-recapture studies, 66% of the salmon were unaccounted for in bypass evaluations, and 82% were unaccounted for in culvert evaluations. More recent studies suggest that Sacramento squawfish is the primary predator at the pumping plant (Cramer 1992), although striped bass were also found with young chinook salmon in their stomachs.

Fish Salvage Release Sites

Orsi (1967) evaluated predation at the Jersey Island release site for salvaged fish from the State and federal fish facilities from mid-June through July in 1966 and 1967. Striped bass was the major predator at the release site, with black crappie and white catfish ranking second and third, respectively. Orsi estimated that overall predation occurred on about 10% of the salvaged fish released per day during multiple releases (one million fish/day), and more than 80% of the predation was from striped bass. He qualified this estimate as potentially being high and not applicable to other sites such as the Sacramento River. Similarly, Pickard et al. (1982) conducted predation studies of salvage release sites from 1976 to 1978. Fish, salvaged from the State's fish facility, were regularly transported and released into the lower Sacramento River at Horseshoe Bend. More predator fish were collected at the release site than at the control site, with striped bass and Sacramento squawfish being the primary predators. Also, more fish remains were found in the predators' stomachs at the release site than at the control site.

Rock Revetment Sites

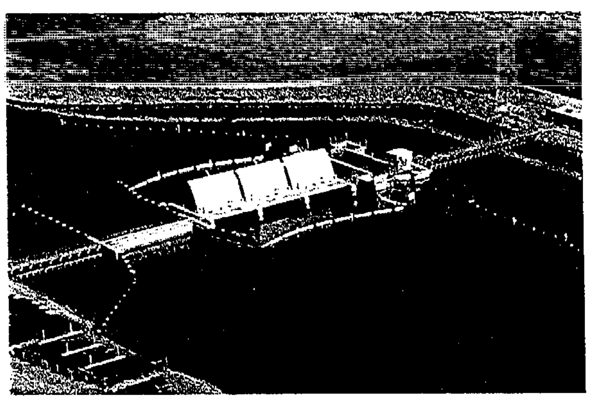
USFWS conducted a study to assess the relationship of juvenile chinook salmon to the rock revetment type bank protection between Chico Landing and Red Bluff (Michny and Hampton 1984). They found that predatory fish, such as Sacramento squawfish and prickly sculpin, were more abundant at riprapped sites than at naturally eroding bank sites with riparian vegetation. Conversely, juvenile salmon were found more frequently in areas adjacent to riparian habitats than at riprapped sites. Riparian habitats provide overhead and submerged cover, an important refuge for juvenile chinook from predators.

Clifton Court Forebay

Overall predation rates for salmon smolts in CCF have been estimated at 63-98% for fall-run chinook (California Department of Fish and Game 1993a), and 77-99% for late-fall-run chinook (Table 4). In mark-recapture studies, estimated mortality rate per mile in CCF was 91.3%, compared with 2.7% for the central Delta and 0.9% for the mainstem Sacramento River (between Ryde and Chipps Island). This difference was thought to result from the greater abundance of predators, primarily striped bass, in CCF, as well as hydraulic actions and the operational and physical design of CCF. During high tide, striped bass density in CCF has been estimated to be three to 17.5 times higher than the density of striped bass in the Delta. At low tide, striped bass density in CCF has been estimated as roughly five to 21 times higher than in the Delta.

SUISUN MARSH SALINITY CONTROL STRUCTURE

The California Department of Fish and Game (DFG) conducted predation studies from 1987 to 1993 at the Suisun Marsh salinity control structure to determine if the structure attracts and concentrates predators. The dominant predator species at the structure was striped bass, and juvenile chinook were identified in their stomach contents. Catch-per-unit-effort (CPUE) of bass has generally increased at the structure from 1987 (less than 0.5, preproject) to 1992 (3.0, postproject), and declined somewhat in 1993 (1.5) (California Department of Fish and Game 1994c). In comparison, CPUE was 3.44 at CCF and 1.65 at the south Delta barriers during the same period, using identical gear.



OCEAN PREDATION

Ocean predation very likely contributes to natural mortality in naturally and hatchery-produced chinook salmon stocks; however, the level of predation is unknown. In general, chinook salmon are prey for pelagic fishes, birds, and marine mammals including harbor seals, sea lions, and killer whales. There have been recent concerns that rebounding seal and sea lion populations, following their protection under the Marine Mammal Protection Act of 1972, have resulted in substantial mortality for salmonids.

Ocean predation rates on Central Valley chinook salmon have not been evaluated, but several studies have been conducted in other estuaries. At the mouth of the Russian River, Hanson (1993) found that maximum population counts of seals and sea lions corresponded with peak periods of salmonid returns to the hatchery upriver.

However, Hanson concluded that predation was minimal on adult salmonids because only a few pinnipeds foraged in the area, their foraging behavior was confined to a short portion of the salmonid migration, and their capture rates were low.

In the lower Klamath River, Hart (1987) reported predation rates of about 4% and 8% in 1981 and 1982, respectively, from harbor seals on chinook, coho and steelhead. It is important to note that marine mammal and chinook salmon populations evolved together and coexisted long before humans played a role in controlling either species.

GENERAL ANALYSIS OF STRIPED BASS PREDATION ON CHINOOK SALMON

Food habit studies conducted by numerous investigators indicate that chinook salmon are not an important component in the diet of striped bass, although, at times, young salmon, primarily fall-run, have constituted a substantial part. Generally, this has occurred in the Sacramento River upstream of the estuary and has been localized at water management structures, bridge abutments, and other predator habitats. It also occurs at structures that cause disorientation of juveniles such as RBDD. In the Delta, it is a known problem in CCF and at sites where large numbers of artificially produced chinook salmon are released.

The studies reveal that, except at localized sites and structures, striped bass are less likely to eat salmon in Suisun Bay and the Delta than in the rivers above the Delta. The greater vulnerability of salmon in the river may be a result of the greater clarity and the smaller width of the river. In many areas, bank protection activities, such as maintaining levees and riprapping, have removed SRA habitat and eliminated escape cover needed by young fish.

Summary of Clifton Court Forebay Prescreen Loss Studies
on Hatchery Juvenile Chinook Salmon

Date	Salmon Run	Prescreen Loss Rate (%)	Temperature (avg/day°F)	Pump Exports (avg. af/day)	Predator Abundance	Size at Entrainment (mm fl)
Oct 76	Fall	97.0	65.4	2,180	NA	114
Oct 78	Late-fall	87.7	57.5	4,351	NA	87
Apr 84	Fall	63.3	61.2	7,433	35,390	79
Apr 85	Fall	74.6	64.1	6,367	NA	44
Jun 92	Fall	98.7	71.7	4,760	162,281	77
Dec 92	Late-fall	77.2	45.4	8,146	156,667	121
Apr 93	Fall	94.0	62.0	6,368	223,808	66
Nov 93	Late-fall	99.2	53.7	7,917	NA	117

NA = estimates not available

Source: California Department of Fish and Game 1993.

OPPORTUNITIES TO REDUCE PREDATION

There have been only limited efforts to reduce predation problems. At RBDD, a squawfish derby was held in 1995 to reduce squawfish abundance. However, this sport fishery is unlikely to measurably alleviate predation from a native migratory species. The fishery could temporarily reduce squawfish abundance, but more squawfish are likely to repopulate the area. Sacramento squawfish are also more abundant at RBDD during spring, and a spring fishery could cause incidental catches of winter-run chinook.

The preferred solution to reduce predation at RBDD is to eliminate or reduce the feeding habitat that RBDD creates by seasonally or permanently raising the gates. It is anticipated that the GCID Hamilton City Pumping Plant will be redesigned and relocated on the main channel of the Sacramento River, upstream of its present location on an oxbow. The new design will eliminate predator habitats and should substantially reduce the existing level of predation and other problems caused by stream channel and gradient changes in the Sacramento River in recent years.

Predation problems occurring in CCF may be resolved by alternative conveyance facilities that reduce the quantity of water drawn directly into the forebay from the Delta.

Another important opportunity to reduce predation on target fish species is by recreating or restoring a more complex mosaic of instream habitats. These habitats can contribute to reduced predation and competition by allowing species to partition themselves among a more diverse array of available habitats.

PREDATION AND COMPETITION WITH HATCHERY-REARED FISH

The extent of predation by hatchery salmonids on naturally produced chinook salmon and steelhead is also not known. Steelhead releases, primarily by the Coleman National Fish Hatchery, may have the greatest potential for inducing unnatural levels of predation on naturally produced chinook salmon. Coleman National Fish Hatchery has a capacity to raise about one million yearling steelhead. Present production targets a release of about 600,000 in January and February at 125-275 millimeters (mm) long (four fish/pound). Predation on hatchery-produced steelhead is thought to be further reduced because these steelhead tend to outmigrate rapidly and during a period when inriver foraging conditions are suboptimal (i.e., high turbidity, low water temperature).

Predation by residualized hatchery-released steelhead, however, could be substantial. The extent of residualization of released steelhead trout smolts is unknown. With a potential annual release of more than one million steelhead trout at Coleman National Fish Hatchery, even a small rate of residualization could result in a substantial predator population.

Predation from steelhead released by Feather River Hatchery and Nimbus Fish Hatchery has not been evaluated but may also be important. Each of these hatcheries has a capacity to raise about 400,000 yearling steelhead to a size of 3-4 fish/pound. Feather River Hatchery fish are planted in the Feather River below Yuba City, most by the end of March, and the Nimbus Fish Hatchery fish are mainly trucked and released in the Carquinez Strait between January and April (California Department of Fish and Game 1990). Feather River hatchery steelhead are released at a large enough size and at a time when they could intercept winter-run chinook. Nimbus Hatchery steelhead would also be large enough to prey on winter-run chinook salmon.

Chinook salmon and steelhead artificially produced at and released from hatcheries may compete with (or displace) their naturally produced counterparts for food or habitat in the river, estuary, and open ocean. The major source of competition from hatchery salmonids in the upper Sacramento River would be from releases from the Coleman National Fish Hatchery on Battle Creek. The extent of competition between naturally produced chinook and releases from other hatcheries is of particular concern. The extent of this competition is unknown but is believed to be low. The size differences between the various chinook salmon stocks may also result in segregation according to size-dependent habitat preferences because juvenile chinook salmon and steelhead move to faster and deeper waters as they grow and do not compete with fry (Everest and Chapman 1972).

Competition between hatchery runs and naturally produced salmon in the ocean is most likely limited in most years. The ocean environment has been assumed to be nonlimiting because, historically, the abundance of wild salmon was much higher than the combined abundances of wild and hatchery salmon at present (Chapman 1986, Bledsoe et al. 1989), and standing stocks and production rates of prey resources were estimated to far exceed the food requirements of the present ocean populations (LaBrasseur 1972, Sanger 1972). A number of studies have found evidence that ocean conditions may limit salmon production and a substantial percentage of the total natural mortality may occur during early marine life (Parker 1968, Mathews and Buckley 1976, Bax 1983, Furnell and Brett 1986, Fisher and Pearcy 1988). However, in many populations, much of this mortality appears to occur in the first month at sea regardless of the number of smolts released. Brodeur et al. (1992) suggested that local depletion of resources could occur, especially of fish prey in a warm year of reduced productivity (e.g., in 1983) when prey were smaller and competitors, such as mackerel, were abundant. But, in general, juvenile salmon do not appear to be food-limited in coastal waters during most normal years (Brodeur et al. 1992, Peterson et al. 1982, Walters et al. 1978).

VISION

The vision for predation and competition is to reduce unnatural levels to restore fish populations by removing, redesigning, or reoperating inwater structures, diversion dams, and hatchery practices.

The ERPP vision for unnatural levels of predation and competition is closely linked to physical habitat restoration objectives and targets in the visions for the Sacramento River Ecological Management Zone, the Sacramento-San Joaquin Delta Ecological Management Zone, the San Joaquin River Ecological Management Zone, and the Suisun Marsh/North San Francisco Bay Ecological Management Zone. In addition, the visions for chinook salmon, steelhead trout, striped bass, and artificial production contain strategies to ameliorate the adverse effects of competition and predation. Cumulatively, these visions present a robust integration of implementation objectives, restoration targets and actions that will contribute substantially to the restoration and maintenance of a healthy ecosystem, and healthy populations of valuable sport and commercial fisheries.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Three major programs to restore chinook salmon and steelhead populations exist within the Central Valley.

The Secretary of the Interior is required by the Central Valley Project Improvement Act (Public Law 102-575) to double the natural production of Central Valley anadromous fish stocks by 2002. The National Marine Fisheries Service is required under the Endangered Species Act to develop and implement a recovery plan for the endangered winter-run chinook salmon and to restore the stock to levels that will allow its removal from the list of endangered species. DFG is required under State legislation (The Salmon, Steelhead Trout and Anadromous Fisheries Program Act of 1988) to double the numbers of salmon and steelhead trout that were present in the Central Valley in 1988.

These programs, together with the ecosystem approach provided in ERPP, will cumulatively provide for substantial improvements in the health of fish populations, their habitats, and the ecosystem processes that create and maintain habitat and lessen the adverse effects of stressors.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

The solutions to reducing unnatural levels of predation and competition are linked to improved hatchery management strategies which include reevaluation of release programs for hatchery produced fish. The solution also include modification to structures that promote predation such as predator habitat provided by instream structures. Some structures, such as RBDD, increase the vulnerability of young fish to predation. The restoration of riparian and riverine aquatic habitats, set back levees, and increases in the area and quality of shallow water habitat throughout the Delta and Suisun Bay will also provide important ecological components to lessen species interactions and the potential for predation.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

The Strategic Objective for predation and competition is to ensure that chinook salmon, steelhead, trout, and striped bass hatchery, rearing, and planting programs do not have detrimental effects on wild populations of native species and ERP actions.

LONG-TERM OBJECTIVE: To rehabilitate man-made structures in the ecosystem to reduce predation losses associated with those structures to levels that will aid in the recovery and restoration of all species. Reduce competition between naturally spawned and hatchery reared species, by establishing hatchery protocols that benefit naturally spawned populations.

SHORT-TERM OBJECTIVE: Reduce the effects of predation associated with operations by better managing the State federal, and private infrastructures associated with aquatic environments. Modify physical characteristics of these facilities to detract from predator use. Study the effects of hatchery reared population have on naturally spawned populations within the ERPP study area.

RATIONALE: Predation related mortality associated with the operation of State, federal, and private facilities within the Sacramento-San Joaquin Estuary and its watershed contributes to the decline of resident and outmigrant aquatic species. Elevated predator levels in and near these man-made structures (screening facilities, diversions, and Clifton Court Forebay) and operational events (temperature plumes from power plants,) have been well documented. These structures have created an environment that is beneficial to predators. Within Clifton Court Forebay (CCF) predators have been documented orienting themselves with the radial gates when they are open, possibly feeding on hapless prey as they are drawn into the forebay (Bolster, 1986). In addition, striped bass have been noted at the trash racks, in front of the primary screens, feeding on marked fish as they are introduced into the water during a marked recapture experiment (DFG unpublished data). In studies done near the outfall of the cooling tower return and resulting thermal plume, predator populations have been demonstrated to increase as compared to other non-thermally elevated areas. Controlling these predators and developing more efficient methods to limit the exposure of prey species to these facilities will assist in the recovery of both listed and non-listed species.

Considerable discussion exists as to the effect of hatchery reared fish on non-hatchery reared fish. This information is not well documented and future efforts will reguire additional information to clarify the issue.

STAGE 1 EXPECTATION: Projects will be undertaken that identify and reduce predation associated with the operation of both State, federal, and private facilities located throughout the ERPP study area. Immediately, programs will be undertaken that reduce the current level of predation related mortality associated with facilities within the ERPP study area.

RESTORATION ACTIONS

The general target is to develop and implement hatchery practices to reduce the potential interactions and competition between artificially produced and naturally produced chinook salmon, steelhead, striped bass, and other resident and estuarine fish. Predation and competition can be further reduced by restoring complex and diverse habitats throughout the mainstem rivers and Bay-Delta.

Actions which can contribute to this vision include:

- reducing shadows and turbulence created by dams, bridges, and diversions that attract predator species,
- replacing or supplementing rock revetment site with natural vegetation including shaded riverine aquatic habitats,
- restoring large blocks of riparian and shaded riverine aquatic habitats along the mainstem Sacramento and San Joaquin Rivers,
- preventing predatory fish from congregating below the Red Bluff Diversion Dam by modifying operations,
- improving fish passage through the flood control bypasses and eliminating low areas with no connection to perennial water courses,
- improving fish release sites used by the State and federal Delta fish salvage facilities,
- reevaluating opportunities to reduce predation in Clifton Court Forebay,
- evaluate alternate release strategies for Central Valley hatcheries to minimize interactions between hatchery and naturally produced fish,

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Implement applicable management measures identified in the restoration plan for the Anadromous Fish Restoration Program and the recovery plan for the native fishes of the Sacramento/San Joaquin Delta.
- Implement management measures identified in the proposed recovery plan for the Sacramento River winter-run chinook salmon.
- To the extent consistent with Program objectives, manage operations at the Red Bluff diversion dam to improve fish passage, reduce the level of predation on juvenile fish, and increase fish survival.

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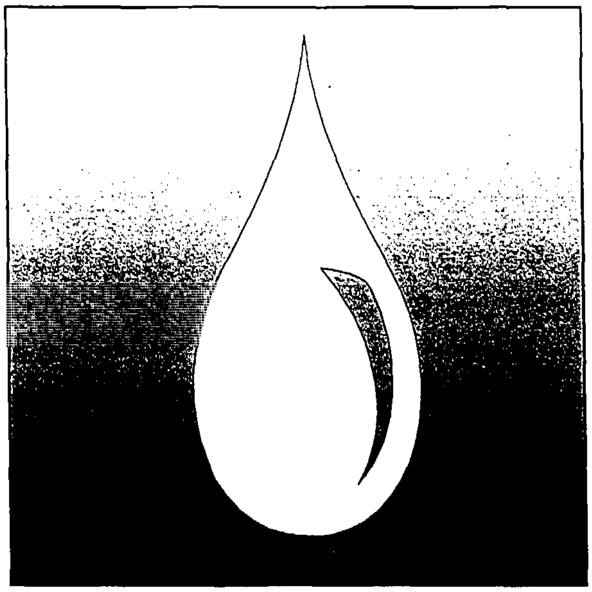

INTRODUCTION

Contaminants are inorganic and organic compounds and biological pathogens that introduce the risk of adverse physiological response in humans, plants, fish, and wildlife resources through waterborne or food-chain exposure. Contamination by these compounds may cause acute toxicity and mortality or long-term toxicity and associated detrimental physiological responses, such as reduced growth or reproductive impairment. Contaminant toxicity has been documented in shellfish, fish, mammal, and bird species from the Bay-Delta. The most serious contaminant problems in the Bay-Delta and its mainstem rivers and tributaries come from mine drainage, agricultural drainage, and urban runoff.

ERPP recognizes that water quality in the Delta must be protected and improved for all beneficial uses including municipal and domestic water supply, irrigation, stock watering, contact and noncontact water-related recreation, hydroelectric power generation, industrial service supply, warm and cold freshwater habitat, warmwater and coldwater spawning, fish migration, and wildlife habitats.

Although cause-and-effect relationships between levels of contaminants and the abundance of aquatic resources have not been conclusively documented, ERP envisions a restored, healthy Bay-Delta ecosystem in which contaminant loads and concentrations are reduced to levels that do not interfere with primary and secondary productivity, nutrient cycling, and foodweb support. Such a restored ecosystem would no longer necessitate human health warnings about consuming fish and wildlife caught in the Bay-Delta estuary.

STRESSOR DESCRIPTION

An estimated 5,000-40,000 tons of contaminants enter the Bay-Delta annually. They are distributed according to complex flow patterns that are heavily influenced by inflow from rivers and the amount of water being pumped from the Delta. Although research confirms that toxicants are affecting lower trophic-level resources to varying degrees in the Bay-Delta, ecosystem- and population-level effects are not well understood. Researchers disagree about the role that contaminants have played in the current poor health of the Bay-Delta.

There are four types of contaminants, inorganic, organic, biological, and toxicity of unknown origin present in the Bay-Delta ecosystem. Inorganic contaminants are substances such as heavy metals, phosphates, and nitrates that enter the Bay-Delta ecosystem primarily in treated municipal wastewater, industrial effluent, agricultural and mine drainage, and urban runoff. Heavy metals in the water column usually occur in trace amounts. They do not break down organically; however, even small amounts of some metals can be toxic. In addition, some metals bioaccumulate within food chains in plant and animal tissue to levels that can be toxic to higher trophic organisms. The heavy metals of greatest concern in mainstem rivers and tributaries of the Bay-Delta are cadmium, copper, mercury, and zinc.

Organic contaminants such as polychlorinated biphenyls (PCBs), plastics, pesticides, fertilizers, solvents, pharmaceuticals, and detergents enter the ecosystem primarily through urban and agricultural runoff. Because they decompose very slowly, some organic contaminants (e.g., DDT and PCBs) remain in the environment for long periods and may accumulate in aquatic foodwebs to levels that are toxic.

Biological pathogens, such as viruses, bacteria, and protozoans that cause disease, enter the system through improperly treated municipal sewage, septic systems, farm and feedlot runoff, recreational boat discharges, and urban runoff. Of particular concern to humans are bacteria that cause cholera, hepatitis, salmonella, and typhoid.

Elements causing toxicity in the Sacramento and San Joaquin river watershed and the Delta have not all bee identified in present evaluations. In approximately half of the toxicity tests conducted in the Sacramento River watershed, the toxicity detected in test species has not been linked to specific chemicals. This is also true for about 30% of the toxic samples collected in the Delta and San Joaquin River watershed.

Since 1986, the Central Valley Regional Water Quality Control Board and the California Department of Fish and Game have been testing the surface waters of the Central Valley for toxicity. Sediment testing has also occurred, but on a much more limited basis. Unknown toxicity is of significant concern because it indicates that there exit agents which are bioavailable and causing toxicity that remain to be identified. Unknown toxicity is also an issue for the Sacramento River Watershed and Delta because it leads to these water bodies not being in compliance with the Narrative Toxicity Objective of the Basin Plan.

Contaminants are present in varying degrees in the water column and sediments of aquatic habitats in all 14 ecological zones of the ERPP study area. Contaminants are suspected or known to adversely affect the sustainability of healthy aquatic foodwebs and interdependent fish and wildlife populations. They also may play a key role in altering the composition of biological resources within affected aquatic and wetland habitats.

In the Sacramento River Basin, acidic drainage water from abandoned mine tailings contribute significant amounts of cadmium, copper, zinc, and mercury to tributaries and mainstem rivers that eventually flow into the Delta. Acute toxicity caused by these trace metals has resulted in fish kills, and long-term exposure is detrimental to growth and impairs reproduction. Of immediate concern is the potential hazard associated with mine drainages just upstream of the spawning area for the endangered winter-run chinook salmon on the Sacramento River. Because of elevated mercury levels, the Bay-Delta, Clear Lake, and Lake Berryessa have consumer advisories for consumption of fish. There are various mercury sources in the Sacramento River watershed including abandoned mines and Coast Range geologic sources.

In the San Joaquin River Basin, selenium leaches into agricultural drainage water during intense irrigation of selenium-rich soils. Selenium has caused reproductive failure in sensitive fish species and developmental deformities in waterfowl and shorebirds. Selenium is also prevalent in the San Francisco Bay, resulting from oil refinery discharges. Loadings of selenium into the Bay-Delta have caused an increase in concentrations of these contaminants in benthic invertebrate, fish, and wildlife populations. Concentrations of some contaminants in water, sediments, and biota of the Bay-Delta estuary are elevated compared with levels at reference sites.

In the Sacramento and San Joaquin River basins, runoff from agricultural crops, pasturelands, and orchards has introduced contaminants into tributaries and mainstem rivers, which ultimately flow into the Delta estuary and Bay. Organophosphate insecticides, such as carbofuran, chlorpyrifos, and diazinon, are present throughout the Central Valley and are dispersed in agricultural and urban runoff. Dormant spray pesticides enter rivers in winter runoff and enter the estuary in concentrations that can be toxic to invertebrates. Although the use of these chemicals has been banned, organochlorine pesticides (e.g., chlordane, DDT, and toxaphene) and organochlorine compounds (e.g., PCBs) persist in the environment. Because they accumulate in living organisms, they can become potent toxicants to fish and wildlife as they move up through the foodweb. Chlorinated pesticides are still being detected in fish and wildlife within the Delta and throughout the world.

Effluents from municipal and industrial sources are common components of mainstem rivers entering the Delta Estuary and Bay. These effluent flows may need to be reduced to restore the health of native fish and wildlife by reducing long-term and acute effects that alter aquatic foodwebs and impair the reproductive potential of these species.

ISSUES AND OPPORTUNITIES

CONTAMINANTS IN THE CENTRAL VALLEY: Researchers frequently discover in bioassays that waters and sediments in various parts of the system are toxic to fish and invertebrates. Although there is only limited evidence connecting these conditions to reductions in abundance, this chronic condition does not seem conducive to long-term restoration. Furthermore, there is an ongoing debate over the long-term consequences to human health of chronic exposure to low concentrations of many organic contaminants. Reducing the impacts of toxic contaminants have been elevated to the status of a specific goal for the ERP.

VISION

The vision for contaminants is to ensure that all waters of mainstem rivers and tributaries entering the Bay-Delta, and all waters of the Bay-Delta, are free of high concentrations of toxic substances.

The vision includes preventing, controlling, or reducing damaging levels of high-priority contaminants by remediating mine wastes, minimizing boat discharges and dredging effects, managing flows, restoring habitat, managing watersheds, and supporting existing programs for controlling agricultural and urban point and nonpoint sources.

ERPP recognizes the complexities inherent in defining processes related to toxic substances and biological responses in the Bay-Delta estuary, where processes operate over a wide range of space and time scales and flow regimes. The process of ecosystem restoration would be initiated by implementing actions to prevent, control, and reduce contaminant sources that represent immediate or potential toxicological hazards to ecosystem processes. The following describes actions that would help to achieve the ERPP vision for contaminants.

One goal is to remediate abandoned mines that contribute significant amounts of heavy metals, sediments, acidified water, and other pollutants to tributaries and mainstem rivers, thereby increasing contaminant loading to the Bay-Delta estuary. Water degradation from mine drainage water can be reduced by controlling runoff based on water quality objectives for specific contaminants; regrading, sealing, and reclaiming strip-mined lands by restoring physical habitat; or using biological or chemical inhibitors to reduce acid formation.

If necessary, financial incentives could be provided to farmers who successfully implement practices to reduce contaminant loading in Central Valley waterways. The successful reduction of rice herbicides in the Sacramento River demonstrates that it is possible to successfully control nonpoint-source contaminants through cooperative efforts by farmers and regulators.

Land use conversion for habitat restoration has the potential to help reduce pesticide, herbicide, mineral salt, and trace element loadings. Converting land from agricultural uses to native wetland and upland habitats would reduce the concentrations and loads of contaminants associated with current agricultural uses. Modifying current farming practices in other areas to be more "wildlife friendly" by changing cultivation practices, introducing postharvest flooding, and reducing pesticide and herbicide application rates would also support reductions in contaminants that could affect adjacent aquatic resources.

ERPP also proposes to reduce the concentration of contaminants entering the Bay-Delta and its tributaries by improving drainwater management. Measures could include reusing drainwater, managing groundwater, scheduling releases to the San Joaquin River to coincide with flows sufficiently large to dilute concentration or acquiring dilution flows from willing sellers, installing drainwater evaporation systems, and encouraging on-farm bioremediation using flow-through systems. Potential lands to be evaluated for retirement could include areas where soils drain poorly; overlay shallow, selenium-laden groundwater tables; or are only marginally productive.

Reducing urban and industrial contaminant loading to the Bay-Delta estuary could be accomplished by assisting formation of partnerships between dischargers and regulators. Using this approach, incentives could be provided to encourage improved source control, better urban planning and development, and wastewater recycling projects that reduce contaminants.

Dredging activities should be monitored and practices developed and implemented to reduce the release and resuspension of toxic substances in contaminated sediments and the discharge of contaminated water from dewatering operations. Studies are needed to evaluate opportunities for reuse of dredged material for proposed ERPP and other habitat restoration projects.

Wetlands management should be considered as a possible means to improve water quality by controlling natural, wastewater, and stormwater contaminants. Wetlands can retain contaminants or reduce loadings by converting contaminants through biochemical processes to less-harmful forms; wetlands also stabilize sediments. Without properly managing contaminants, however, wetlands can degrade and subsequently threaten the food chains they support.

Risks of bacterial and viral contamination from domestic wastewater could be reduced by enforcing boat-discharge regulations in the Bay-Delta estuary and tributaries, reducing recreational overuse and building of recreational homes near streams or Delta waterways, and endorsing wastewater reclamation projects.

Point- and nonpoint-source contaminants can be reduced by developing or implementing existing watershed management plans that effectively reduce contaminant loadings affecting ecosystem processes. Management practices that reduce loading include reducing contaminant loading to reservoirs, protecting groundwater, controlling erosion, reclaiming mines, better planning for land use, controlling animal waste, and screening and identifying nonpoint-source contaminants.

Studies are needed to determine if sediments in the Bay-Delta are toxic. Successfully reducing contaminant loadings will require working closely with agencies that have regulatory authority to develop water and sediment quality objectives for contaminants of concern for which none have been set.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

The CALFED Water Quality Program goal is to provide good water quality for environmental, agricultural, drinking water, industrial, and recreational beneficial uses. The water quality program includes programmatic actions to reduce water quality degradation for agricultural drainage, urban and industrial runoff, acid mine drainage, wastewater and industrial discharges, and natural sources which affect Bay-Delta water quality.

The geographic scope of the CALFED Water Quality Program is the legally defined Delta. This program is developing a strategy to resolve water quality problems that affect beneficial uses of the estuary. Included in this strategy is the intent to resolve water quality problems for certain species (e.g., anadromous fish) that inhabit the Delta but may be impacted at different life stages by conditions outside the Delta. In resolving the water quality problems of the Delta, CALFED may undertake actions throughout the ERPP Study Area.

Other ongoing water quality and contaminant monitoring programs are administered by the California Department of Water Resources, State Water Resources Control Board and the regional water quality control boards, U.S. Environmental Protection Agency, U.S. Geological Survey, local water districts, and many other local agencies and organizations. Some of these programs have made significant progress in controlling contaminant loading to the Bay-Delta, primarily by controlling point-source discharges from municipal wastewater treatment plants and industrial facilities. Monitoring programs that identify long-term trends in contaminants found in ecosystem biota have helped to guide restoration efforts. Current programs in the Bay-Delta are beginning to focus on assessing the toxic effects on ecosystem processes, identifying transport and fate of toxic substances, and quantifying ecological responses to toxic substances.

Many agency and organizations are concerned with the quality of water in the Central Valley and have implemented or assist in water quality monitoring and remediation programs. The total list is extensive and a few of the major elements follow:

- National Water Quality Assessment Program
- Clean Water Act
- Porter-Cologne Act
- State Water Resources Control Board's D-1485,1978 Water Quality Control Plan, and 1995 Water Quality Control Plan
- Federal Lead and Copper Rule
- California Nonpoint Source Program.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

The presence of contaminants in the Bay-Delta system can adversely impair efforts to restore fish, wildlife, and plant species to a healthy state. The individual species affected vary throughout the system and the adverse effects or presence of contaminants varies as well. For example, juvenile winter-run chinook salmon rearing in the Sacramento River below Keswick Dam can be harmed by heavy metals originating from Iron Mountain Mine. Lower in the system, all aquatic organisms can be adversely effected after storms by runoff of acute levels of pesticides applied in the late winter and early spring to orchards. Riparian communities can be adversely effected by overspray of herbicides.

OBJECTIVES, TARGETS, ACTIONS, AND MEASURES

There are three Strategic Objectives that address contaminants.

> The first Strategic Objective is to reduce the loadings and concentrations of toxic contaminants in all aquatic environments in the Bay-Delta estuary and watershed to levels that do not adversely affect aquatic organisms, wildlife, and human health.

LONG-TERM OBJECTIVE: Reduce concentrations and loadings of contaminants to levels that do not cause adverse affects on all organisms and ecosystems in the aquatic environment. Reduce contaminant loads in harvested fish, wildlife and invertebrates from the Bay-Delta system so that they are safe for consumption.

SHORT-TERM OBJECTIVE: Reduce concentrations and loadings of contaminants that affect the health of organisms and ecosystems in water and sediments to the extent feasible based on benefits achieved, cost and technological feasibility. Identify major sources of contaminants (e.g., heavy metals) in the flesh of harvested fish and invertebrates to see if reduction in sources of contaminants is likely to reduce contaminant loads in fish, wildlife and invertebrates.

RATIONALE: A wide variety of pesticides including herbicides, fungicides, algicides and other toxic materials enter the aquatic environment of the Bay-Delta from many sources. The number and variety of contaminants entering the rivers and estuary is poorly known, as are their toxic effects, in part because the amounts and kinds are constantly changing. However, there is good reason to think that toxic compounds are having many negative effects on aquatic organisms, both acute and chronic. These same compounds can have effects on human health, so reducing their entry into the aquatic systems should have positive health benefits as well. Reducing concentrations of toxic contaminants in the aquatic environment is not easy because it will require broad changes in land management practices and pest control practices in agricultural and residential areas. It will require reductions in the risk of contamination from pesticide use through reduction in the amount of pesticide applied, and changes in the types of pesticides and methods of application to reduce their ability to contaminate aquatic ecosystems. Changes in industrial practices that result in contaminants being released (e.g., hydrocarbons from oil refineries) will also be required. Many resident fish, wildlife and invertebrates contain high levels of heavy metals and other contaminants, resulting in warnings that their consumption may be harmful to human health. Elimination of this contamination in the short run is unlikely, but systematic reduction of sources may eventually make all harvested organisms in the estuary and watershed safe to eat. In some cases, such as mercury, reduction of loads to safe levels may be extremely difficult because of deposits in sediments and through absorption and bioaccumulation, but strategies to reduce concentrations are still needed.

STAGE 1 EXPECTATIONS: Strategies and financial incentives will have been developed and implemented that reduce the risk of contamination of toxic materials. Examples include the proper use of pesticides within Integrated Pest Management (IPM) frameworks, proper disposal of unused products and containers, and minimization of the movement of pesticides off-site. The monitoring of contaminants should be substantially increased, both as applied and in the environment to get a better handle on what is going where and on the association of contaminants with declines of aquatic species. Annual goals will have been established for the reduction of concentration of selected contaminants in the environment (e.g., carbofuran, chlorpyrifos, diazinon, hydrocarbons, selenium) and monitoring programs set up to determine success of reduction programs. Major sources of contaminants in fish will have been identified and drainage-specific plans developed to reduce their entry into the ecosystems.

> The second Strategic Objective for contaminants it to reduce fine sediment loadings from human activities into rivers and streams to levels that do not cause adverse ecological effects.

LONG-TERM OBJECTIVE: Implement watershed management plans for all watersheds in the Central Valley in the Delta to reduce or eliminate contaminant loads flowing into aquatic ecosystems.

SHORT-TERM OBJECTIVE: Assist existing programs and encourage new watershed management programs to develop watershed management plans to reduce or eliminate contaminant loads flowing into aquatic ecosystems.

RATIONALE: Contaminants from agricultural, industrial, and urban runoff are potentially major sources of mortality to aquatic organisms and can cause damage to aquatic ecosystems that is often hard to detect and regulate. Therefore, the best approach to the regulation of non-point source contaminants seems to be cooperative watershed plans with built-in incentives for reducing contaminant loadings of waterways. any watershed management programs in the Bay-Delta have been successful and they

STAGE 1 EXPECTATIONS: The CALFED Watershed Management Program will assist existing watershed programs and encourage the formation of new watershed groups in achieving these objectives. Using existing data and analyses, major watersheds in the Central Valley will have been rated or ranked according to the amount they are impaired by contaminants. Plans to reduce contaminant loads in at least 10 watersheds for which such plans do not exist at the present time should be developed an implemented.

> The third Strategic Objective for contaminants is to reduce loadings of oxygen-depleting substances from human activities into aquatic ecosystems in the Bay-Delta watershed to levels that do not cause adverse ecological effects.

LONG-TERM OBJECTIVE: Eliminate runoff and discharges that contain undesirable concentrations of animal wastes, sewage, and other substances that can deplete oxygen levels in streams and sloughs.

SHORT-TERM OBJECTIVE: Identify major sources of oxygen-depleting substances throughout the CALFED region and develop strategies for their reduction; reduce the aquatic areas regarded as degraded by animal waste, sewage, and other organic substance.

RATIONALE: As a result of the Clean Water Act, Safe Drinking Water Act, Toxic Substance Act, etc., local, regional, State and federal agencies have greatly decreased the amount of contamination of California's waters by sewage, animal wastes, and other substances that deplete oxygen in the water. These organic materials cause rapid eutrophication, resulting in fish kills and dominance by undesirable organisms. Such contamination, although diminished, is still common and needs to be reduced further, especially from agricultural sources. For example, low oxygen levels in the lower San Joaquin River are often a barrier to the movement of salmon and other fish. It is worth noting, however, that release of organic nutrients into aquatic systems is not necessarily always harmful, especially if the nutrients derived from human sources essentially replace those no longer entering the system from natural sources.

Some East Coast estuaries have experienced problems with pathogens that appear to be related to eutrophication and oxygen depletion. Although there are reasons not to expect these problems in the Bay-Delta system, any indication of such problems should elicit a rapid response to investigate and control these problems.

STAGE 1 EXPECTATIONS: Sources or areas of problem releases of oxygen-depleting substances will have been identified and incentive programs developed to reduce the amount of organic contamination coming from agricultural, industrial, and residential areas.

RESTORATION ACTIONS

The general target for contaminants is to reduce loading, concentrations, and bioaccumulation in the food chain to levels that do not impair other efforts to restore health to fish, wildlife, and plant populations in the ERPP Study Area.

Agricultural point- and nonpoint-source controls on pesticides, herbicides, mineral salts, and trace elements could be achieved using best management practices such as:

- improving irrigation and tillage techniques,
- placing areal restrictions on pesticide spray and using integrated pest management to reduce pesticide use and consequent discharge to waterways during rainstorms,
- improving fertilizer application technologies,
- altering the amount of time pesticides are present, and
- improving water-use efficiencies.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Restore and enhance delta smelt and longfin smelt habitat to provide suitable water quality (i.e., low concentrations of pollutants) and substrates for egg attachment (submerged tree roots, branches, rock, and emergent vegetation) in important spawning areas.
- To the extent consistent with CALFED objectives, protect Sacramento splittail spawning areas by providing suitable water quality (i.e., low concentrations of pollutants) and substrates for egg attachment (e.g., submerged tree roots and branches and emersed and submersed vegetation).
- Implement applicable management measures identified in the restoration plan for the Anadromous Fish Restoration Program and the recovery plan for the native fishes of the Sacramento/San Joaquin Delta.
- Implement management measures identified in the proposed recovery plan for the Sacramento River winter-run chinook salmon.

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◆ FISH AND WILDLIFE HARVEST

INTRODUCTION

Many Central Valley fish and wildlife species whose populations are declining are not harvested commercially or recreationally (e.g., delta smelt). This suggests that underlying problems with ecosystem processes and functions and habitat conditions throughout the Bay-Delta watershed are primary causes of the decline.

For many populations, it is highly likely that harvest restrictions, in the absence of an integrated ecosystem management program, will have little benefit in the long-term sustainability of these species.

Under current harvest levels, harvest is not a stressor limiting populations of waterfowl and upland game in the Bay-Delta. Proposed restoration of wetland and upland habitats is expected to increase resident and wintering waterfowl and upland game populations. However, the Ecosystem Restoration Program Plan (ERPP) anticipates that harvest levels would also increase in response to increased species abundance. Opportunities for increased access for public hunting may also increase as a result of some proposed actions. For example, restoration of wetland and upland habitats would involve acquiring lands through conservation easements or purchase from willing sellers and, depending on the conditions of such agreements, access for hunting may be provided.

Harvest management tools include regulations that control daily and seasonal bag limits, size limits, limits based on sex, gear restrictions, and open and closed harvest seasons based on time or location.

STRESSOR DESCRIPTION

Controlling harvest, in and of itself, is unlikely to restore fish and wildlife populations to a sustainable healthy state. The present harvest management processes are sufficient to protect species and allow population increases by restoring ecological processes that create and maintain habitats. The possible exception is related to chinook salmon and modestly reducing harvest of this species may make a significant contribution to restoring populations to desired levels. ERPP visions for chinook, salmon, steelhead, and striped bass emphasize reactivating or improving ecosystem processes that create and maintain the habitats that support fish and wildlife populations. Conservative harvest strategies during the period when habitats are being restored will accelerate the rebuilding of fish and wildlife populations.

SALMON HARVEST

In addition to applying the principles of traditional harvest management, it is necessary to consider the complexities of the interactions and dependencies between harvest, health of habitat, and the overall productivity of individual salmon populations. Harvest influences salmon productivity by reducing the number of adult fish in the spawning population, the age structure of the spawning population, and the overall fecundity (fertility) of the population because older female fish are generally larger and carry more eggs. In a much broader perspective, harvest management should strive to protect the productive capacity of individual salmon stocks by pursuing the reasonable and essential objective of protecting the genetic diversity of salmon populations upon which production ultimately depends.

Extensive ocean recreational and ocean commercial troll chinook salmon fisheries exist along the California central coast, and an inland recreational fishery exists in the Central Valley. Support of these economic and recreational uses is an important component in the overall effort to restore and maintain ecological health of the Central Valley ecosystem. Elimination of chinook salmon harvest will not restore ecological health to the system. Likewise, restoring ecological processes in the absence of conservative short-term harvest management may not provide for a sufficiently rapid rebuilding of naturally spawning chinook stocks. However, past observations indicate that Central Valley chinook populations have the ability to rapidly increase in size when there are the required riverine habitat conditions and sufficient flows for juvenile rearing and emigration.

Overall chinook salmon harvest rates must be consistent with the ERPP goal of rebuilding important salmon stocks as evaluated using the Cohort Replacement Rate method. Generally, stable chinook populations will exhibit a long-term average cohort replacement rate of 1.0. During rebuilding (which may require 10-15 years), harvest and inland conditions will be improving and rebuilding will require an average replacement rate greater than 2.0 for the less abundant runs such as the winter run and spring run.

One harvest strategy may be to implement a selective ocean fishery for hatchery stocks to reduce the harvest of naturally produced stocks. This would require the mass marking of all hatchery chinook produced at Central Valley hatcheries and perhaps in the Klamath basin, Trinity basin, and southern Oregon. Another, and perhaps more realistic option, may be to consider economic incentives for commercial and charterboat operators, as well as local businesses dependent on fishing to offset negative economic impacts associated with highly restrictive fishing.

Before 1986, harvest rates were estimated at 65-75% (PFMC 1996), which may have been too high to support a sustainable fishery. Beginning in 1986, harvest rates increased coincidently with the closure of the fishery north of Fort Bragg, California. This fishery was closed to meet harvest-sharing obligations on Klamath River stocks to Native American Tribes. This closure shifted the ocean troll fishery south to the Central Valley index area.

Many conservation biologists believe that a harvest rate of about 67% is a sustainable, conservative level for naturally spawning stocks, if quality habitat conditions exist inland. Hatchery-produced stocks can support higher rates, but sustaining high rates in the ocean mixed-stock chinook fishery also requires high harvest of naturally produced stocks.

In 1996, the Pacific Fishery Management Council (PFMC) increased the minimum size limits and decreased season length in both recreational and commercial fisheries. These actions were implemented to reduce the fishery impacts on winter-run chinook salmon by 50%. Reducing harvest is one of several major elements that will contribute in both the short and long term to restoring healthy fish populations, but it will not contribute to restoring health of important ecological processes, functions, and habitat. According to available information, it appears that a sustainable chinook salmon fishery can be maintained if habitat conditions and ecosystem processes are restored throughout the Bay-Delta watershed, and if the ocean harvest index on naturally produced fall-run chinook salmon stocks is reduced by 10% below present levels.

Alternative actions that may support harvest reductions include a selective fishery that targets only externally marked chinook salmon and that releases unmarked fish. Selective fisheries can reduce harvest rates on unmarked fish by as much as 70-80% for gear types with low release and dropoff (shaker) mortality rates. However, the reduced harvest rates can be as little as 10-50% for gear types with high release and dropoff mortality rates. The application and benefits of a selective fishery for the central California coast ocean mixed-stock fishery are unknown. The potential effectiveness of a selective fishery in increasing spawning escapements of unmarked fish depends on the following factors:

- the proportion of a naturally spawning stock that would be harvested by the fishery in the absence of selective regulations,
- the impact of nonselective fisheries that harvest unmarked fish that are released in selective fisheries,

- the degree to which reduction in total abundance caused by mortality resulting from application of tags or other distinguishing marks increases harvest rates in nonselective fisheries that operate under catch quotas or bag limits, and

- the magnitude of harvest rate reductions resulting from the selective fishery.

In addition to considering the potential implementation of a mass marking and selective fishery along the California coast, ERPP is also considering the feasibility of providing economic incentives for commercial and charterboat operators to offset negative economic effects of short-term reduced harvest.

Attainment of the ERPP vision for chinook salmon harvest will rely on actions by the California Fish and Game Commission and PFMC. PFMC and seven other regional councils were created by the Magnuson Fishery Conservation and Management Act in 1976. Their primary role is to develop, monitor, and revise management plans for fisheries conducted within 3 to 200 miles of the United States coast. PFMC develops plans for ocean fisheries off California, Oregon, and Washington.

The ocean salmon fisheries off Washington, Oregon, and California have been managed by the PFMC since 1977 by using Fishery Management Plans (FMP). Since the beginning of the 1985 season, the ocean salmon fishery has been managed by a framework FMP that allows flexibility to adjust annual regulations in response to varying stock abundance.

The framework FMP contains fixed management objectives and goals that guide the PFMC's choice of flexible annual management measures. Within specified limits, PFMC may vary season length, management boundaries, bag limits, gear restrictions, and quotas annually to achieve the fixed objectives of the FMP. Some of the major provisions of the FMP are a description of the salmon stocks comprising the management unit, management objectives, and escapement goals and procedures for determining and allocating ocean harvests and in-season management procedures.

It is important to distinguish ERPP's vision for chinook salmon and the roles and responsibility of other management authorities, particularly PFMC. Although ERPP provides a long-term comprehensive plan to restore the ecosystem health of the Bay-Delta system, the harvest management objectives of PFMC are to:

- establish ocean harvest rates for commercial and recreational fisheries that are consistent with requirements for optimum spawning escapements, treaty obligations, and continuance of established recreational and commercial fisheries within the constraints of meeting conservation and allocation objectives.

- minimize fishery mortalities for those fish not landed from all ocean salmon fisheries as consistent with optimum yield;

- manage and regulate fisheries so the optimum yield encompasses the quantity and value of food produced and the recreational, social, and economic values of the fisheries;

- develop fair and creative approaches to managing fishing effort and evaluate and apply management systems as appropriate to achieve these management objectives;

- achieve long-term coordination with the member states of PFMC, the treaty Native American tribes, and management entities that are responsible for salmon habitat or production in the development of a coastwide salmon management plan;

- manage in a manner consistent with any United States-Canada salmon treaty; and

- support the enhancement of salmon stock abundance in fishing-effort management programs to facilitate a return to economically viable and socially acceptable commercial, recreational, and tribal seasons.

In addition to its management objectives, PFMC has established a set of conservation goals, many of which are consistent with ERPP. In recognizing that maintenance of a healthy resource is necessary to achieve continuing benefits to the nation, PFMC will adhere to the following conservation goals:

- Assume a more aggressive role in protecting and enhancing anadromous and marine fish habitat. PFMC will play a leadership and coordination role to support the agencies having management responsibilities and authorities.

- Manage for viable salmon stocks and maintain genetic diversity. PFMC recognizes that in areas of importance to particular stocks, habitat degradation and water development may leave no alternative but to manage for hatchery production or a combination of hatchery and natural production.
- Strengthen its efforts to work with other jurisdictions, both domestic and international, to manage stocks of fish over their entire range.
- Strongly support development of concepts and practices for managing mixed-stock and multispecies complexes and rebuild those complexes to best meet the economic and allocation objectives of PFMC.
- Support additional data collection and analyses that will improve the basis for management measures.
- Develop management measures that constrain incidental catches of fish and other animals within acceptable limits while target species are being harvested.

STEELHEAD TROUT HARVEST

The harvest of both naturally and hatchery- produced juvenile steelhead takes place throughout the Sacramento basin. Juvenile harvest is not desirable because it reduces the future adult population size, the opportunity for anglers to harvest adult steelhead, and the overall productivity and fecundity of spawning populations.

More restrictive angling regulation may be necessary to protect steelhead from overharvest and still allow anglers the opportunity for continued sport fishing. The following elements might be considered as additional protective measures for steelhead: catch-and-release fishing only, catch-and-release fishing where hooked fish are not removed from the water to decrease handling mortality, size limits to protect either juvenile fish or larger adult spawners, and barbless hooks to reduce latent mortality.

ERPP supports special recognition of the steelhead fishery of the Yuba River as an important wild steelhead fishery. As part of this recognition, regulations should be enacted to protect this valuable stock while allowing controlled angling opportunities that have a minimal adverse effect on the spawning population. ERPP also supports prohibiting the harvest of juvenile steelhead and rainbow trout in the Yuba River while providing anglers with opportunities for catch-and-release fishing for wild steelhead in other streams.

STRIPED BASS HARVEST

Adult striped bass support the most important sport fishery in the Sacramento-San Joaquin estuary, and the condition of this fishery is publicly recognized as a barometer of the status of the estuary and its biological resources. Statewide, more than 400,000 anglers fish for striped bass and most of this effort is directed at the Sacramento-San Joaquin estuary population. Unfortunately, because of the depressed state of the population, the present annual harvest of striped bass from the Sacramento-San Joaquin system is only about 80,000 fish. Recent annual harvest rates have ranged from 9-14%. In the early 1970s, when striped bass were more abundant and more anglers fished, harvest rates of 16-24% led to the harvest of more than 300,000 legal-sized fish annually. Annual harvest may have reached 750,000 fish from the high populations of the early 1960s.

ERPP supports the legal harvest of striped bass because it has not caused the decline in abundance that has occurred since the 1960s and 1970s. At the same time, efforts to curtail illegal harvest (taking undersized fish and catching over limits) should be vigorously continued. The goal of increased legal harvest should be attained by maintaining present angling regulations while increasing the abundance of adult fish. Although angler participation most likely will expand as fishing success increases, it is anticipated that present angling regulations will keep harvest rates at sustainable levels (<20%).

WHITE STURGEON HARVEST

White sturgeon provides for an important recreational fishery in the Bay-Delta. Although, commercial fishing for sturgeon is prohibited in California, historical accounts indicate that commercial fisheries greatly reduced west coast sturgeon populations, including the Sacramento-San Joaquin population, in the late 1800s. As a result, all sturgeon fishing was prohibited in 1917; the fishery was reopened in 1954 to sport angling only. With the exception of 1956 to 1963, when the minimum size limit was raised to 50-inch total length (TL), the sport fishery had the same regulations from its inception until 1989: a year-round season, 40-inch TL minimum size limit and a one-fish-per-day creel limit.

Although fluctuations in legal-sized white sturgeon abundance have been primarily dependent on variable recruitment, historical depletion by the commercial fishery indicates that the population is readily subject to overharvest. Consequently, a 40% increase in the average annual harvest rate from 7% in the 1960s and 1970s to 10% in the 1980s was cause for concern and was the impetus for angling regulation changes in the early 1990s. Starting in 1990, a maximum size limit of 72 inches was instituted and the minimum size limit was increased in 2-inch annual increments until it reached 46 inches in 1992. This slot limit is designed to protect older, more productive fish and younger fish that will be recruited into the spawning population and also to reduce overall harvest.

These angling regulations have achieved their purpose; estimated harvest rates have been <3% in recent years. Therefore, ERPP envisions supporting the present harvest strategy that protects the white sturgeon from overexploitation while providing anglers with a sustainable trophy fishery.

HARVEST OF WILDLIFE

Under current harvest levels, harvest is not a stressor limiting populations of waterfowl and upland game in the Bay-Delta. Because proposed restoration of wetland and upland habitats is expected to increase resident and wintering waterfowl and upland game populations, however, ERPP anticipates that harvest levels would also increase in response to increased species abundance. Opportunities for increased access for public hunting may also increase as a result of some proposed actions. For example, restoration of wetland and upland habitats would involve acquiring lands through conservation easements or purchase from willing sellers and, depending on the conditions of such agreements, access for hunting may be provided.

ILLEGAL HARVEST OF FISH AND WILDLIFE

The illegal harvest of fish and wildlife is known to be a problem throughout the Bay-Delta watershed. It may range from the illegal take of adult spring-run chinook salmon from their oversummering habitats in the upper sections of stream tributary to the Sacramento River, to the illegal take of undersized striped bass in the Delta. Illegal harvest can also be in the nature of a more commercial activity such as using gillnets to catch adult salmon, sturgeon, and striped bass in the Delta for sale and profit.

By its very nature, illegal harvest is difficult to control or eliminate. ERPP envisions that the California Fish and Game Code will be enforced by increasing law enforcement officer staff and that reductions in the illegal take of fish and wildlife could make important contributions in rebuilding depleted stocks. ERPP also envisions that directed enforcement is only one avenue to reduce illegal harvest and that a strong public education program is critical to the success of the enforcement effort.

VISION

The vision for fish and wildlife harvest is to support strategies that maintain a sustainable commercial and recreational chinook salmon fishery in a manner consistent with the recovery; of individual stocks; steelhead trout harvest strategies that fully protect naturally spawning stocks while redirecting harvest to hatchery-produced stocks; the continued legal harvest of striped bass and reduction of illegal harvest; and the present white sturgeon harvest strategy, which protects the species from overexploitation while providing a sustainable trophy fishery.

The vision for salmon harvest is to implement strategies that support and maintain sustainable commercial and recreational fisheries. Achieving this vision would be consistent with ecosystem restoration and recovery of endangered species and species of special concern. ERPP proposes both short-term and long-term strategies for harvesting chinook salmon.

The short-term strategy is to support the rebuilding of chinook salmon stocks to desired levels by reducing harvest of naturally produced fish.

The long-term strategy is to increase chinook salmon populations by restoring important ecosystem processes and reducing or eliminating stressors that cause direct and indirect mortality. In the long-term vision, ERPP anticipates sustainable ocean commercial harvest landings of 750,000 to 1,500,000 chinook salmon and recreational landings of 500,000 to 750,000 per season.

The vision for steelhead trout is to support harvest strategies that fully protect naturally spawning stocks while redirecting harvest to hatchery-produced stocks. This will require a marking program similar to the mass marking program proposed for chinook salmon, except the number of fish to mark would be lower. In this vision, adult steelhead harvest would be directed to steelhead produced at Coleman National Fish Hatchery on Battle Creek, Feather River Hatchery on the Feather River, Nimbus Hatchery on the American River, and Mokelumne River Fish Installation on the Mokelumne River. Harvest of these stocks would also occur on the mainstem of the Sacramento River.

The vision for striped bass harvest is to support artificial production needed to sustain annual recreational harvest of about 20% of the adult population. The vision for striped bass is closely integrated with visions for other ecosystem elements that will contribute to higher survival of resident, estuarine, and anadromous fish. This higher survival will be achieved through extensive habitat restoration, reduction or elimination of stressors, and the reactivation of ecological processes that create and maintain habitats.

The vision for white sturgeon is to support the annual recreational harvest of less than 3% of the adult population which will protect population while providing opportunity for a trophy fishery. The vision for white sturgeon is also closely linked to the visions for Central Valley streamflows, habitat improvement, and the reduction of elimination of stressors that cause direct and indirect mortality to young fish.

The vision for illegal harvest is that increased enforcement efforts and public education will reduce the adverse effects to a level consistent with restoring fish and wildlife populations.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Three major programs to restore chinook salmon and steelhead populations exist within the Central Valley.

- The Secretary of the Interior is required by the Central Valley Project Improvement Act to double the natural production of Central Valley anadromous fish stocks by 2002 (USFWS 1997).
- The National Marine Fisheries Service is required under the federal Endangered Species Act to develop and implement a recovery plan for the endangered winter-run chinook salmon and to restore the stock to levels that will allow its removal from the list of endangered species (NMFS 1997).
- The California Department of Fish and Game is required under State legislation (The Salmon, Steelhead Trout and Anadromous Fisheries Program Act of 1988) to double the numbers of salmon and steelhead trout that were present in the Central Valley in 1988 (Reynolds et al. 1993, McEwan and Jackson 1996).

In addition the Fish and Game Commission adopts regulations for the harvest of fish and wildlife, sets seasons, bag limits, closed areas, gear restrictions and a variety of other tools to control the harvest of fish and wildlife species. The Pacific Fishery Management Council annually sets harvest regulations for the areas along the Pacific Coast south of British Columbia.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

One of the most important components of the ERPP is restoring health to fish populations in the ERPP Study Area. Some of these species, such as winter-run chinook salmon, are State or federally listed endangered species. Others species, such as splittail and steelhead, are species of concern, and spring-run chinook salmon is designated a monitored species by the Fish and Game Commission. Overall health of fish and wildlife species is closely linked to the health of ecological processes that create and maintain habitats needed by these species. Improving the ecological functions will also improve habitat. Concurrently, a reduction or elimination of stressors will contribute to improved functions, habitats, and species.

OBJECTIVES, TARGETS, ACTIONS, AND MEASURES

The Strategic Objectives for harvest of fish and wildlife are to enhance, to the extent consistent with ERP goals, population of waterfowl and upland game for harvest by hunting and for non-consumptive recreation; maintain, to the extent consistent with ERP goals, fisheries for striped bass, American shad, signal crayfish, grass shrimp, and non-native warmwater gamefishes, and enhance fisheries for salmonids, white sturgeon, Pacific herring, and native cyprinid fishes.

LONG-TERM OBJECTIVE: Efforts by CALFED will need to be integrated into the Pacific Fishery Management Council (PFMC) and the National Marine Fishery Service (NMFS) objectives to manage chinook salmon species with-in and adjacent-to the California coast with regards to harvest limits and regulations. Other anadromous species like the white sturgeon and striped bass will need to meet the long-term goals established in the CVPIA and DFG's Anadromous Fish Restoration Plan for their respective species. Maintain self-sustaining populations of native wildlife so that opportunities exist for viewing and hunting throughout the ERPP study area.

SHORT-TERM OBJECTIVE: Areas within the Sacramento-San Joaquin Estuary and watershed will be evaluated to determine extent of illegal harvest and exploitation rates for all gamefish and terrestrial species that reside within the ERPP Study area. This information will then be used to develop and refine current management plans and restoration efforts.

RATIONALE: Many of the fishing limits established in the ocean off the coast of California are regulated by the U.S. Department of Commerce under recommendations from the PFMC. Changes or alteration to these regulations would be implemented through the PFMC meetings under the Magneson Act. The level of illegal harvest is not well known for all species of aquatic species throughout California. In addition, the exploitation/harvest rate for many of the popular game species (white sturgeon, striped bass, largemouth bass, and white catfish) is documented.

RESTORATION ACTIONS

The general target is to control harvest in a manner which contributes to attainment of fish population goals established by State and federal legislation and in a manner consistent with restoration of ecosystem health.

Actions which will contribute to this vision include:

- Adaptive management and focused research programs to mark hatchery produced chinook salmon to provide harvest and return data to better manage harvest.
- Reduce ocean harvest rates to 40-50%.
- Mark all hatchery produced steelhead and evaluate the benefits of implementing a selective fishery which targets only marked fish.
- Provide special recognition to the Yuba River as an important wild steelhead fishery.
- Augment the striped bass population and recreational fishery by artificial production.
- Maintain the existing regulations for the white sturgeon trophy fishery.
- Increase enforcement efforts directed at illegal harvest.
- Develop a public education program designed to reduce the illegal harvest of fish and wildlife in the ERPP Study Area.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- To the extent consistent with CALFED objectives, reduce losses of adult splittail spawners during their upstream migrations to recreational fishery harvest.

- Implement applicable management measures identified in the restoration plan for the Anadromous Fish Restoration Program and the recovery plan for the native fishes of the Sacramento/San Joaquin Delta.
- Implement management measures identified in the proposed recovery plan for the Sacramento River winter-run chinook salmon.

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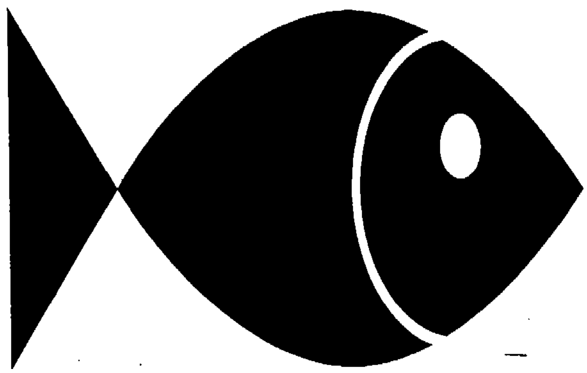
◆ ARTIFICIAL FISH PROPAGATION



INTRODUCTION

The Ecosystem Restoration Program Plan (ERPP) recognizes that artificial propagation of fish has been an important tool used by salmon managers in the Central Valley for over a century. The intended goal of hatchery operation has consistently been for mitigation—typically for the non-retrievable loss of valuable migration, holding, spawning, rearing, and emigration habitats that were cut off by large dams throughout the Central Valley.

Hatchery production makes a significant contribution to commercial and sport fisheries as well as their role in providing mitigation for loss of habitats from the construction of large dams. ERPP envisions the integration of an effective management program of existing or new hatchery facilities with harvest and population management strategies that will work together to restore and sustain the health of fish species dependent on the Bay-Delta. In addition, the artificial propagation of striped bass would be an interim measure to provide for the maintenance of a healthy population and valuable sustainable sport fishery until such time that striped bass are capable of sustaining naturally spawning population levels present in the late 1960s and early 1970s (approximately three million adults).

STRESSOR DESCRIPTION

Five hatcheries currently produce chinook salmon in the Central Valley. The three largest hatcheries (Coleman, Feather River, and Nimbus) are in the Sacramento River Basin (see table), and the Mokelumne and Merced River hatcheries are in the San Joaquin Basin. Most of these salmon hatcheries were constructed between 1940 and 1970 as mitigation for specific dams and water projects, and are funded by mitigation agreements with State, federal, and public agencies and monies collected from commercial salmon fishers.

Before 1967, Nimbus and Coleman were the only hatcheries with substantial production rates, but between 1967 and 1991, total Central Valley salmon production nearly doubled. Central Valley hatcheries now produce an annual average of nearly 33 million juvenile fall-run chinook, more than one million juvenile spring-run chinook, about 0.6 million juvenile late-fall-run chinook, and more than 2.5 million juvenile steelhead.

Releasing large numbers of hatchery fish, however, can pose a threat to wild chinook stocks. Potential consequences include genetic impacts on wild fish (e.g., outbreeding and inbreeding), competition for food and other resources between wild and hatchery fish, predation of hatchery fish on wild fish, and increased fishing pressure on wild stocks as a result of hatchery production (Waples 1991). Potential impacts to native gene pools must be evaluated in light of evidence for genetic changes in hatchery stocks (e.g., random genetic drift, selection, stock transfers, and straying), which can determine the nature and magnitude of interactions between hatchery and wild fish.

There is little evidence with which to evaluate past and current genetic impacts of Central Valley salmonid hatchery programs on the naturally spawning chinook salmon and steelhead populations. Bartley and Gall (1990), using protein electrophoresis, found that populations of chinook salmon from Central Valley hatcheries were genetically similar to wild populations and speculated that the releasing hatchery fish in the Delta may have resulted in abnormally high straying and gene flow to native stocks. However, the great genetic similarity among all Central Valley chinook populations makes it difficult to detect genetic impacts from hatchery releases. An alternative hypothesis that cannot be

Central Valley Salmon and Steelhead Production Hatcheries and the Average Annual Production of Chinook Salmon and Steelhead

		Average Annual Production				
		Chinook Salmon Stock				
Facility[1] and Period of Record	Location	Fall	Spring	Late-Fall	Winter	Steelhead
Feather River Hatchery (1968-1993)	Feather River	7,434,000	1,219,000[2]	N.P.[3]	N.P.	751,000
Nimbus Hatchery (1965-1993)	American River	8,810,000	N.P.	N.P.	N.P.	767,000
Mokelumne River Hatchery (1965-1993)	Mokelumne River	946,000	N.P.	N.P.	N.P.	161,000
Merced River Hatchery (1970-1993)	Merced River	579,000	N.P.	N.P.	N.P.	N.P.
Coleman National Fish Hatchery (1940-1993)	Battle Creek[4]	14,941,000	N.P.	639,000	26,000	814,000
Sum of average statewide production		32,710,000	1,219,000	639,000	26,000	2,493,000

1 All facilities are operated by the California Department of Fish and Game, except that Coleman National Fish Hatchery is operated by the U.S. Fish and Wildlife Service.

2 Spring-run chinook propagated at Feather River Hatchery are believed to have interbred with fall-run chinook.

3 N.P. = not produced.

4 Battle Creek is a tributary of the Sacramento River.

disproved with present data is that Central Valley hatchery stocks have diverged little from their wild ancestors, in which case the near-term genetic impacts of hatchery programs might be minimal. DNA studies may shed light on this problem (Nielsen et al. 1994).

The general literature on the genetic impacts of artificial propagation programs on Pacific salmonids suggests that Central Valley hatcheries could have serious, direct and indirect, negative effects on the naturally spawning chinook salmon and steelhead. Straying hatchery fish, for example, is a major cause of hybridization between hatchery and wild fish (Waples 1991). Although straying, primarily among neighboring streams, is a natural phenomenon, hatchery fish have been documented to stray farther and at a higher rate than wild fish. In the Central Valley, two hatchery practices in particular might contribute to elevated straying levels: trucking smolts and yearlings to distant sites for release and transferring eggs and young fish between hatcheries. These are both practiced at Feather River and Nimbus hatcheries.

Increased production and survival of hatchery chinook salmon have resulted in increasing contributions of hatchery fish to adult spawning escapements since 1967. When hatcheries are successful at producing adult fish, the potential harvest rate may become very high. Fewer adults are needed to maintain a hatchery run because of high survival from eggs to smolts under hatchery conditions. This plants high percentages of returning hatchery fish to be harvested while still sustaining the hatchery run. As harvest rates are raised to match the potential productivity of hatchery stocks, wild stocks may become overfished.

Current harvest rates of Central Valley chinook salmon stocks are high enough to adversely affect the natural production in some rivers and adversely affect naturally produced chinook salmon stocks. Accurate quantification of the Central Valley hatchery contribution to the ocean catch of chinook salmon has not been developed because of the lack of a consistent hatchery marking program in the Central Valley. Nonetheless, Dettman and Kelley (1987) estimated that from 1978 through 1984, an average of 11% of ocean catches off California comprised Feather River hatchery fish, and an average of 13% comprised American River hatchery fish. The percentage of annual contributions of hatchery fish to escapement in recent years has been estimated as follows:

- for the Feather River, 26% average for 1975-1987 (Cramer 1990) and 78% average for 1975-1984 (Dettman and Kelley 1987);
- for the American River, 29% average for 1975-1987 (Cramer 1990) and 86.6% average for 1975-1984 (Dettman and Kelley 1987);
- for the middle Sacramento River, 40% average for 1975-1987 (Cramer 1990); and
- for the upper Sacramento River, 41% average for 1975-1988 (Cramer 1990).

VISION

The vision for the artificial propagation of fish is to modify existing hatcheries and hatchery practices in ways to augment salmon and steelhead populations without having detrimental effects on naturally spawning populations of salmon and steelhead.

The existing level of reliance on artificially produced fish in the Central Valley is clear evidence that there are great deficiencies in the existing ecosystem processes that create and maintain habitat for anadromous fish. Extensive restoration activities will be required to shift the balance back to naturally produced fish populations.

The vision for the artificial propagation of fish is closely linked to ERPP visions for harvest, chinook salmon, steelhead trout, and striped bass. Cumulatively, these visions present a robust integration of production, harvest, and restoration targets and actions that will contribute substantially to restoring and maintaining a healthy ecosystem and healthy populations of valuable sport and commercial fisheries.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Three major programs to restore chinook salmon and steelhead populations exist within the Central Valley. The Secretary of the Interior is required by the Central Valley Project Improvement Act (Public Law 102-575) to double the natural production of Central Valley anadromous fish stocks by 2002 (USFWS 1995). The National Marine Fisheries Service is required under the federal Endangered Species Act to develop and implement a recovery plan for the endangered winter-run chinook salmon and to restore the stock to levels that will allow its removal from the list of endangered species. NMFS released this document in August 1997 (NMFS 1997). In August 1996, NMFS published a proposed rule to list tem Evolutionarily Significant Units west coast steelhead at threatened or endangered under the ESA. Included in this proposed rule was a proposal to list the Central Valley stock of steelhead as endangered. NMFS subsequently deferred list the Central Valley steelhead stock for six month due to scientific disagreement about the status of the stock.

The California Department of Fish and Game is required under State legislation (The Salmon, Steelhead Trout and Anadromous Fisheries Program Act of 1988) to double the numbers of salmon and steelhead trout that were present in the Central Valley in 1988 (Reynolds et al. 1993, McEwan and Jackson 1996).

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

One of the most important components of the ERPP is restoring health to fish populations in the ERPP Study Area. Some of these species, such as delta smelt and winter-run chinook salmon, are State or federally listed endangered species while others, such as splittail and steelhead, are species of concern. Artificial production programs in the ERPP Study Area need to be consistent with the principles of maintaining genetic diversity of natural stocks. These programs also need to be adaptive and implement operations to limit hatchery and wild fish interactions to reduce competition, predation, and the potential spread of diseases.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

> The Strategic Objective is to ensure that chinook salmon, steelhead, trout, and striped bass hatchery, rearing, and planting programs do not have detrimental effects on wild populations of native species and ERP actions.

LONG-TERM OBJECTIVE: Develop a hatchery system and hatchery practices that truly augment salmon and steelhead populations without having detrimental effects on wild populations of salmon. Make sure that trout hatcheries and their associated planting programs do not interfere with or negate ERP actions.

SHORT-TERM OBJECTIVE: Evaluate closely all salmon and steelhead hatcheries and hatchery practices in the CALFED region to determine their effects on wild populations of salmon and steelhead. Take the first steps to change these practices if needed. Construct, where needed, additional artificial production capacity to augment salmon and steelhead using hatchery operation plans that avoid impacts to wild stocks and retain stock genetic integrity. Evaluate the trout hatchery and stocking program in California to determine its impact on populations of wild trout and other fish.

RATIONALE: The hatchery system in the Central Valley for salmon and steelhead was developed with the best of intentions, to maintain the fishery for these species that would otherwise be lost or severely depleted as the result of dams and diversions blocking access to spawning habitat. Hatcheries have generally succeeded by maintaining the commercial and sport fishery for chinook salmon, particularly fall-run chinook salmon. Regardless of the hatcheries, there has been a continued decline of other runs of salmon, of wild runs of fall-run chinook, and of native steelhead stocks. Salmon and steelhead originating from hatcheries may actually have aggravated this problem by interacting with wild fish and may have resulted in elevated harvest levels on those other runs of salmon and on wild fall-run in fisheries. A major emphasis of the CALFED ERP is to restore wild runs of salmon and steelhead by improving habitat conditions for them and by augmenting flows in spawning streams. The role that hatcheries, whether state, federal, or private (non-profit) can play in this recovery is uncertain. Recent strategies have focused on hatcheries that simply augment runs under poor hydrologic conditions when under pre-water development conditions a rivers system would have supported a much larger run. For severely depleted stocks hatchery rearing can provide a temporary insurance policy against extinction due to major natural and unnatural events. For more abundant stocks, however, hatcheries producing large numbers of salmon have the potential to confuse and contravene natural means. The role of hatcheries on every run of salmon and steelhead needs to be carefully evaluated to determine if and how hatchery practices should be changed.

State, federal, and private, have long attempted to satisfy angler demands for catchable trout by rearing domesticated fish for planting in streams, reservoirs, and lakes. There is little question that these planting programs are successful in providing angling for many people, especially in reservoirs and tailwaters of reservoirs. However, in some streams angling for domestic trout may put artificially high pressure on wild stocks of trout and steelhead or planting of domestic trout may introduce diseases to which other trout (and other organisms, including native frogs) are not immune. In some alpine lakes, regular plantings of trout are endangered native frog populations. There is thus a need to closely evaluate all trout stocking programs that take place in the CALFED area to make sure they are compatible with the CALFED goals.

STAGE 1 EXPECTATIONS: The role of every hatchery in the Central Valley in restoring salmon should be evaluated by an independent panel of experts. Where information is lacking, research programs should be conducted. Artificial propagation of salmon smolts of the San Joaquin basin as a research tool for designing and operating an augmentation hatchery that uses methods that do not conflict with restoring Central Valley salmon and steelhead. San Joaquin Basin artificial propagation will be providing needed juvenile salmon fry and smolts critical for adaptive management experiments on the San Joaquin River. A team of experts should be appointed to formally evaluate all aspects of the state and federal trout hatchery programs and issue recommendations in 1-2 years.

RESTORATION ACTIONS

The general targets for the artificial production of fish are:

- propagation programs would be managed consistent with rehabilitation of chinook salmon and steelhead stocks and the conservation of ecological and genetic values;
- propagation programs would adopt a goal of maintaining the genetic diversity that exists between and within hatchery and naturally spawning populations;
- all artificially propagated fish should receive identifiable marks; and
- decision making about the uses of hatcheries and artificially propagated fish should occur within the context of a fully implemented adaptive management program that focuses on restoration of ecological processes and habitats, not simply the number and quality of fish successfully propagated.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Operate hatcheries such that the maintenance and expansion of natural populations are not threatened by the release of hatchery fish.
- Implement applicable management measures identified in the restoration plan for the Anadromous Fish Restoration Program and the recovery plan for the native fishes of the Sacramento/San Joaquin Delta.
- Implement management measures identified in the proposed recovery plan for the Sacramento River winter-run chinook salmon.

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INTRODUCTION

Stranding of juvenile and adult fish is a natural part of a healthy Central Valley ecosystem. Trapped fish provided a valuable source of protein and nutrients to several levels of the food chain, including mammals, avian predators and native peoples. Although stranding causes individual mortality, these losses historically would have been offset by strong in-channel production of the survivors. Stranding of fish in intermittent streams or floodplain areas represented part of the cost of maintaining a broad range, genetic diversity and access to potentially higher quality rearing habitat.

Although stranding was historically a natural event, today it is generally considered a stressor that contributes to the loss of important aquatic resources including adults and juveniles of important fishes. Anthropogenic changes to the valley and its tributaries have led to unnatural topography such as borrow ponds, which can trap large numbers of fish. Similarly, multiple stressors have led to declines in native fish populations, resulting in lower production to offset stranding losses. Efforts to reduce excessive stranding losses represent an important component in improving the natural production of Central Valley fish communities. Resolution of stranding in the Central Valley will require additional research and monitoring to better understand the scope of the problem and to identify key areas where stranding is a serious problem, and the implementation of experiments to refine restoration opportunities.

STRESSOR DESCRIPTION

Stranding appears to be of primary concern for migratory species such as chinook salmon, steelhead trout, sturgeon and splittail. This stressor is much less of an issue for nonnative game fish species such as largemouth and smallmouth bass, which frequently thrive in isolated ponds. Important mechanisms for stranding include: 1) stranding of adults and juveniles on bypass floodplains; 2) stranding of natal and non-natal juveniles within floodplains confined by setback levees; 3) stranding of salmonid redds as a result of flow fluctuation in river channels; and 4) stranding of migratory and resident species from Delta levee breaches.

FLOODPLAIN STRANDING ON BYPASSES

The region's largest floodplains are the Yolo and Sacramento bypasses, representing an integral parts the Sacramento Valley Flood Control System. Stranding principally occurs in wetter years, when fish mortality occurs as a result of predation, high temperature, dessication and perhaps disease or reduced oxygen levels. The Sacramento River, however, has overflowed into the Sutter Bypass every year since 1945, except during the 1977 drought, thus providing significant risk of fish mortality. Stranding is a problem in many drier years as well because weirs spill beginning at Sacramento River flows of only 30,000 cfs. The issue has been best-studied in the Yolo Bypass, a 59,000 acre engineered floodplain. Studies by California Department of Water Resources (1997, 1998a) showed that at least 40 species of fish use the basin during high flow events. Many of these fish are stranded when floodwaters recede. Notable examples of stranded juvenile fish include chinook salmon (fall-run, spring-run and winter-run size classes), steelhead trout, Sacramento splittail and Sacramento pikeminnow. Most of the same species are also present in the Sutter Bypass.

California Department of Water Resources (1997) identified three types of ponds in the Yolo Bypass where stranding occurs: 1) isolated ponds; 2) ponds that maintain some connection to the Delta; and 3) very shallow ponds, typically a few inches of water between row crops. Based on seining surveys and interpretation of aerial photographs, they provided a "ballpark" 1998 stranding estimate for the Yolo Bypass of 300,000-2 million juvenile salmon, depending on pond type. While this represents a substantial number of fish, results from 1998 sampling suggest that majority of young salmon successfully emigrate from the floodplain (California Department of Water Resources 1998a). Generally, emigration from certain types of overflow areas is relatively good because the land has been graded by farmers to drain properly. A contributing factor to the successful emigration is that Central Valley fish populations are probably adapted to take advantage of flood cycles. For example, there is evidence that growth of young salmon in the Yolo Bypass is superior to growth in the Sacramento River as a result of an abundant food supply and warmer water temperatures. Further evaluations are need, however, to determine if sampling bias affects the apparent higher growth rate. For example, when the bypass overflow stops, no additional fish are recruited into the bypass. Comparison of average size of stranded fish versus Sacramento River fish may be biased as there is continual recruitment of fish of all sizes, small and large, in the Sacramento River

This type of floodplain rearing may have been an integral part of the life history strategy for fall-run chinook and perhaps other salmon races. Additional evidence of the growth potential of bypass/floodplain areas was provided by the 1995-96 spring-run chinook salmon tagging study on upper Butte Creek (Hill 1996). Spring-run chinook fry tagged near Chico during January 1996 exhibited significant growth by the time they were recaptured downstream in the Sutter Bypass during March and April.

Recent studies (Maslin 1997 and 1998, Moore 1997) have demonstrated widespread non-natal use by juvenile salmonids of small upper Sacramento River tributaries, often finding fish several miles up the tributary from the river. Entry to these non-natal areas often occurs as the result of floodplain inundation with stranding occurring after flow recession and after low tributary flows sever the interconnectivity with the river. Preliminary results suggest that up to 10,000 winter-run chinook salmon were rearing in Mud Creek, a small tributary that joins Big Chico Creek near the Sacramento River (Maslin 1998). Such non-natal rearing was identified in 19 other small tributaries to the upper Sacramento River between Redding and Chico.

The California Department of Fish and Game has periodically rescued stranded adult chinook salmon in the ponded areas below the Tisdale, Colusa, and Moulton weirs. The magnitude of this stranding is not known as there is no consistent effort to identify stranding, and only easily accessible ponded areas are included in any rescue attempts. During April 1995, the California Department of Fish and Game rescued 74 adult spring-run chinook salmon from a pond located below the Moulton Weir (Meyer 1995).

Five overflow and recession events from the Sacramento River into the Sutter Bypass occurred between January 6 and May 15, 1995, thus providing significant opportunities for stranding. During that period, more that 50% of the entire upper Sacramento River flow was diverted through the Sutter Bypass. Stranding caused by the overflow weirs along the Sacramento River has not been systematically investigated. This source of stranding may be significant.

Additional areas where stranding needs further evaluation include managed and unmanaged wetlands, Liberty Island, Providence Island, lower Feather River floodplain, American basin, and many canals and ditches that have no connection to the rivers after overflow events.

California Department of Water Resources (1997 and unpublished data) note several locations in the Yolo Bypass where stranding rates could be reduced using relatively simple techniques. One example is Sacramento Weir, where leaky flashboards divert fish from the Sacramento River onto the Sacramento Bypass ponds, resulting in stranding rates approximately an order of magnitude higher than any other Yolo Bypass location. Similarly, adult spring run salmon, striped bass and sturgeon are stranded in deeper ponds and channels in part as a result of an outdated, inefficient fish ladder located at Fremont Weir, the upstream limit of the Yolo Bypass. Although the magnitude of this problem has not been documented, the fact that there is a popular sport fishery after the Yolo Bypass recedes suggests that fairly large numbers of adults are stranded. Both the Sacramento and Fremont Weir problems could be fixed or at least improved with fairly minor structural changes.

STRANDING OF YOUNG FISH WITHIN FLOODPLAINS CONFINED BY SET BACK LEVEES

Juvenile and adult fish are also stranded in floodplains adjacent to river channels. For the major rivers of the Central Valley, these floodplains are confined by set back levees. Examples include the Feather, Yuba, American, Mokelumne, Stanislaus and Tuolumne rivers. Fish stranded in these areas a subject to similar sources of mortality as for the bypasses. The level of stranding dependents on fish population levels, topography and the timing and magnitude of flow fluctuation.

In the Feather River, California Department of Water Resources (1998b) studied the effects of a relatively minor winter flow reduction (less than 10 percent) on stranding rates. They concluded that the relatively small numbers of salmon were stranded in depressions on gravel bars below Thermalito Afterbay Outlet were not biologically significant. The low stranding rates were consistent with instream flow model results, which predicted only minor ponding from the flow change. California Department of Fish and Game (1991) used similar instream flow methods for the Mokelumne River and that minor flow fluctuations resulted in little stranding area provided that discharge levels remained above 400 cfs.

Major flow fluctuations distribute fish over a much broader area, frequently exposing them to more variable topography and longer migration path to return to the channel. Whereas minor flow fluctuations occur in all water year types, large scale flow changes are most common in above normal to wet years. In contrast to the low numbers of salmon found in January 1998 in the Feather River below Thermalito Afterbay Outlet following a minor flow fluctuation, in April 1998 Jones and Stokes Associates (unpublished data) found thousands of young salmon in shallow ponds on a broad, downstream floodplain located near Nelson Slough following major flood releases in the Feather River. Fish trapped in these types of ponds may thrive if later flow pulses provide an escape route.

Stranding mortality rates are probably highest in gravel pits, borrow ponds, and spoil deposition areas. Large scale aggregate mining has been conducted for decades in Valley rivers such as the Feather, Tuolumne and Stanislaus rivers. Aggregate mines historically extracted sand and gravel from both the river channel and its adjacent floodplain. Older mines were usually created directly in the channel, creating large depressions. Some remain within the active channels of rivers such as the Tuolumne River. Both in-channel and floodplain ponds can become connected to the main channel during high flow events. These pits support warmwater predators such as largemouth and smallmouth bass that prey on juvenile salmon that migrate through the pits and become trapped after floodwaters recede. Similarly, gold mining activities resulted in dredging and deposition of tailings, converting large areas of floodplain habitat to variegated landscapes with sloughs and borrow ponds that trap migrating salmon and other fish during periods of high water.

Adult Stranding in River Channels

In the Central Valley, steelhead trout and most races of chinook salmon spawn in late summer or autumn. If flows are reduced substantially during the next three months, redds may be isolated, resulting in egg mortality from low oxygen levels or dessication. Although many Central Valley rivers have streamflow fluctuation requirements during critical periods for salmon, unusual spawning events may put fish at risk. For example, in 1991 flow fluctuations from water transfers on the Yuba River led to the stranding or isolation of hundreds of fall-run adult salmon which spawned much earlier than expected.

Stranding of Migratory and Resident Species from Delta Levee Breaches

Delta islands regularly breach in very wet years as a result of land subsidence and antiquated levees. Breaches essentially create a large-scale diversion that can draw thousands of acre-feet of water and fish onto Delta islands. Levees are generally repaired while or after the islands are emptied. During drainage fish are either stranded or pass through hazardous pumps. The magnitude of this problem has not been quantified, however accounts of extensive fish stranding during the 1996 draining of Prospect Island following a levee breach suggest that mortality can be substantial. This type of stranding is also a problem in Feather, American, and Cosumnes floodplains as well as in the Natomas Cross Channel, north of Sacramento.

Vision

The vision for stranding is to reduce the magnitude of the number of aquatic organisms lost when rivers recede or overflow into flood bypasses and to reconnect areas that become isolated with flowing water and to reduce the frequency by which low-lying areas are inundated.

The vision includes improving the structure of channels and floodplains and stabilizing flows during critical periods. Achieving this vision would help to maintain or restore riparian and floodplain habitat and sustain streamflow levels that would improve fish spawning, rearing and emigration.

For bypass floodplains, the strategy is to improve drainage to allow young fish to emigrate and to modify weirs that strand juvenile fish or create passage problems for adults after floodwaters recede. Options to achieve this would be through the construction of year-round low flow channels for drainage and fish passage and the construction of fish ladders to permit upstream passage of adult fish. The focus for these actions would be the Yolo and Sutter bypasses, including the overflow weirs and bypasses which connect them to the river and which comprise the Sacramento Valley's engineered floodplains. In riparian and floodplain areas between river channels and set back levees, restoration activities would emphasize recontouring of poorly-drained areas heavily impacted by historical mining activities. Where possible, gravel and borrow ponds that connect to the main channel during high water periods would be removed or filled. Many borrow ponds provide good habitat during much of the year for a variety of aquatic dependent species and the preferred means to reduce stranding losses is to create and maintain connections with the rivers and streams. Alternatively, levees would be improved or constructed to keep these ponds separated from the active channel. In addition, flows in the smaller non-natal tributaries should be maintained as much as possible to allow positive avenues of escape for rearing juveniles. Stranding of adult spawners and their redds could be avoided by reducing flow fluctuations during critical time periods. Stranding losses from Delta levee breaks would be reduced through levee improvements or conversion of flood-prone islands to tidal wetlands and shallow water habitat.

Integration with Other Restoration Programs

Efforts to reduce stranding will involve the cooperation and support of established programs underway to restore habitat and fish populations in the basin:

- The Central Valley Project Improvement Act (CVPIA) calls for doubling of the anadromous fish populations (including striped bass, salmon, steelhead, sturgeon and American shad) by 2002 through changes in flow, project facilities and operations. The program involves actions that may reduce stranding rates through habitat or flow improvements.
- The California Department of Fish and Game is required under State Legislation (The Salmon, Steelhead, Trout and Anadromous Fisheries Program Act of 1988) to restore numbers of anadromous fish in the Central Valley.
- The Four Pumps and Tracy Fish Mitigation Agreements. These two agreements involve mitigation in the Sacramento and San Joaquin basins to offset fish losses at the SWP and CVP pumping plants. Restoration projects in these programs frequently deal directly or indirectly with fish stranding issues.

Linkage with Other Ecosystem Elements

Reducing stranding is linked to restoration of riparian, floodplain and riverine aquatic habitats and creation of set back levees. Population effects of stranding losses will be mitigated by efforts to reduce stressors to resident and migratory fish. For example, reducing levels of invasive aquatic organisms, reducing predation and competition, gravel restoration, screening of water diversions and reducing levels of toxins should help to improve fish population levels to offset unavoidable stranding losses.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

> The Strategic Objective for stranding is to reestablish frequent inundation of floodplains by removing, breaching, or setting back levees and, in regulated rivers, by providing flow releases capable of inundating floodplains were feasible.

LONG-TERM OBJECTIVE: Implement a comprehensive program to reduce stranding effects in the Delta and its tributary streams.

SHORT-TERM OBJECTIVE: Reduce the adverse effects of stranding by physical modifications to problem areas and, where feasible, implementation of flow schedules that minimize adult stranding.

RATIONALE: Recontouring of floodplains including removing or isolating borrow ponds should promote successful emigration of fish following high water events and create valuable rearing habitat at the river margins. Improving at bypass weirs would eliminate diversion of fish onto floodplain ponds by leaky flashboards and provide for adult upstream passage. Reducing flow fluctuations during spawning periods would help to avoid losses of adults and eggs. Stranding losses from Delta levee breaks would be reduced through levee improvements or conversion of flood-prone islands to tidal wetlands and shallow water habitat.

STAGE 1 EXPECTATION: Initial assessments will be completed of the potential for stranding of juvenile and adult fish in the floodplains and bypasses in the Central Valley. Small-scale adaptive experimentation projects will be implemented to reduce the potential losses due to stranding and to increase the value of bypasses as rearing habitat for splittail and juvenile chinook salmon.

RESTORATION ACTIONS

Actions which can contribute to this vision for bypass floodplains include:

- Improving drainage to allow young fish to emigrate. For example, check boxes could be installed in fields with low levees that border the drains for the Yolo and Sutter bypasses.
- Modifying Sacramento Weir to eliminate leakage through flashboards.
- Constructing a fish ladder at Fremont Weir and provide permanent flow to facilitate adult upstream passage.
- Constructing of a permanent low flow channel through the Yolo Bypass to improve adult passage and drainage following flow events.
- Constructing permanent low flow channels through the Moulton and Colusa bypasses.
- Investigating the potential to develop permanent low flow channels connecting the M&T, 3-B's, and Goose Lake overflow structures with Butte Creek and the Sutter Bypass.
- Developing maintenance flows to provide extended interconnectivity of upper Sacramento River non-natal rearing tributaries.

Actions which can contribute to this vision for floodplains within setback levees include:

- Recontouring heavily corrugated landscapes to improve drainage to the river channel.
- Filling gravel and borrow ponds that connect to the main channel during high water periods or, preferably, creating connectors to allow fish to migrate from ponds into the river.
- for large ponds that are uneconomical to fill, constructing or improving levees to isolate these areas from the active river channel.

Actions which can contribute to this vision for adult spawning include:

- reducing flow fluctuations during critical time periods for adult spawning and egg incubation.

Actions which can contribute to this vision for Delta islands include:

- improving levees to reduce the probability of breakage.
- converting flood-prone islands to tidal wetlands and shallow water habitat.

MSCS Conservation Measures

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Implement applicable management measures identified in the restoration plan for the Anadromous Fish Restoration Program and the recovery plan for the native fishes of the Sacramento/San Joaquin Delta.
- Implement management measures identified in the proposed recovery plan for the Sacramento River winter-run chinook salmon.
- To the extent consistent with CALFED objectives, minimize flow fluctuations to reduce or avoid stranding of juvenile steelhead.
- To the extent consistent with CALFED objectives, design and construct overflow basins from existing leveed lands in stages using construction design and operating schemes and procedures developed through pilot studies and project experience to minimize the potential for stranding as waters recede from overflow areas.
- To the extend practicable, design seasonal wetlands that have hydrological connectivity with occupied channels to reduce the likelihood for stranding splittail and to provide the structural conditions necessary for spawning.

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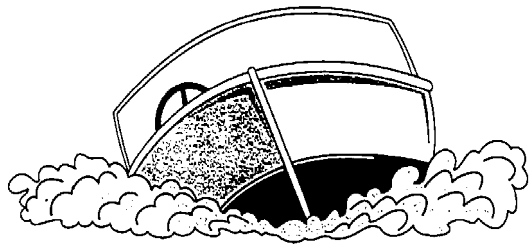
◆ DISTURBANCE



INTRODUCTION

Disturbance resulting from human activities can adversely affect habitat for a substantial variety of fish, wildlife, and plant communities including many special-status species and plant communities listed as endangered or threatened on the California and federal Endangered Species Acts (ESAs) lists. The types of disturbance include those associated with recreational boating, angling and picnicking, airplane and vehicle traffic, and the secondary effects of residential development adjacent to wildlife habitat

The Ecosystem Restoration Program Plan (ERPP) proposes to reduce disturbance where species, such as the Swainson's hawk, nest. Establishing habitat buffers around sensitive habitat or wildlife use areas (e.g., Swainson's hawk nest sites) screens wildlife from disturbance associated with motor vehicle traffic and reduces recreation-related disturbance while still allowing for careful wildlife observation activities.

Carefully designing recreational access points can also reduce the level of disturbance on wildlife (e.g., locating access points to avoid impacts to levees and to keep trespassing and vandalism of private lands to a minimum).

The vision includes providing opportunities for recreational boating in a manner that reduces the impacts of those activities on fish and wildlife. This could be achieved by improving recreational boating opportunities in selected areas of the Delta for both motorized and non-motorized craft while reducing or eliminating boating by closing sensitive biological areas during specific seasons.

STRESSOR DESCRIPTION

Recreational boating is a popular activity in the ERPP study area, particularly in the Sacramento-San Joaquin Delta and Suisun Marsh/North San Francisco Bay Ecological Management Zones. Boating activities include the use of small, human-powered craft, such as canoes and kayaks, and individual motorized craft such as jet skis, sail boats, boats ranging from small fishing skiffs to ski boats, and larger pleasure craft. Wind surfing is also expanding in popularity. Excessive, unrestricted boating activities can result in increased erosion of adjacent channel banks, increased turbidity, and conflicts with other boat operators using the same channels.

Angling and picnicking are also popular activities. Unrestricted human entry for these and other activities has contributed to levee degradation in the Delta, littering, and wildfires and can increase the likelihood of trespass and vandalism on private lands.

Vehicle traffic close to wildlife habitat reduces the value of that habitat to wildlife, particularly to species such as the greater sandhill crane. Aircraft traffic (both fixed-wing and helicopter) associated with the application of agricultural chemicals can also contribute to the disturbance of wildlife in the Delta.

Disturbance associated with the pets of people who live near wildlife habitat can result in harassment of wildlife, particularly ground-nesting birds.

VISION

The vision for disturbance is to reduce the adverse effects of boating and other recreational activities, temporary habitat disturbances, and other human activities on wildlife and their habitats in the Bay-Delta.

ERPP's general approach to achieving the vision for this stressor will be to ensure that the location of restored habitat takes into account adjacent land uses, that adequate buffer areas to protect against disturbance are used, and that recreational activities are managed to avoid or minimize conflicts with fish and wildlife habitat. Recreationists should be provided with adequate facilities in areas that are not sensitive to fish and wildlife and where trespass onto adjacent private lands can be avoided.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Agencies charged with regulating activities within their respective jurisdictions include the U.S. Coast Guard, California Department of Boating and Waterways, California Department of Parks and Recreation, local park districts such as the East Bay Municipal Parks District, local sheriffs in the affected counties, California Department of Fish and Game, California Department of Water Resources, and U.S. Fish and Wildlife Service.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Human caused disturbance adversely affects habitats and species. Boat wake shoreline erosion can impair ERPP efforts to protect and restore shoreline vegetation and shallow water emergent vegetation, particularly in the Delta and along the mainstem Sacramento and San Joaquin Rivers. Human presence can also disturb populations of special status fish, wildlife, and plant species.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

> The Strategic Objective for disturbance is to contribute to the recovery of at-risk native species in Bay-Delta estuary and its watershed.

LONG-TERM OBJECTIVE: Eliminate or greatly reduce the adverse influence of human-induced disturbance on important fish and wildlife species by controlling access during critical times.

SHORT-TERM OBJECTIVE: Evaluate the location of public use access sites to identify potential site that may adversely influence fish and wildlife populations and identify alternative sites for public access that will reduce human-wildlife interactions.

RATIONALE: Some of the species that are known to be adversely influenced by human-induced disturbance include Swainson's hawk, California black rail, California clapper rail, greater sandhill crane, and spring-run chinook salmon. Restoration elements for these example species are strongly directed at restoring or improving habitat for nesting or spawning, forage, loafing, and other habitats required for successful completion of their life cycles. These species are particularly susceptible to disturbance during critical segments of their life cycle, especially those related to reproduction such as nesting and spawning. Reducing human disturbance is an integral component to restoring these and similar species.

STAGE 1 EXPECTATIONS: Surveys will have been completed that identify critical areas and critical times for fully protecting species that are vulnerable to human-induced disturbance. This information will have been used in refining and implementing restoration actions and in identifying sites that can be developed for recreational and public uses.

RESTORATION ACTIONS

The following approaches would help achieve this vision:

- Cooperate with agencies responsible for managing the State's recreational activities to ensure properly sized and sited facilities will be provided and maintained.

- Cooperate with the Department of Boating and Waterways, U.S. Coast Guard, and local mariner organizations to identify the need and feasibility of, and implement where feasible, seasonal boating closures in sensitive wildlife use areas while maintaining alternative boating opportunities.

MSCS CONSERVATION MEASURE

The following conservation measure was included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

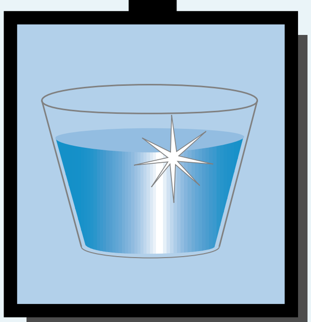
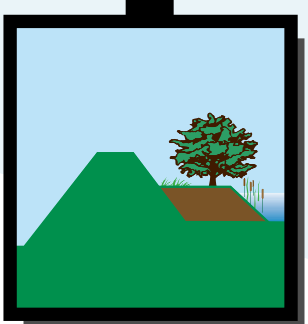
- Manage enhanced and restored habitat areas to avoid or minimize potential impacts associated with recreational uses on lands acquired or managed under conservation easements on the saltmarsh common yellowthroat.

REFERENCES

Multi-Species Conservation Strategy. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.



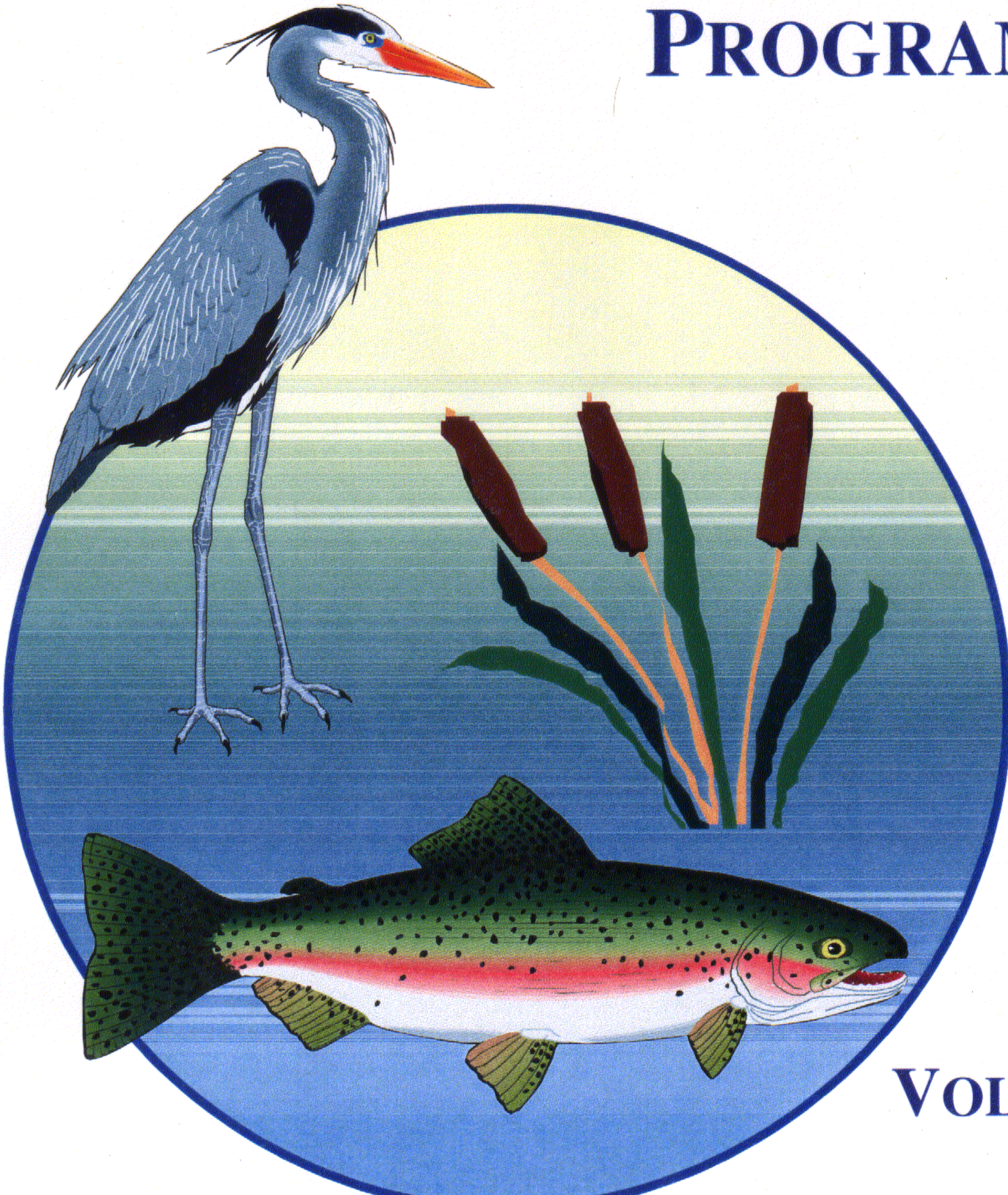

CALFED BAY-DELTA PROGRAM

Ecosystem Restoration Program Plan Volume II: Ecological Management Zone Visions

Final Programmatic EIS/EIR Technical Appendix

July 2000

ECOSYSTEM RESTORATION PROGRAM PLAN



VOLUME II

ECOLOGICAL MANAGEMENT ZONE VISIONS

CALFED BAY-DELTA PROGRAM

JULY 2000

CALFED BAY-DELTA PROGRAM
ECOSYSTEM RESTORATION PROGRAM PLAN

VOLUME II: ECOLOGICAL MANAGEMENT ZONE VISIONS

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CALFED BAY-DELTA PROGRAM
ECOSYSTEM RESTORATION PROGRAM PLAN

OVERVIEW

The mission of the CALFED Bay-Delta Program is to develop a long-term comprehensive plan that will restore ecosystem health and improve water management for beneficial uses of the Bay-Delta system. The Program addresses problems in four resource areas: ecosystem quality, water quality, levee system integrity, and water supply reliability. Programs to address problems in the four resource areas have been designed and integrated to fulfill the CALFED mission.

Ecosystem goals presented in the *Strategic Plan for Ecosystem Restoration* will guide the Ecosystem Restoration Program (ERP) during its implementation phase. Strategic Goals include the following:

1 Achieve recovery of at-risk native species dependent on the Delta and Suisun Bay as the first step toward establishing large, self-sustaining populations of these species; support similar recovery of at-risk native species in the Bay-Delta estuary and the watershed above the estuary; and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed.

2 Rehabilitate natural processes in the Bay-Delta estuary and its watershed to fully support, with minimal ongoing human intervention, natural aquatic and associated terrestrial biotic communities and habitats, in ways that favor native members of those communities.

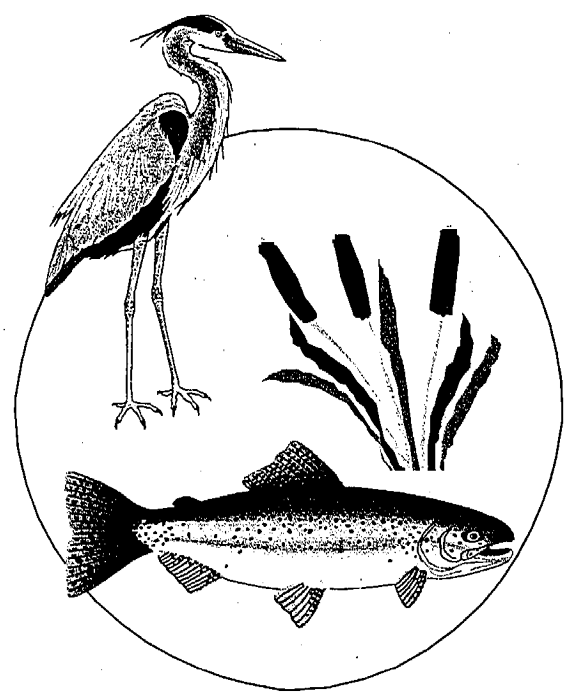
3 Maintain and/or enhance populations of selected species for sustainable commercial and recreational harvest, consistent with the other ERP strategic goals.

4 Protect and/or restore functional habitat types throughout the Bay-Delta estuary and its watershed for ecological and public values such as supporting species and biotic communities, ecological processes, recreation, scientific research, and aesthetics.

5 Prevent the establishment of additional non-native invasive species and reduce the negative ecological and economic impacts of established non-native species in the Bay-Delta estuary and its watershed.

6 Improve and/or maintain water and sediment quality conditions that fully support healthy and diverse aquatic ecosystems in the Bay-Delta estuary and watershed; and eliminate, to the extent possible, toxic impacts to aquatic organisms, wildlife, and people.

The ERP addresses these Strategic Goals by restoration of ecological processes associated with streamflow, stream channels, watersheds, and floodplains. These processes create and maintain habitats essential to the life history of species dependent on the Delta. In addition, the Program aims to reduce the effects of stressors that inhibit ecological processes, habitats, and species.



ORGANIZATION OF THE PLAN

The ERP comprises three volumes: a Strategic Plan and the two volume restoration plan.

- Strategic Plan for Ecosystem Restoration
- Volume I: Ecological Attributes of the San Francisco Bay-Delta Watershed
- Volume II: Ecological Management Zone Visions.

STRATEGIC PLAN FOR ECOSYSTEM RESTORATION is the guidance document for implementing the Ecosystem Restoration Program Plan. It defines an ecosystem-based approach that is comprehensive, flexible, and iterative, designed to respond to changes in the complex, variable Bay-Delta system and changes in the understanding of how this system works. The Strategic Plan also presents broad strategic goals and objectives and establishes "Adaptive Management" as the primary tool for achieving ecosystem restoration objectives. The Strategic Plan describes how conceptual models should be used in developing restoration programs and defining information needs.

VOLUME I: ECOLOGICAL ATTRIBUTES OF THE SAN FRANCISCO BAY-DELTA WATERSHED presents the visions for ecological processes and functions, fish and wildlife habitats, species, and stressors that impair the health of the processes, habitats, and species. The visions presented in Volume I are the foundation of the ERP and display how the many ecosystem elements relate to one another and establish a basis for actions which are presented in Volume II.

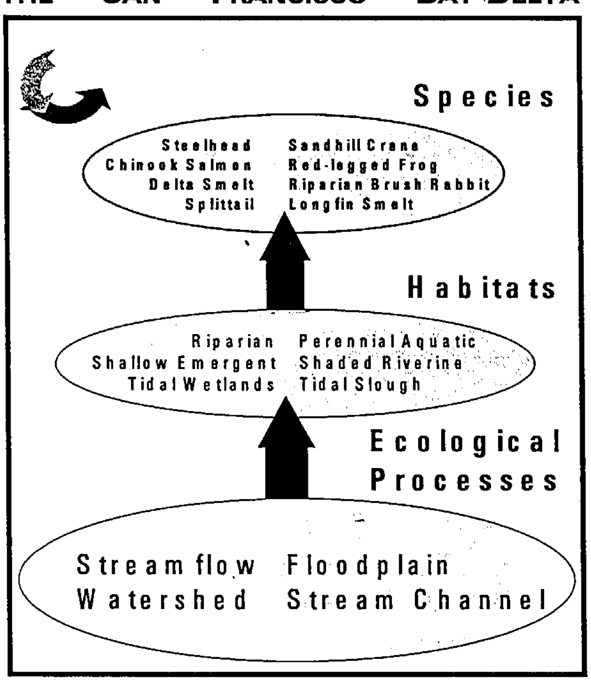


Figure 1. Relationship of ecological processes, habitats, and species in the Ecosystem Restoration Program Plan.

VOLUME II: ECOLOGICAL MANAGEMENT ZONE VISIONS presents the visions for the 14 ecological management zones and their respective ecological management units. Each individual ecological management zone vision contains a brief description of the management zone and units, important ecological functions associated with the zone, important habitats, species which use the habitats, and stressors which impair the functioning or utilization of the processes and habitats. Volume II also contains strategic objectives, targets, programmatic actions, and conservation measures which describe the ERP approach, and which balances and integrates the needs of the Multi-Species Conservation Strategy (2000) in order to improve the ecological health of the zone and its contribution to the health of the Delta. Rationales are also contained in Volume II which clarify, justify, or support the targets and programmatic actions.

INTRODUCTION TO VOLUME II

Volume II, Ecological Management Zone Visions, integrates the landscape ecological concepts for processes, habitats, species, and stressors presented in Volume I: Visions for Ecosystem Elements. Volume II presents this information in population targets, actions and MSCS Conservation Measures for species and 14 visions for the Ecological Management Zones which comprise the ERPP Study Area (Table 1).

Each Ecological Management Zone (Zone) is further divided into component Ecological Management Units (Unit). For example, the East San Joaquin Zone is divided into three Units: Stanislaus River, Tuolumne River, and Merced River. The vision for each Ecological Management Zone provides introductory information; Zone and Unit descriptions which identify the status of ecological processes, habitats, and species; and describes how stressors adversely affect those ecosystem elements.

Table 1. Ecological Management Zones and Ecological Management Units within the ERPP Study Area.

Ecological Management Zone	Ecological Management Unit	
Sacramento-San Joaquin Delta	North Delta South Delta	East Delta Central and West Delta
Suisun Marsh/North San Francisco Bay	Suisun Bay and Marsh Sonoma Creek San Pablo Bay	Napa River Petaluma River
Sacramento River	Keswick to Red Bluff Chico Landing to Colusa Verona to Sacramento	Red Bluff to Chico Landing Colusa to Verona
North Sacramento Valley	Clear Creek Bear Creek	Cow Creek Battle Creek
Cottonwood Creek	Upper Cottonwood Creek Lower Cottonwood Creek	
Colusa Basin	Stony Creek Thomes Creek	Elder Creek Colusa Basin
Butte Basin	Paynes Creek Mill Creek Big Chico Creek Butte Creek Butte Sink	Antelope Creek Deer Creek
Feather River/Sutter Basin	Feather River Bear River Sutter Bypass	Yuba River Honcut Creek
American River Basin	American Basin Lower American River	
Yolo Basin	Cache Creek Solano	Putah Creek Willow Slough
Eastside Delta Tributaries	Cosumnes River Mokelumne River Calaveras River	
San Joaquin River	Vernalis to Merced Mendota Pool to Gravelly Ford	Merced to Mendota Pool Gravelly Ford to Friant
East San Joaquin	Stanislaus River Tuolumne River Merced River	
West San Joaquin	----	

PERSPECTIVE

The ecological hub of the Central Valley is the Sacramento-San Joaquin Delta and Bay. The ERP signals a fundamental shift in the way ecological resources of the Central Valley are managed. For many decades, government entities, non-profit organizations, and the private sector have engaged in managing, protecting, regulating, and in some cases propagating fish and wildlife species of the Bay and Delta - yet many populations have not recovered sufficiently and remain in decline. In spite of constant human intervention to repopulate fish and wildlife that have commercial, recreational, and biological importance to society (e.g., hatchery programs and expensive re-engineered water diversions), populations have not been sustained at stable, healthy levels that support historic use of those resources.

Historic efforts of individual species regulation and management will be replaced by an integrated systems approach that aims to reverse the fundamental causes of decline in fish and wildlife populations. A systems approach will recognize the natural forces that created historic habitats and use these forces to help regenerate habitats. The Bay-Delta ecosystem is not simply a list of species. Rather, it is a complex living system sustained by innumerable interactions that are physical, climatic, chemical, and biological in nature, both within and outside of the geographic boundaries of the Delta.

The ERP is fundamentally different from many past efforts in another way, as well. It is not designed as mitigation for projects to improve water supply reliability or to bolster the integrity of Delta levees; improving ecological processes and increasing the amount and quality of habitat are co-equal with other program goals related to water supply reliability, water quality, and levee system integrity. Solving serious and long-standing problems in each of these resource areas will require an ambitious, integrated, long-term program. We do not know the balance needed between restoration efforts in the Delta and Bay and restoration efforts upstream. However, aquatic species cannot be the sole driving force for ecosystem restoration. Ecosystem restoration must involve the integration of the needs of terrestrial and aquatic species and plant communities.

The central theme of the ERPP is the recognition that truly durable and resilient populations of fish and wildlife inhabiting the Bay and Delta require, above all else, the rehabilitation of ecological processes throughout the Central Valley river and estuary systems and watersheds.

The ERP, like all components of Bay-Delta solution alternatives, is being developed and evaluated at a programmatic level. The complex and comprehensive nature of a Bay-Delta solution means that it will necessarily be composed of many different programs, projects, and actions that will be implemented over time. During the current phase of the Program, solution alternatives have been evaluated as sets of programs and projects and broad benefits and impacts have been identified. In the implementation phase of the Program, more focused analysis, environmental documentation, and implementation of specific programs and actions will occur. The CALFED goal for ecosystem quality will be achieved by further developing and adhering to the *Strategic Plan for Ecosystem Restoration*. A major effort toward reaching target levels will be emphasized during the first 7 years of the implementation program. Special effort will be directed to actions that can be implemented to restore ecological processes. The restoration of these processes is intended to restore and maintain habitats, and to provide for the needs of the species dependent on a healthy Bay-Delta system. For example, restoring stream channels contributes to sediments, nutrients, and a variety of habitats. The strategy recognizes that not all processes can or should be completely restored and that intervention, manipulation, and management will be required. For example, streambed gravel may have to be introduced, habitats may have to be constructed, and vegetation planted. Still, an important part of the approach is to recommend measures that in the long-term will limit the need for continued human intervention.

Implementation of the ERP is further guided by the recognition that all landscape units and physical and biological components of the ecosystem are interdependent and dynamic. Interdependence means that actions and stressors in one part of the system can and do affect populations and conditions that may be separated by hundreds of miles (e.g., in watersheds and spawning tributaries), or affect the food web in ways that may not be felt for several years.

Natural systems are dynamic; i.e., they are characterized by response to cycles of change and episodic catastrophes that are driven by natural or human factors. Most habitats undergo expansions and contractions, or shifts in space and time. The dynamic nature of healthy habitats is the cause of much biological diversity, and complex habitats tend to make species populations more resilient to change. If the mosaic of habitats distributed across a broad landscape is complex, and if large areas of habitat are connected by smaller patches and corridors such as those associated with riparian systems, then healthy areas of the ecosystem can be relied upon to sustain species during temporary setbacks in other areas.

GEOGRAPHIC SCOPE

The geographic (spatial) scope of the ERP is defined by the interdependence and linkage of the ecological zones which encompass the Central Valley. These ecological zones include the upland river-riparian systems, alluvial river-riparian systems, the Delta, and Greater San Francisco Bay (Note: These ecological zones are more fully described in the section on Key Ecological Attributes of the San Francisco-Bay Delta Watershed which follows this section). The geographic scope defines the locations where actions might be implemented to maintain, protect, restore, or enhance important ecological processes, habitats, and species. Some rivers or watersheds have ecological attributes which are valued higher than the attributes present in others areas. These ecological values include the condition of important ecological processes and how well they support a diversity of habitats and biotic communities. The communities include the fish, wildlife, and plants which occupy or utilize the habitats within these local areas.

Species and biotic communities addressed in the ERP depend on habitat conditions in Suisun Bay, the Delta, Sacramento River, San Joaquin River, and many of their tributary streams. For these reasons, the primary geographic focus of the ERP is the Sacramento-San Joaquin Delta, Suisun Bay, the Sacramento River below Shasta Dam, the San Joaquin River below the confluence with the Merced River, and their major tributary watersheds directly connected to the Bay-Delta system below major dams and reservoirs. In addition, streams such as Mill Creek, Deer Creek, Cottonwood Creek, and Cosumnes River, are emphasized due to their free-flowing status and relative high quality of habitats and ecological processes.

Secondarily, the ERP addresses, at a broader, programmatic level, Central and South San Francisco Bay and their local watersheds (Note: The primary geographic focus area for the ERP can be divided into 14 management zones, each characterized by a predominant physical habitat type and species assemblage, Figure - 2). These 14 ecological management zones constitute the geographic areas in which the majority of restoration actions will occur. The upper watersheds surrounding the primary focus area are important and addressed through general actions that focus on watershed processes and watershed planning, management and restoration. The CALFED Watershed Program addresses the coordination of planning and restoration actions in the upper watershed.

MULTI-SPECIES CONSERVATION STRATEGY

CALFED has developed a Multi-Species Conservation Strategy to serve as the framework for compliance with the Federal Endangered Species Act (FESA), the California Endangered Species Act (CESA), and the State's Natural Community Conservation Planning Act (NCCPA) (Multi-Species Conservation Strategy 2000). The Conservation Strategy has identified a subset of species which are federally and State listed, proposed, or candidate species, other species identified by CALFED that may be affected by and for which the CALFED Program and the ERP have responsibility related to (1) recovery of the species, (2) contribute to their recovery, or (3) maintain existing populations.

IMPLEMENTATION STRATEGY

A large and diverse ecosystem like the Bay-Delta is extremely complex. There are many processes and relationships at work in the ecosystem that are not

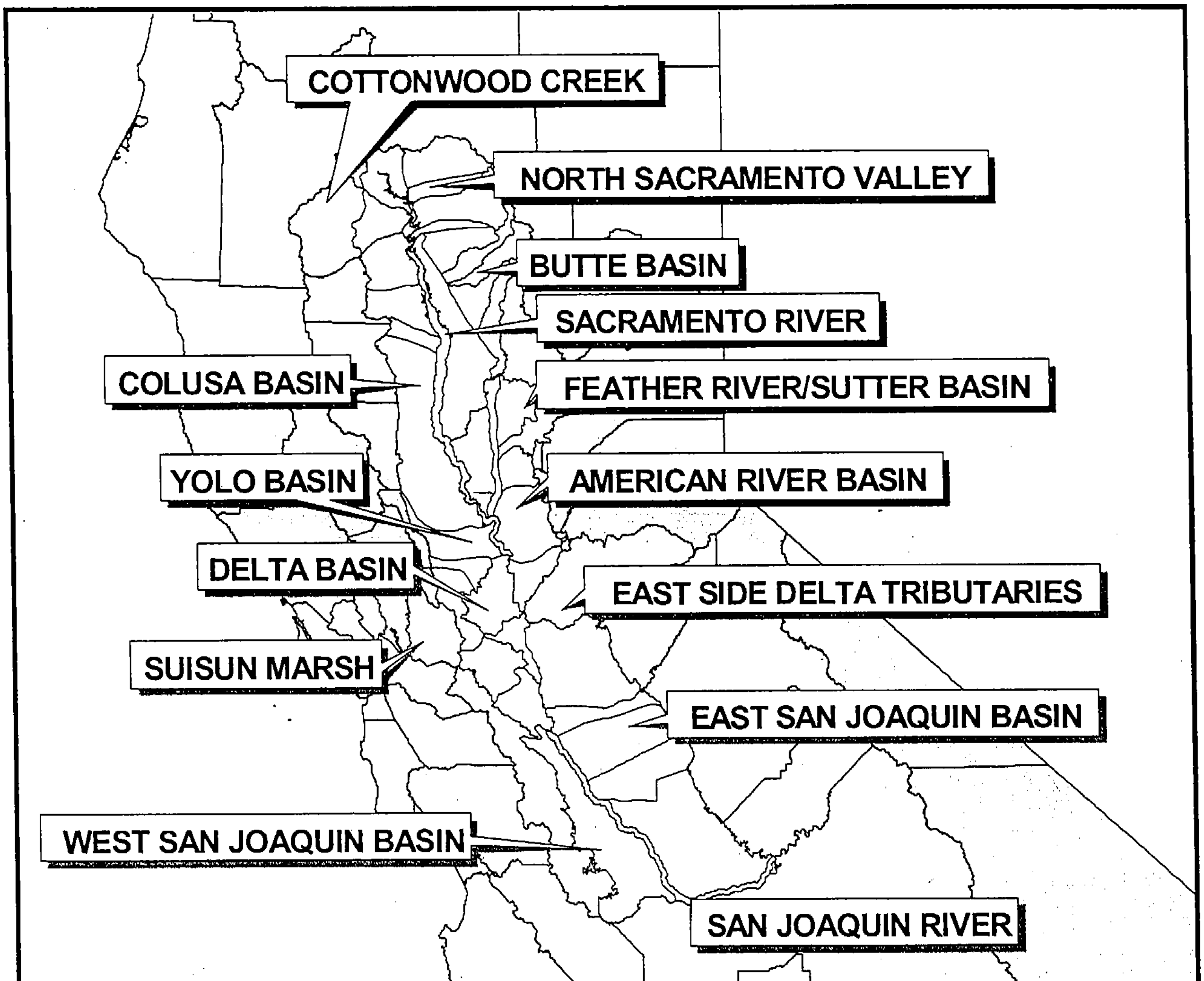


Figure 2. Location Map of the 14 Ecosystem Restoration Program Ecological Management Zones

fully understood. Thus, there are many difficulties and uncertainties associated with a program to improve ecosystem health. In some cases, problems are well understood and the steps to improvement are clear. In other cases, there is some understanding of the reasons for decline but this understanding is not sufficient to warrant full-scale implementation of remedial measures. In still other cases, additional research is needed before solutions can be identified with certainty.

The difficulties and uncertainties of ecosystem restoration call for an implementation strategy that is flexible and can accommodate and respond to new information. The foundation of the ERP implementation strategy is adaptive management. Adaptive management is a process of testing alternative ways of meeting objectives, and adapting future management actions according to what is learned. Adaptive management relies upon the identification of indicators of ecosystem health, comprehensive monitoring of indicators to measure improvement over time, focused research, and phasing of actions.

INDICATORS are quantitative measures of ecosystem attributes or elements that are expected to change over time in response to implementation of the ERP. Indicators are selected to provide measurable evaluations of important ecological processes, habitats, and species whose status individually and cumulatively provide an assessment of ecological health. Indicators of ecosystem health are the gauges we will use to measure progress toward the goal. Some indicators are very broad in scale while others are very specific. For example, a very broad or landscape level indicator of ecosystem health might be a comparison of the total area of riparian forest to historic coverage or an evaluation of the average distance between patches of such forest with closer patches indicating better health than more distant patches. A more specific indicator might be the concentration of toxic substances in the flesh of adult striped bass.

COMPREHENSIVE MONITORING is the process of measuring the abundance, distribution, change or status of indicators. For example, contaminant concentrations in fish tissues can be measured at various locations and times in the system to determine if contaminant levels are changing. This will allow progress to be measured, allow actions to be modified if necessary, and provide assurances that the restoration objectives are being achieved. (Note: A Comprehensive Monitoring, Assessment, and Research Program is being developed. A description of that program is presented later in this section.)

DIRECTED RESEARCH will help answer questions about the system and its components and increase the certainty surrounding the relationships of ecological processes, habitats, and species. For example, the relationships among streamflow, storm events, flow-related shaping of river channels to modify habitat, and the physical and chemical signals that flow provides for aquatic species all need to be better understood for effective management of the system.

STAGED IMPLEMENTATION is the logical sequence of implementing restoration actions to achieve CALFED goals as effectively as possible. Phasing will consider all targets and programmatic actions and will be used to prioritize actions. For example, actions directed at recovering endangered species and which are consistent with the long-term restoration program and contribute to ecological resilience have a high priority.

Stage I implementation is defined as the first 7 year stage of the program and will include restoration of ecological processes and habitats that are most important for endangered species recovery, reduction of stressors that affect threatened and endangered species, and other actions that may reduce conflicts between beneficial uses in the system. Later implementation stages will be shaped through adaptive management by the results of restoration actions in the first 7 years of the program.

The ERP will be refined and implemented according to the steps listed below.

1. **REFINE THE ERP** based on broad public participation, and using the best scientific knowledge currently available in the short term.
2. **CREATE AN ECOSYSTEM SCIENCE PROGRAM** to provide ongoing scientific evaluation of the ERP. The Science Program will be a collaborative effort among local and national, independent stakeholder and agency scientists and technical experts convened to address outstanding scientific issues and review the ERP.
3. **PREPARE CONCEPTUAL MODELS** to describe the Bay-Delta ecosystem and the proposed actions of the ERP. Restoration or rehabilitation programs for complex ecosystems must be based on clear concepts about how the system is believed to function, how it has been altered or degraded, and how various actions might improve conditions in the system. Conceptual models can provide a basis for quantitative modeling or identify critical information needs for research or monitoring. In ecosystem restoration, they can be used to link human activities or management actions to outcomes important to society. In adaptive management, the most important uses of conceptual models are for: linking human activities to valued outcomes, highlighting key uncertainties where research or adaptive probing might be necessary, and identifying monitoring needs.
4. **DEVELOP TESTABLE HYPOTHESES** for proposed ERP actions. The hypotheses underlying the ERP will be tested through experiments using the conceptual models and on-the-ground research. The results from these experiments will feed back into the adaptive management process and will support proposed actions, suggest revisions to actions, and identify needs for further research.

5. **CONDUCT IMMEDIATE DIRECTED RESEARCH** to improve understanding of the ecosystem and the causes of problems identified in the conceptual models and testable hypotheses. Use results from short-term studies to adjust the way that objectives are achieved, making refinements to the final ERP targets, actions, and implementation schedule.

6. **DEVELOP AND BEGIN A STAGED IMPLEMENTATION PROGRAM THAT ENTAILS:**

- short-term implementation of ecosystem restoration demonstration projects including stressor reduction measures, to help at-risk populations begin recovering and to test the viability and effectiveness of targets and actions,
- coordinated monitoring, evaluation, and reporting of the results of recovery efforts, and the status of ecological indicators in the Bay-Delta and other zones, and
- adaptive management of each successive phase of ERP implementation, including pragmatic adjustments to ecosystem targets, funding priorities, and restoration techniques to ensure that public and private resources are well spent and complement other related efforts.

During refinement and implementation of the ERP, public accountability and program effectiveness will be assured through continuing public involvement as well as environmental impact analysis and documentation.

COMPREHENSIVE MONITORING, ASSESSMENT, AND RESEARCH PROGRAM

The CALFED Bay-Delta Program is organized around the concept of adaptive management because there is incomplete knowledge of how the ecosystem functions and the effects of individual project actions on populations and processes. Monitoring key system functions (or indicators), completing focused research to obtain better understanding, and staging implementation based on information gained are all central to the adaptive management process. The process necessarily includes numerous assessment and feedback loops so that management decisions are based on the best and most current information. This process entails an institutional framework to ensure that the correct questions are identified for monitoring and research actions, that monitoring and research are conducted appropriately, that the data collected and obtained are stored properly and available to those with an interest, and that relevant information is developed from the data obtained to further the incremental process of adaptive management. The Comprehensive Monitoring, Assessment and Research Program (CMARP) is being developed to meet these needs.

A substantial monitoring effort in the Bay and Delta has been carried out for many years under the auspices of the Interagency Ecological Program (IEP). The purpose of the CMARP is to build on the work of IEP and other efforts to assure that information gathering and evaluation necessary to the success of the CALFED Program is developed and carried out. CMARP will help provide those new facts and scientific interpretations necessary for implementing the CALFED Program and for the public to judge the Program's success. Major efforts will include documenting and explaining the status and trends of the resources, providing timely information for real-time management, and participating in design, execution, and analysis of adaptive experiments. CMARP must routinely make available information on major indicators of program progress. CMARP efforts must be subjected periodically to independent scientific review to evaluate the Program's relevance and approach and to maintain public confidence in the Program.

CMARP SCOPE

CMARP is designed to provide information on all of the CALFED program elements, including the Ecosystem Restoration Program, the Multi-Species Conservation Strategy, Water Quality Program, Levee Program, Water Use Efficiency Program, Water Transfer Program, Storage, Conveyance, and the Watershed Program. CMARP also has responsibility for organizing and evaluating data generated by projects of the Restoration Coordination Program. In addition, CMARP will contribute to the design of monitoring for any mitigation efforts of CALFED. Finally, CMARP will be coordinated with existing monitoring and research programs so that they can provide a foundation of information for the

Program. The CMARP will include options to ensure that monitoring, assessment, and research needs are:

- identified
- coordinated to provide comprehensive system-wide coverage
- performed by the most appropriate party
- completed in a comparable manner by all parties
- accomplished with minimum redundancy and optimum efficiency and effectiveness.

The CMARP must also ensure that results from the monitoring are:

- interpreted
- made readily available to all interested parties in a timely manner
- incorporated as feedback to facilitate adaptive management.

CMARP must also assure that study and monitoring designs are sufficient to detect statistically significant and ecologically relevant impacts or changes.

The scope of CMARP includes both institutional and environmental considerations. It seeks to balance specific knowledge needs of water managers and the public versus an understanding of ecosystem processes and what can actually be obtained and measured from the field. For example, CALFED agencies presently monitor the abundance of several key species and environmental attributes such as streamflow at the State and federal diversion facilities in the Delta to understand better which species are entrained, when, how many, during what life stage and under what kind of environmental conditions. Although much of this monitoring is designed to address institutional needs, limits on knowledge obtained are based on limitations of monitoring design which in turn are limited by the physical system to be monitored. Thus, the programmatic scope of CMARP must consider both institutional needs and environmental considerations and should maintain sufficient flexibility to respond to both as they change over time.

CALFED has determined that monitoring, assessment, and research efforts are a critical component of the adaptive management process, and should be integral to all program elements. The application of CMARP will be very different for individual CALFED programs. However, each program element has similar needs that include gathering and assessing data. In addition, the CMARP must also address the monitoring and assessment needs of the CALFED Conservation Strategy, as well as any mitigation required as a result of CALFED program actions.

Restoration projects require special consideration. A requirement for funding is that project proposals contain monitoring elements to determine if stated objectives have been met and to provide guidance for assessing future rehabilitation needs. CMARP will include recommendations to ensure that monitoring data from all these projects are technically sound, broadly usable, and provide meaningful information to guide future actions.

The CMARP Plan will take into consideration the broad variety of factors that can affect the environment, its physical structure, chemical makeup and biotic communities. The recommended program will necessarily be limited to monitoring only a small fraction of the possible physical chemical, and biological, attributes of the environment. Conceptual modeling will play a key role in helping decide which attributes to monitor.

CMARP OBJECTIVES

Objectives have been established for CMARP's monitoring and assessment and research functions that are consistent with the adaptive management strategy adopted by CALFED.

MONITORING AND ASSESSMENT PROGRAM OBJECTIVES

- Provide information necessary to evaluate the effectiveness of program actions and to support ongoing adaptive management actions.
- Describe conditions in the Bay-Delta and its watershed on appropriate temporal and spatial scales.
- Evaluate trends in the measures of environmental conditions.
- Identify the major factors that may explain the observed trends.
- Analyze data and report results to stakeholders and agencies on a timely basis.

Research Program Objectives

- Build an understanding of physical, chemical and biological processes in the Bay-Delta and its watershed that are relevant to CALFED program actions.
- Provide information useful in evaluating the effectiveness of existing monitoring protocols and the appropriateness of environmental attributes.
- Test causal relationships among environmental variables identified in conceptual models
- Reduce areas of scientific uncertainty regarding management actions.
- Incorporate relevant new information from all sources.
- Revise conceptual models as understanding of the system increases.

CMARP Program Activities

The CMARP development process has included the following steps:

1. **Identify the goals, objectives and needs** of CALFED Program elements, related programs, and agency major program goals and objectives.

2. **Develop a conceptual framework** that focuses on development of explicit conceptual models for use in designing monitoring and research programs. (This task is being accomplished in coordination with monitoring and research programs from Puget Sound, Chesapeake Bay and South Florida).

3. **Monitoring program design**
   - Inventory existing monitoring programs
   - Develop monitoring elements
   - Develop a process for data management
   - Develop a process for data analysis and monitoring
   - Restoration coordination monitoring institutional process

4. **Design a CALFED focused research program** to investigate causes and trends, reduce areas of scientific uncertainty, and corroborate relationships in conceptual models.

5. **Develop an institutional structure for monitoring, assessment and research** to focus on identifying institutional functions, and recommending how a monitoring and research program should operate. The *CMARP Program Report*, a separate appendix to this *Programmatic EIS/EIR*, recommends that there be a chief scientist, a science coordination team, and a science review board.

CALFED recognizes the need for reducing uncertainties about the factors affecting the resources of the Bay-Delta system. Although a traditional monitoring, assessment and research program will meet this need over a period of decades, CALFED needs to reduce key uncertainties at a more rapid rate to meet program goals. Therefore, CALFED will undertake an active program of adaptive resource management. Such a program will require a partnership between resource managers and scientists in which effects of key factors are better defined by informed management experiments. Resource managers will thereby increase chances of avoiding catastrophes and responding successfully to unexpected events. Informed adaptive experiments require policy-level recognition and acceptance of some risks to the resources.

Terms Used in the ERPP

The following terms are used in the ERP:

Conservation Measure: Two types of conservation measures were developed under the MSCS: 1) measures designed to avoid, minimize, and compensate for CALFED's adverse effects on NCCP communities and evaluated species (applicable to species with "R," "r," and "m" conservation goals; and 2) measures to enhance NCCP communities and evaluated species that are not directly linked to CALFED's adverse impacts. The conservation measures presented in Volume 1 and Volume II of the ERP are the latter type: conservation measures to enhance NCCP communities and evaluated species.

Ecosystem-Based Management: Ecosystem-based management is a resource management concept of achieving species management objectives by sustaining and enhancing the fundamental ecological structures and processes that contribute to the well being of the species. A basic tenet of CALFED's implementation of ecosystem-based management is, to the extent feasible, to restore or rehabilitate the natural processes that create and maintain the important elements of ecosystem structure. Ecosystem-based management differs fundamentally from the more traditional approach of species-based management, which seeks to manipulate specific environmental factors (e.g., direct removal of predators from the environment to reduce predation levels on the target species) thought to be limiting target species populations at levels below management objectives.

ECOSYSTEM ELEMENT: An ecosystem element is a basic component or function which, when combined with other ecosystem elements, make up an ecosystem. An ecosystem element can be categorized as a process, habitat, species, species community, or stressor.

ECOSYSTEM REHABILITATION: Within CALFED's concept of ecosystem restoration, the ERP will largely focus on ecosystem rehabilitation. In the context of CALFED, ecosystem rehabilitation is defined as the process by which resource managers reestablish or refurbish key elements of ecological structure and function within the Bay-Delta ecosystem to a level necessary to achieve ERP goals and objectives.

ECOSYSTEM RESTORATION: Ecosystem restoration is a term sometimes used to imply the process of recreating the structural and functional configurations of an ecosystem to that present at some agreed to time in the past. Because the structure and function of many elements of the Bay-Delta ecosystem have been severely disrupted and cannot be feasiblely restored to a specified historic condition, within the context of CALFED, ecosystem restoration is more realistically defined as the process by which resource managers ensure that the capacity of the ecosystem to provide ecological outcomes valued by society is maintained, enhanced, or restored.

ECOLOGICAL PROCESS: Ecological processes act directly, indirectly, or in combination, to shape and form the ecosystem. These include streamflow, stream channel, and floodplain processes. Stream channel processes include stream meander, gravel recruitment and transport, water temperature, and hydraulic conditions. Floodplain processes include overbank flooding and sediment retention and deposition.

HABITATS: Habitats are areas that provide specific conditions necessary to support plant, fish, and wildlife communities. Some important habitats include gravel bars and riffles for salmon spawning, winter seasonal floodplains that support juvenile fish and waterbirds, and shallow near-shore aquatic habitat shaded by overhanging tule marsh and riparian forest.

LONG- AND SHORT-TERM OBJECTIVES: Objectives can be both short-term and long-term. Short-term objectives should be clearly feasible, relatively easy to measure, and achievable in reasonable length of time (usually less than 25 years). The time period is not the same as Stage I of the CALFED process. Long-term objectives may be more difficult to determine and require additional resources and knowledge to achieve. (Note: these differ from Strategic Objectives which are defined later in this section.)

PROGRAMMATIC ACTION: A programmatic action represents a physical, operational, legal, or institutional change or alternative means to achieve a target. The number of actions and their level of implementation is subject to adjustment by adaptive management. For example, the number of diversions screened may be adjusted up or down depending on the overall response of fish populations to screening and other restoration actions.

An example of a programmatic action is to develop a cooperative program to acquire and restore 1,500 acres of tidal perennial aquatic habitat in the Suisun Bay and Marsh Ecological Management Unit.

SPECIES DESIGNATION: The classification system used to organize species by status. The species designations used in the ERP for species evaluated in the MSCS are identical to the designations used in the MSCS (recover, contribute to recovery, and maintain), and include additional designations for species or biotic communities not addressed in the MSCS. The two additional ERP designation include enhance and/or conserve native biotic communities, and maintain and/or enhance harvested species. The species designated for recovery, contribute to recovery, maintain, and enhance and/or conserve native biotic are addressed by Strategic Goal 1. Species designated as maintain and/or enhance harvested species are addressed by Strategic Goal 3 (maintain and/or enhance populations of selected species for sustainable commercial and recreational harvest consistent with the other ERP strategic goals).

SPECIES GOAL: Goals recommended by the Multi-Species Conservation Strategy Team for evaluated species. The MSCS species goals include recover, contribute to recovery, and maintain. The analogous ERP terms are found in the Strategic Objective for Strategic Goal 1 which addresses at-risk species.

SPECIES GOAL PRESCRIPTIONS: A performance standard to measure progress toward the species goal by providing habitat or population targets. (Note: Species Goal Prescriptions originate from the MSCS. The ERP equivalent is species target. For species designated as recover, contribute to recovery, or maintain, the ERP species target is identical to the MSCS species goal prescription. For species not evaluated in the MSCS, the ERP species target is the performance standard to measure progress toward the objective.)

SPECIES AND SPECIES GROUPS: Certain species or groups of species are given particular attention in the ERP. This focus is based on three criteria that might be met by a species (including fish, wildlife, and plants): 1) is it a formally listed threatened or endangered species (e.g., winter-run chinook salmon, delta smelt), or is it a species proposed for listing; 2) it is economically important, supporting a sport or commercial fishery (e.g., striped bass, signal crayfish); 3) is it a native species or species community that is presently not listed by which could be if population abundance or distribution declines, or 4) it is an important prey species (e.g., Pacific herring).

STAGE 1 EXPECTATIONS: Stage 1 expectations are meant to be measures of the progress towards meeting short-term objectives in the first 7 years of implementation program. These expectations have two basic components: improvements in information to allow better management of the ecosystem and improvements in physical and biological properties of the Bay-Delta ecosystem and watershed.

STRATEGIC GOAL: Strategic goals are the broad statements that define the scope and purposes of the ERP. Strategic goals provide guidance in structuring Strategic Objectives, developing targets, and evaluating proposed restoration actions.

The hierarchy for goals, objectives, targets and programmatic actions follows:

- *Strategic Goal*
  - *Strategic Objective*
    - *Target*
      - *Programmatic Action.*

STRATEGIC OBJECTIVES: Strategic Objectives are associated with the Strategic Goals and are intended to assess progress toward achieving the associated goals. Strategic Objectives are fixed and are not expected to change over time. Strategic objectives are a more detailed delineation of the Strategic Goal components and provide a framework to develop and organize targets and programmatic actions. A strategic objective is the most specific and detailed description of what the ERP strives to maintain or achieve for an ecosystem element. The objectives are stated primarily in terms of management actions designed to have a favorable impact on the Bay-Delta system, however, some are also stated in terms of studies that will teach us how the ecosystem behaves so that principles of adaptive management can be better employed. (Note: Strategic Objectives differ from long- and short-term objectives.)

STRESSORS: Stressors are natural and unnatural events or activities that adversely affect ecosystem processes, habitats, and species. Environmental stressors include water diversions, water contaminants, levee confinement, stream channelization and bank armoring, mining and dredging in streams and estuaries, excessive harvest of fish and wildlife, introduced predator and competitor species, and invasive plants in aquatic and riparian zones. Some major stressors affecting the ecosystem are permanent features on the landscape, such as large dams and reservoirs that block transport of the natural supply of woody debris and sediment in rivers or alter unimpaired flows.

TARGET: A target is a qualitative or quantitative statement of a Strategic Objective. Targets are something to strive for but, unlike Strategic Objectives, may change over the life of the program with new information and progress, or may vary according to the configuration of storage and conveyance in all alternatives. Target adjustments will be science driven and based on the results of adaptive management. Targets may include a range of values or a narrative description of the proposed future value of an ecosystem element. Targets are to be set based upon realistic expectations, must be balanced against other resource needs and must be reasonable, affordable, cost effective, and practicably achievable.

The intent of the ERP is to achieve ecosystem health; targets are flexible tools to guide the effort. The level of implementation for each target will be determined or adjusted through adaptive management. Targets are categorized according to the three levels of certainty described above: (1) targets that have sufficient certainty of success to justify full implementation in accordance with program priorities and staged implementation; (2) targets which will be implemented in stages with the appropriate monitoring and evaluation to judge benefits and successes; and (3) targets for which additional research, demonstration and evaluations are needed to determine feasibility or ecosystem response.

Examples of targets include restoring 2,000 acres of tidal perennial aquatic habitat in the South Delta Ecological Management Unit (quantitative target) and reducing entrainment of juvenile salmon, steelhead, sturgeon, and splittail into water diversions to levels that will not impair stock rebuilding or species restoration (qualitative target).

VISION: A vision is what the ERP will accomplish with the stated objectives, targets, and programmatic actions for an ecological process, habitat, species or species group, stressor, or geographical unit. The vision statements included in the ERP provide technical background to increase understanding of the ecosystem and its elements. Two types of vision statements are included in the ERP: visions for ecosystem elements (landscape level visions in Volume I) and visions for ecological zones and units (ecological zone level visions in Volume II).

The broad landscape level resource visions address an individual ecological processes, habitat, species or species group, or stressor, while the ecological zone and unit visions address the integration of ecological processes, habitats, species, and stressors within a clearly delineated geographical area. Cumulatively, the visions also provide detailed descriptions of the ecosystem and its elements as they will look and function after restoration is accomplished.

Table 2. Crosswalk of ERP and MSCS Terminology.

ERP Term	MSCS Term	Clarification
Strategic Goal	-----	The MSCS has no equivalent term for strategic goal.
Strategic Objective	Species Goal	The ERP has adopted the MSCS species goals for evaluated species (recover, contribute to recovery, and maintain) which are reflected in three of the objectives for at-risk species. The ERP has two additional species-oriented objectives that include enhancing and conserving biotic communities and maintaining and enhancing harvested species.
Target	Species Goal Prescription	ERP species targets are analogous to the MSCS use of species goal prescriptions for evaluated species. The ERP includes targets for species not evaluated in the MSCS including biotic communities and harvested species. The ERP terminology is "target" for processes, habitats, and stressors and "species target" for species to differentiate from the MSCS use of "species goal prescription" for evaluated species.
Programmatic Action	Conservation Measure	ERP programmatic actions and MSCS conservation measures are closely related but are not synonomous. Programmatic actions are physical, operational, or regulatory activities to improve ecological health while conservation measures provide guidance on the manner in which the programmatic actions are implemented. MSCS conservation measures also provide additional detail to some ERP programmatic actions.

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◆ Targets, Actions, and Measures for Species and Communities

Introduction

This section has been revised to clarify and integrate diverse species designations previously described in the Strategic Plan for Ecosystem Restoration, the Ecosystem Restoration Program Plan, and the Multi-Species Conservation Strategy.

Strategic Goals

Two Strategic Goals are closely related to efforts to restore species in the Bay-Delta system.

1. Achieve, first, recovery and then large self-sustaining populations of at-risk native species dependent on the Delta and Suisun Bay; support similar recovery of at-risk native species in the Bay-Delta estuary and its watershed; and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed.

3. Maintain and/or enhance populations of selected species for sustainable commercial and recreational harvest, consistent with the other ERP strategic goals.

Species Designations

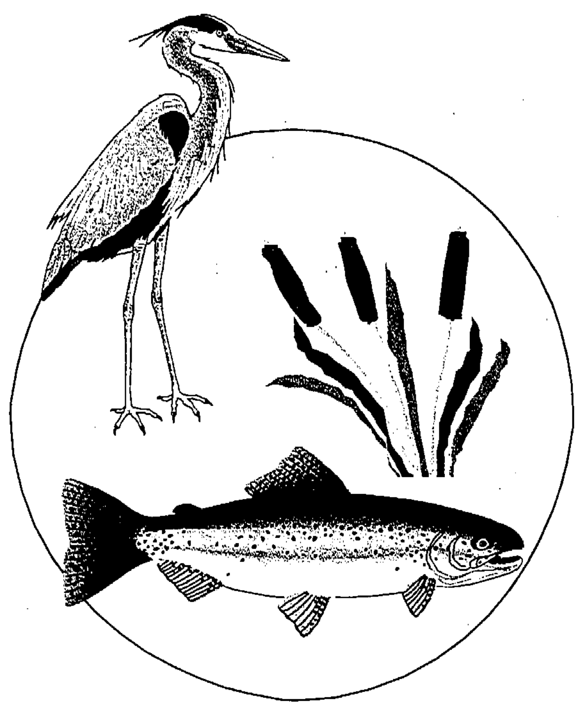
The Multi-Species Conservation Strategy (MSCS) addresses all federally and State listed, proposed, and candidate species that may be affected by the CALFED Program; other species identified by CALFED that may be affected by the Program and for which adequate information is available also are addressed in the MSCS. The term "evaluated species" is used to refer to all of the species addressed by the Conservation Strategy. Please refer to the MSCS appendix (Multi-Species Conservation Strategy 1999) for more information and for a complete list of evaluated species.

The following is a discussion and definition of each of the five species designations used in the ERP. These designations have evolved during the development of the ERP. The present set of designations differs from designations previously presented in the ERP. Table 3, following the designation descriptions, provides a crosswalk of previous designations and how they are related to the present designations.

Recover

Recovery "R": For species designated "R," the CALFED Program has established a goal to recover the species within the CALFED ERP Ecological Management Zones. A goal of "recovery" was assigned to those species whose recovery is dependent on restoration of the Delta and Suisun Bay/Marsh ecosystems and for which CALFED could reasonably be expected to undertake all or most of the actions necessary to recover the species. Recovery is achieved when the decline of a species is arrested or revered, threats to the species are neutralized, and the species; long-term survival in nature is assured.

Recovery is equivalent, at a minimum, to the requirements of delisting a species under FESA and CESA. Certain species, such as anadromous fish, have threats outside the geographic scope or purview of CALFED (e.g., harvest regulated under the Magnuson-Stevens Act). Therefore, in some instances CALFED may not be able to complete all actions potentially necessary to recover the species; however,



CALFED will implement all necessary recovery actions within the ERP Ecological Management Zones. For other species, CALFED may choose a goal that aims to achieve more than would be required for delisting (e.g., restoration of a species and/or its habitat to a level beyond delisting requirements). The effort required to achieve the goal of "recovery" may be highly variable between species. In sum, a goal of "recovery" implies that CALFED is expected to undertake all actions within the ERP Ecological Management Zones and Program scope necessary to recover the species.

CONTRIBUTE TO RECOVERY

CONTRIBUTE TO RECOVERY ("r"): For species designated "r," the CALFED Program will make specific contributions toward the recovery of the species. The goal "contribute to recovery" was assigned to species for which CALFED actions affect only a limited portion of the species range and/or CALFED actions have limited effects on the species.

To achieve the goal of contributing to a species' recovery, CALFED is expected to undertake some of the actions under its control and within its scope that are necessary to recover the species. When a species has a recovery plan, CALFED may implement both plan measures that are within the CALFED Problem Area, and some measures that are outside the Problem Area. For species without a recovery plan, CALFED will need to implement specific measures that will benefit the species.

MAINTAIN

MAINTAIN ("m"): For species designated "m," the CALFED will undertake actions to maintain the species. This category is less rigorous that "contribute to recovery." The goal "maintain" was assigned to species expected to be minimally affected by CALFED actions. For this category, CALFED will avoid, minimize, and compensate for any adverse effects to the species commensurate with the level of effect on the species. Actions may not actually contribute to the recovery of the species; however, at a minimum, they will be expected to not contribute to the need to list a species or degrade the status of a listed species. CALFED will also, to the extent practicable, improve habitat conditions for these species.

ENHANCE AND/OR CONSERVE BIOTIC COMMUNITIES

ENHANCE AND/OR CONSERVE BIOTIC COMMUNITIES ("E"): For those communities designated "E," the ERP will undertake actions to conserve and enhance their diversity, abundance and distribution in a manner that contributes to their long-term sustainability without adversely affecting efforts to improve conditions for other at-risk species.

MAINTAIN AND/OR ENHANCE HARVESTED SPECIES

MAINTAIN AND/OR ENHANCE HARVESTED SPECIES ("H"): For those species designated "H" the CALFED Program will undertake actions to maintain the species at levels which support or enhance sustainable harvest rates. The goal "maintain harvested species" was generally assigned to species which are harvested for recreational or commercial purposes and which are not already covered under one of the four previous designations. A key to maintaining harvestable surplus levels is to recognize the need to recover, contribute to recovery, or maintain other species. Thus, species interactions such as competition and predation and habitat needs for space and flow need to be balanced in favor of species designated for recovery, contribute to recovery and maintain. Those three designations apply only to native species and assemblages while the "maintain harvested surplus" species include some native species and non-native species. Thus, actions implemented to maintain harvestable surplus would be expected, *at a minimum*, to not contribute to the need to list an unlisted species, degrade the status of an already listed species, or impair in any way efforts to recover, contribute to recovery, or maintain native species.

MSCS CONSERVATION MEASURES

The MSCS defines "conserve, conserving, and conservation" as the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to ESA and CESA are no longer necessary. These methods and procedures include, but are not limited to, all activities associated with scientific resources management, such as research, census, law enforcement, habitat acquisition, restoration and maintenance, propagation, live trapping and transplantation, and, in the extraordinary case where population pressures within a given ecosystem cannot be otherwise relieved, may include regulated taking (Multi-Species Conservation Strategy 1999).

Two types of conservation measures were developed under the MSCS: 1) measures to avoid, minimize, or compensate for CALFED Program impacts on NCCP communities and evaluated species; and 2) additional measures that ensure the Program meets the species conservation goals. The majority of measures designed to help the Program meet the species conservation goals incorporate and refine existing ERP and other CALFED actions. The scope, location, and timing of a particular CALFED Program action or group of actions, as well as the current status, distribution, and needs of the affected species, will determine which conservation measures would be necessary to compensate for adverse impacts. NCCP habitat conservation measures are primarily directed at conserving the quality and quantity of natural habitats.

Generally, measures to avoid, minimize and compensate adverse effects are addressed early in site-specific project development and are specific components of the project. The identification of additional measures to ensure the that species conservation goals are met are more global in nature and developed *to provide additional detail to ERP programmatic actions.*

An important addition to this version of the ERP is the inclusion of specific conservation measures that provide additional levels of detail to ERP programmatic actions. These conservation measures were designed specifically for MSCS covered species. This version of the ERP displays throughout Volumes I and II where the conservation measures fit in and support existing programmatic actions.

Volume I of the ERP is structured by 1) ecological process, 2) habitat, 3) species, and 4) stressors. Generally, few conservation measures were developed specifically for ecological processes, some habitats and stressors were emphasized in the conservation measures, and most species are directly addressed in one or more conservation measures.

The conservation measures that add detail to ERP programmatic actions are from Attachment 5 of the MSCS.

Table 3. List of Species Comparing Strategic Plan/ERP Classification, MSCS Designation, and Revised ERP Designation.

Species or Biotic Community	Previous Strategic Plan/ERP Classification	MSCS Designation [a/]	Revised ERP Designation
Delta smelt	Priority Group I	Recover	Recover
Longfin smelt	Priority Group I	Recover	Recover
Green sturgeon	Priority Group I	Recover	Recover
Sacramento splittail	Priority Group I	Recover	Recover
Winter-run chinook salmon	Priority Group I	Recover	Recover
Spring-run chinook salmon	Priority Group I	Recover	Recover
Central Valley fall-run chinook salmon	Priority Group I	Recover	Recover
Central Valley steelhead	Priority Group I	Recover	Recover
Mason's lilaeopsis	Priority Group II	Recover	Recover
Suisun Marsh aster	Priority Group II	Recover	Recover
Suisun thistle	Priority Group II	Recover	Recover
Soft bird's-beak	Priority Group II	Recover	Recover
Antioch Dunes evening-primrose	Priority Group II	Recover	Recover
Contra Costa wallflower	Priority Group II	Recover	Recover
Lange's metalmark butterfly	Priority Group III	Recover	Recover

Species or Biotic Community	Previous Strategic Plan/ERP Classification	MSCS Designation [a]	Revised ERP Designation
Valley elderberry longhorn beetle	Priority Group II	Recover	Recover
Suisun ornate shrew	Priority Group II	Recover	Recover
Suisun song sparrow	Priority Group II	Recover	Recover
San Pablo song sparrow	New to ERP	Recover	Recover
California clapper rail	Priority Group II	Contribute to Recovery	Contribute to Recovery
California black rail	Priority Group II	Contribute to Recovery	Contribute to Recovery
Swainson's hawk	Priority Group II	Contribute to Recovery	Contribute to Recovery
Salt marsh harvest mouse	Priority Group II	Contribute to Recovery	Contribute to Recovery
San Pablo California vole	Priority Group II	Contribute to Recovery	Contribute to Recovery
Sacramento perch	Priority Group III	Contribute to Recovery	Contribute to Recovery
Riparian brush rabbit	Priority Group III	Contribute to Recovery	Contribute to Recovery
San Joaquin Valley woodrat	Priority Group III	Contribute to Recovery	Contribute to Recovery
Greater sandhill crane	Priority Group III	Contribute to Recovery	Contribute to Recovery
California yellow warbler	Priority Group III	Contribute to Recovery	Contribute to Recovery
Least Bell's vireo	Priority Group III	Contribute to Recovery	Contribute to Recovery
Western yellow-billed cuckoo	Priority Group III	Contribute to Recovery	Contribute to Recovery
Bank swallow	Priority Group III	Contribute to Recovery	Contribute to Recovery
Little willow flycatcher	Priority Group III	Contribute to Recovery	Contribute to Recovery
Giant garter snake	Priority Group III	Contribute to Recovery	Contribute to Recovery
Delta green ground beetle	Priority Group III	Contribute to Recovery	Contribute to Recovery
Saltmarsh common yellowthroat	New to ERP	Contribute to Recovery	Contribute to Recovery
Bristly sedge	Priority Group II	Contribute to Recovery	Contribute to Recovery
Point Reyes bird's-beak	New to ERP	Contribute to Recovery	Contribute to Recovery
Crampton's tuctoria	Priority Group II	Contribute to Recovery	Contribute to Recovery
Delta tule pea	Priority Group II	Contribute to Recovery	Contribute to Recovery
Delta mudwort	Priority Group II	Contribute to Recovery	Contribute to Recovery
Alkali milk-vetch	Priority Group II	Contribute to Recovery	Contribute to Recovery
Delta coyote-thistle	New to ERP	Contribute to Recovery	Contribute to Recovery
Northern California black walnut	Not in ERP	Contribute to Recovery	Contribute to Recovery
Mad-dog skullcap	Priority Group II	Maintain	Maintain
Rose-mallow	Priority Group II	Maintain	Maintain
Eel-grass pondweed	Priority Group II	Maintain	Maintain
Colusa grass	Priority Group II	Maintain	Maintain
Boggs Lake hedge-hyssop	Priority Group II	Maintain	Maintain
Contra Costa goldfields	Priority Group II	Maintain	Maintain
Greene's legenere	Priority Group II	Maintain	Maintain
Recurved larkspur	Priority Group II	Maintain	Maintain
Heartscale	Priority Group II	Maintain	Maintain
California freshwater shrimp	Priority Group III	Maintain	Maintain
Hardhead	Priority Group III	Maintain	Maintain
Western Least bittern	Priority Group III	Maintain	Maintain
California red-legged frog	Priority Group III	Maintain	Maintain
California tiger salamander	Priority Group III	Maintain	Maintain

Species or Biotic Community	Previous Strategic Plan/ERP Classification	MSCS Designation [a]	Revised ERP Designation
Western pond turtle	Priority Group III	Maintain	Maintain
Western spadefoot toad	Priority Group IV	Maintain	Maintain
Lamprey family	Priority Group II	Not Evaluated [b]	Enhance and/or Conserve
Native resident fishes	Priority Group III	Not Evaluated as a group [c]	Enhance and/or Conserve
Native anuran amphibians	Priority Group III	Not Evaluated	Enhance and/or Conserve
Migratory waterfowl	Priority Group IV	Not Evaluated as a group	Enhance and/or Conserve
Shorebird guild	Priority Group IV	Not Evaluated as a group	Enhance and/or Conserve
Wading bird guild	Priority Group IV	Not Evaluated as a group	Enhance and/or Conserve
Neotropical migratory birds	Priority Group IV	Not Evaluated as a group	Enhance and/or Conserve
Planktonic (foodweb) organisms	Priority Group IV	Not Considered [d]	Enhance and/or Conserve
Aquatic habitat plant community	Priority Group IV	NCCP Habitat equivalent [e]	Enhance and/or Conserve
Tidal brackish and freshwater marsh habitat plant community	Priority Group IV	NCCP Habitat equivalent	Enhance and/or Conserve
Seasonal wetland habitat plant community	Priority Group IV	NCCP Habitat equivalent	Enhance and/or Conserve
Inland dune habitat plant community	Priority Group IV	NCCP Habitat equivalent	Enhance and/or Conserve
White sturgeon	Harvestable Species	Not Considered	Maintain Harvest
Striped bass	Harvestable Species	Excluded [f]	Maintain Harvest
American shad	Harvestable Species	Excluded	Maintain Harvest
Non-native warmwater gamefish	Harvestable Species	Excluded	Maintain Harvest
Pacific herring	Harvestable Species	Not Considered	Maintain Harvest
Grass shrimp	Harvestable Species	Not Considered	Maintain Harvest
Signal crayfish	Harvestable Species	Excluded	Maintain Harvest
Upland game	Priority Group IV	Not Considered	Maintain Harvest

Footnotes for Table 3.

a/: Recover, contribute to recovery, maintain, enhance and/or conserve, and maintain harvest are defined in the text.

b: Not Evaluated species are species initially considered for inclusion in the MSCS but not evaluated (e.g., Kern brook lamprey, river lamprey, and Pacific lamprey were considered but not evaluated).

c: Not Evaluated as a Group includes species assemblages described in the ERP but not evaluated as a group in the MSCS. Individual species, however, may have been considered or evaluated (e.g., native resident fishes were not evaluated as a group in the MSCS but Sacramento perch and hardhead were considered and evaluated in the MSCS).

d: Not Considered species are native species that were screened from consideration by not being on any list of special status species.

e: NCCP Habitat equivalent denotes an ERP plant community that is analogous to one or more of the 18 NCCP habitats which are broad categories, each of which includes a number of habitat or vegetation types recognized in frequently used habitat classification systems.

f: Excluded species are non-native organisms not eligible for consideration under the State or federal endangered species acts and thus excluded from consideration or evaluation under the MSCS.

SPECIES GOALS AND CONSERVATION MEASURES

Species with the designation "Recovery."

DELTA SMELT

MSCS SPECIES GOAL PRESCRIPTION: Distribution Criteria: The fall mid-water trawl survey in September and October must capture delta smelt in all zones in 2 out of 5 consecutive years and in at least 2 zones in 3 out of the 5 consecutive years, and in at least 1 zone in all 5 years; and the 5 consecutive years must include 2 sequential extreme outflow years (i.e., at least one critical or dry year followed by a critical, dry, or wet year). Abundance Criteria: the fall mid-water trawl catch for September and October must exceed 239 for 2 out of 5 years and not fall below 84 for more than 2 consecutive years.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve delta smelt species habitat or population targets.

- Coordinate protection, enhancement, and restoration of occupied delta smelt habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, the Anadromous Fish Restoration Program, and the U.S. Fish and Wildlife Service recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- To the extent consistent with CALFED objectives, direct ERP actions towards setting back levees in the south Delta to increase shallow water habitat.
- Restore and enhance delta smelt habitat to provide suitable water quality (i.e., low concentrations of pollutants) and substrates for egg attachment (submerged tree roots, branches, rock, and emergent vegetation) to important spawning areas.
- Expand Interagency Ecological Program (IEP) monitoring efforts in the south Delta for delta smelt.
- To the extent consistent with CALFED objectives, initiate implementation of the USFWS' "Rainbow Report" or similar documentation to provide increased water quality in the south Delta and eliminate or reduce the need for installation of barriers.
- Monitor to determine if artificial substrates are used by delta smelt for spawning.
- Protect critical rearing habitat from high salinity (>2 ppt) and high concentrations of pollutants from February 1 to August 31.
- Allow delta smelt unrestricted access to suitable spawning habitat and protect these areas from physical disturbance (e.g., heavy equipment operation) and flow disruption in the period from December to July by maintaining adequate flow and suitable water quality to attract migrating adults in the Sacramento and San Joaquin River channels and their tributaries, including Cache and Montezuma sloughs and their tributaries.
- All in-channel modification projects implemented under CALFED should use best management practices to minimize mobilization of sediments that might contain toxins, localize sediment movement, and reduce turbidity.

RATIONALE: *The recovery objective for delta smelt is to remove delta smelt from the Federal list of threatened species through restoration of it abundance and distribution. Recovery of delta smelt should not be at the expense of other native fishes. The basic strategy for recovery is to manage the estuary in such a way that it is a better habitat for native fish in general and delta smelt in particular. Improved habitat will allow delta smelt to be widely distributed throughout the Delta and Suisun Bay, recognizing that areas of abundance change with season.*

Recovery of delta smelt will consist of two phases, restoration and delisting. Separate restoration and delisting periods were selected because it is possible *that restoration criteria could be met quicky in the absence of consecutive extreme outflow years (i.e., extremely wet or dry years). However, without the population being tested by extreme outflows there is no assurance of long-term survival for the species.*

Thus restoration is defined as a return of the population to pre-decline levels, but delisting is not recommended until the population has been tested by extreme outflows. Delta smelt will be considered restored when its population dynamics and distribution pattern within the estuary are similar to those that existed in the 1967-1981 period. This period was chosen because it includes the earliest continuous data on delta smelt abundances and was a period in which populations stayed reasonably high in most years. The species will be considered recovered and qualify for delisting when it experiences a five-year period that includes two sequential years of extreme outflows, one of which must be dry or critically dry. Delta smelt will be considered for delisting when the species meets recovery criteria under stressor conditions comparable to those that led to listing and mechanisms are in place that insure the species' continued existence.

Improved spring inflow and outflow should benefit the population by providing attraction flow to adults moving into the Delta to spawn, by stimulating aquatic foodweb production to help ensure young delta smelt survival, and by providing transport flow to larval delta smelt to move them from the Delta into prime nursery habitat in the western Delta and Suisun Bay. Improving channel hydraulics would increase the aquatic foodweb and improve spawning and rearing habitat. Reducing the effects of water diversions and contaminants would help to improve survival of young and adult delta smelt.

LONGFIN SMELT

MSCS SPECIES GOAL PRESCRIPTION: The recovery goal will be achieved when 1) the fall mid-water trawl surveys in September and October result in the capture of longfin smelt in all zones in 5 out of 10 years, 2) in 2 zones for an additional year, 3) in at least one zone during 3 of the 4 remaining years in the 10 year period with no failure to meet site criteria in consecutive years, and 4) abundance must be equal to or greater that predicted abundance for 5 of the 10 year period.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve longfin smelt species habitat or population targets.

- Coordinate protection, enhancement, and restoration of occupied longfin smelt habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, the Anadromous Fish Restoration Program, and the U.S. Fish and Wildlife Service recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Improve January and February flows for the longfin smelt during the second and subsequent years of drought periods.
- Provide sufficient Delta outflows for the longfin smelt during December through March.
- Provide suitable water quality and substrates for egg attachment (submerged tree roots, branches, rock, and emergent vegetation) to spawning areas in the Delta and tributaries of northern Suisun Bay.
- Provide unrestricted access to suitable spawning habitat and protect these areas from physical disturbance (e.g., heavy equipment operation) and flow disruption in the period from December to July by maintaining adequate flow and suitable water quality to attract migrating adults in the Sacramento and San Joaquin River channels and their tributaries, including Cache and Montezuma sloughs and their tributaries.
- Conduct research to determine the relationship between X2 and longfin smelt abundance and distribution.
- Consistent with CALFED objectives, mobilize organic carbon in the Yolo Bypass to improve food supplies by ensuring flow through the bypass at least every other year.
- Consistent with CALFED objectives, operate diversions to minimize adverse affects of

diversions on longfin smelt during the peak spawning period (January - March).

- To the extent consistent with CALFED objectives protect the Sacramento and San Joaquin river and tributary channels from physical disturbance (e.g., sand and gravel mining, diking, dredging, and levee or bank protection and maintenance) and flow disruption (e.g., water diversion that result in entrainment and in-channel barriers or tidal gates) for the period February 1 to August 31.
- Protect critical rearing habitat from high salinity (>2 ppt) and high concentration of pollutants from the beginning of February to the end of August.

RATIONALE: *General restoration objectives are the same as those described for delta smelt. Longfin smelt will be considered restored when its population dynamics and distribution patterns within the estuary are similar to those that existed in the 1967-1984 period. This period was chosen because it includes the earliest continuous data on longfin smelt abundances and was a period in which populations stayed reasonably high in most years.*

Meeting the targets of the Native Fish Recovery Plan will indicate an increase in the longfin smelt population. Without such an increase in the population, there would be no guarantee that recovery is occurring. Improved spring inflow and outflow should benefit the population by providing attraction flow to adults moving into the Delta to spawn, by stimulating aquatic foodweb production to help ensure young longfin smelt survival, and by providing transport flow to larval longfin smelt to move them from the Delta into prime nursery habitat in the western Delta and Suisun Bay.

Improving channel hydraulics would increase the aquatic foodweb and improve spawning and rearing habitat. Reducing the effects of water diversions and contaminants would help to improve survival of young and adult longfin smelt. Reevaluation of stocking striped bass and chinook salmon into prime nursery habitats of longfin smelt in San Pablo Bay and Suisun Bay would reduce predation on young longfin smelt. Alternative locations and time of stocking may limit predation on longfin smelt.

GREEN STURGEON

MSCS SPECIES GOAL PRESCRIPTION: The recovery goal will be achieved when 1) the median population of mature fish (over 1 meter in length) has reached 1,000 fish, including 500 females over 1.3 meters in total length, over a 50 years period or for 5 generations.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve green sturgeon species habitat or population targets.

- Coordinate protection, enhancement, and restoration of occupied and historic green sturgeon habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, the Anadromous Fish Restoration Program, the U.S. Fish and Wildlife Service recovery plans, the SB 1086 program, and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Provide inflows to the Delta from the Sacramento River greater than 25,000 cfs during the March to May spawning period in at least 2 of every 5 years.
- Identify and implement measures to eliminate stranding of green sturgeon in the Yolo Bypass or to return stranded fish to the Sacramento River.
- Conduct research in the MSCS focus area to determine green sturgeon habitat requirements, distribution, spawning habitat flow requirements, and factors limiting population abundance.

RATIONALE: *Green sturgeon will be considered restored in the Sacramento-San Joaquin estuary once the median population of mature individuals (over 1 meter total length) has reached 1,000 individuals (including 500 females over 1.3 meters total length) over a 50 year period or for five generations (10 years* *is the minimum age of sexual maturity). If population estimates are fewer that 1,000 fish for more than three years in a row, the restoration period will be restarted. (Note: This definition is subject to revision as more information becomes available.) Restoration will be measured by determining population sizes from tagging programs or other suitable means. The present sturgeon tagging programs, which focus on white sturgeon, are inadequate for determining accurately the abundance of green sturgeon. Therefore, a median population goal of 1,000 fish over 1 meter total length (including 500 females over 1.3 meters total length) is achievable with numbers determined through a monitoring program that focuses specifically on green sturgeon. Thus, the first restoration criterion will be establishment–of an adequate population determination through a monitoring program. Once that program is in place, the minimum population goals can be re-evaluated and a realistic, presumably higher, goal established. It may be desirable to have the numbers high enough to support the removal of a minimum of 50 fish over 1 meter total length per year by a fishery (assuming an exploitation rate of 5 percent is sustainable) (U.S. Fish and Wildlife Service 1996).*

Improved spring inflow and outflow should benefit the populations by providing attraction flow to adults moving through the Delta into the rivers to spawn, by stimulating aquatic foodweb production to help ensure young sturgeon survival, and by providing transport flow to larval sturgeon to move them from the rivers into prime nursery habitat in the Delta and Suisun Bay. Improving channel hydraulics would increase the aquatic foodweb and improve juvenile rearing habitat. Reducing the effects of water diversions and contaminants would help to improve survival of young and adult sturgeon.

SPLITTAIL

MSCS SPECIES GOAL PRESCRIPTION: Species recovery objectives will be achieved when 2 of the following 3 criteria are met in at least 4 of every 5 years for a 15-year period: 1) the fall mid-water trawl survey numbers must be 19 or greater for 7 of 15 years, 2) Suisun Marsh catch per trawl must be 3.8 or greater and the catch of young-of-year must exceed 3.1 per trawl for 3 of 15 years, and 3) Bay Study otter trawls must be 18 or greater AND catch of young-of-year must exceed 14 for 3 out of 15 years.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve splittail species habitat or population targets.

- Coordinate protection, enhancement, and restoration of occupied and historic Sacramento splittail habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, the Anadromous Fish Restoration Program, the U.S. Fish and Wildlife Service recovery plans, the SB 1086 program, and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- To the extent consistent with CALFED objectives, remove diversion dams that block splittail access to lower floodplain river spawning areas.
- Minimize changes in the timing and volume of freshwater flows in the rivers to the Bay-Delta.
- To the extent consistent with CALFED objectives, direct ERP actions towards setting back levees in the south Delta to increase shallow water habitat.
- To the extent consistent with CALFED objectives, reduce the extent of reversed flows in the lower San Joaquin and Delta during the period from February through June.
- Reduce loss of splittail at south Delta pumping plants from predation and salvage handling and transport.
- Reduce the loss of young splittail to entrainment into south Delta pumping plants.
- To the extent practicable, reduce the loss of splittail at 1,800 unscreened diversions in the Delta.
- Reduce losses of adult splittail spawners during their upstream migration to recreational fishery harvest.

- To the extent consistent with CALFED objectives, improve Delta water quality particularly in dry years when pesticide levels and total dissolved solids are high.
- To the extent consistent with CALFED objectives, modify operation of the Delta Cross Channel to minimize potential to increase exposure of splittail population in the Delta to the south Delta pumping plants.
- Modify operation of the barrier at the Head of Old River to minimize the potential for drawing splittail toward the south Delta pumping plants.
- To the extent practicable, design and construct overflow basins from existing leveed lands in stages using construction design and operating schemes and procedures developed through pilot studies and project experience to minimize the potential for stranding as waters recede from overflow areas.
- Consistent with CALFED objectives, design modifications to South Delta channels to improve circulation and transport of north of Delta water to the south Delta pumping plants to ensure habitat supports splittail and to not increase transport of splittail to the south Delta pumping plants.
- To the extent practicable with CALFED objectives, design seasonal wetlands that have hydrological connectivity with occupied channels to reduce the likelihood for stranding and to provide the structural conditions necessary for spawning.
- To the extent consistent with CALFED objectives, protect spawning areas by providing suitable water quality (i.e., low concentrations of pollutants) and substrates for egg attachment (e.g., submerged tree roots and branches and emersed and submerged vegetation).
- Avoid or minimize adverse effects on rearing habitat of physical disturbance (e.g., sand and gravel mining, diking, dredging, and levee or bank protection and maintenance) and flow disruption (e.g., water diversions, in-channel barriers, or tidal gates).
- To the extent consistent with CALFED objectives, maintain a low salinity zone in historical occupied habitat areas of the Bay and Delta from February 1 to August 31.
- To the extent consistent with CALFED objectives, provide unrestricted access of adults to spawning habitat from December to July by maintaining adequate flow and water quality, and minimizing disturbance and flow disruption.
- Expand the IEP monitoring efforts in the south Delta for Sacramento splittail.
- To the extent consistent with CALFED objectives, initiate implementation of the USFWS' "Rainbow Report" or similar documentation to provide increased water quality in the south Delta and eliminate or reduce the need for installation of barriers.
- To the extent consistent with CALFED objectives, reduce the effects on splittail from changes in reservoir operations and ramping rates for flood control.
- To the extent consistent with CALFED objectives, reduce the loss of freshwater and low-salinity splittail habitat in the Bay-Delta as a result of reductions in Delta inflow and outflow.
- To the extent consistent with CALFED objectives, increase the frequency of flood bypass flooding in non-wet years to improve splittail spawning and early rearing habitat.
- To the extent consistent with CALFED objectives, ensure that the Yolo and Sutter Bypasses are flooded during the spawning season at least once every 5 years.
- To the extent consistent with CALFED objectives, improve the frequency, duration, and extent of bypass flooding in all years.
- Develop a water management plan to allocated multiyear water supply in reservoirs to protect drought year supplies and sources of winter-spring Delta inflow and outflow needed to sustain splittail and their habitat.

RATIONALE: *Improved spring inflow and outflow should benefit the population by providing attraction flow to adults moving upstream into the Delta and rivers to spawn, by increasing flooding of riparian vegetation and flood plain processes which provide important spawning habitat of splittail, by* *stimulating aquatic foodweb production to help ensure young splittail survival. Improving channel hydraulics would increase the aquatic foodweb and improve spawning and rearing habitat. Improving shallow water, slough, and wetland habitats should increase the spawning and rearing habitat of splittail. Reducing the effects of water diversions and contaminants would help to improve survival of young and adult splittail.*

SACRAMENTO WINTER-RUN CHINOOK SALMON ESU

MSCS SPECIES GOAL PRESCRIPTION: The mean annual spawning abundance over any 13 consecutive years will be 10,000 females. The geometric mean of the Cohort Replacement Rate over those same 13 years will be greater than 1.0. Estimates of these criteria will be based on natural production alone and will not include hatchery-produced fish. If the precision for estimating spawning run abundance has a standard error greater than 25%, then the sampling period over which the geometric mean of the Cohort Replacement Rate is estimated will be increased by 1 additional year for each 10% of additional error over 25%.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Coordinate protection, enhancement, and restoration of occupied and historic chinook salmon habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, the Anadromous Fish Restoration Program, the U.S. Fish and Wildlife Service recovery plans, the SB 1086 Program, and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Implement management measures identified in the proposed recovery plan for the Sacramento River winter-run chinook salmon.
- To the extent consistent with CALFED objectives, manage operations at the Red Bluff diversion dam to improve fish passage, reduce the level of predation on juvenile fish, and increase fish survival.

RATIONALE: *The goal of the Sacramento River winter-run chinook salmon is to establish a framework for the recovery of the population through a logical program of improving the habitat and environment of the species. Specifically, the recovery of this species requires actions which increase their abundance and improve their habitat to the point that the probability of subsequent extinction will be very low. When the underlying causes of the species' decline are no longer in effect and the species has rebounded to relatively healthy levels, winter-run chinook can be removed from the list of threatened and endangered species; that is, it can be "delisted."*

An extinction model was used to develop the delisting criteria to ensure a low probability of extinction once the criteria have been reached. The risk level chosen was a probability of less than 0.1 within the 50 years following delisting. Assurance of the probability of extinction required specification of the population growth rate in addition to population abundance.

Improved spring inflow and outflow should benefit the populations by providing attraction flow to adults moving through the Delta into the rivers to spawn, by stimulating aquatic foodweb production to help ensure young survival, and by providing transport flow to juvenile salmon to move them from the rivers into prime nursery habitat in the Delta and Bay. Improving channel hydraulics would increase the aquatic foodweb and improve juvenile rearing habitat. Reducing the effects of water diversions and contaminants would help to improve survival of young and adult salmon.

SACRAMENTO SPRING-RUN CHINOOK SALMON ESU

MSCS SPECIES GOAL PRESCRIPTION: The Central Valley spring-run chinook salmon Evolutionarily Significant Unit (ESU) will be regarded as restored when the ESU meets specific viability criteria to be established in the NMFS recovery plan for Central Valley salmonids. Viability of the Central Valley spring-run ESU will be assessed according to the "Viable Salmonid Populations"

(VSP) framework developed by the NMFS. The framework deals with four population characteristics:

1. **ABUNDANCE:** populations are large enough to resist extinction due to random environmental, demographic and genetic variation.

2. **PRODUCTIVITY:** populations have enough reproductive capacity to ensure resistance to episodes of poor freshwater or ocean conditions and the ability to rebound rapidly during favorable periods, without the aid of artificial propagation.

3. **SPATIAL DISTRIBUTION:** populations are distributed widely and with sufficient connectivity such that catastrophic events do not deplete all populations and stronger populations can rescue depleted populations.

4. **DIVERSITY:** populations have enough genetic and life history diversity to enable adaptation to long-term changes in the environment. Populations achieve sufficient expression of historic life history strategies (migration timing, spawning distribution), are not negatively impacted by outbreeding depression resulting from straying of domesticated hatchery fish, and are not negatively impacted by inbreeding depression due to small population size and inadequate connectivity between populations.

The NMFS recovery planning for Central Valley salmonids will proceed in two phases. The first phase will be conducted by a technical recovery team (TRT) that will produce numeric recovery criteria for populations and the ESU following the VSP framework, factors for decline, early actions for recovery, and provide plans for monitoring and evaluation. The TRT will review existing salmonid population recovery goals and management programs being implemented by federal and State agencies and will coordinate with agency scientists, CALFED staff and Central Valley science/restoration teams such as the Interagency Ecological Program work teams during this first phase. TRT products will be peer-reviewed and made available for public comment.

The second phase will be identification of recovery measures and estimates of cost and time required to achieve recovery. The second phase will involve participation by agency and CALFED staff as well as involvement by a broad range of stakeholders, including local and private entities, with the TRT providing technical guidance on biological issues.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Coordinate protection, enhancement, and restoration of occupied and historic chinook salmon habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, the Anadromous Fish Restoration Program, the U.S. Fish and Wildlife Service recovery plans, the SB 1086 Program, and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.

- Implement applicable management measures identified in the restoration plan for the Anadromous Fish Restoration Program and the recovery plan for the native fishes of the Sacramento/San Joaquin Delta.

- To the extent consistent with CALFED objectives, operate existing inchannel barriers and any new barriers that may be constructed to avoid changes in Delta channel hydraulics that increase the number of fish or proportions of fish populations drawn toward the pumps or affected by poor water quality.

- Manage operations at the Red Bluff diversion dam to improve fish passage, reduce the level of predation on juvenile fish, and increase fish survival.

RATIONALE: *Spring-run chinook salmon are listed as a threatened species under the California Endangered Species Act and proposed for listing under the ESA. Because of their life history patterns, spring-run chinook enter the Sacramento River early in the year and ascend to tributaries where they oversummer to spawn during the following fall. Young fish may rear for a year or longer in the* *tributaries before entering the Sacramento River during their seaward migration.*

The status of a spring-run chinook salmon in the mainstem Sacramento River is uncertain, however, evidence suggests that there may be a significant introgression with fall-run chinook. The role of the Sacramento River in sustaining spring-run chinook salmon is primarily to provide adult fish passage to the tributary streams and to provide rearing and emigration habitat for juveniles during their seaward migration.

Natural populations and their essential habitat must be sufficiently abundant to ensure Sacramento River spring-run chinook salmon's long-term survival. In order to achieve recovery, the remaining natural, non-introgressed populations of spring run and any re-established natural populations must be protected, monitored, and proven to be self-sustaining to the satisfaction of the Department of Fish and Game and the Fish and Game Commission. Recovery goals must ensure that the individual populations, as well as the collective metapopulation, are sufficiently abundant to avoid genetic risks of small population size. Thus, recovery goals need to address abundance levels (adult spawning escapements), population stability criteria, population distribution, and length of time for determining sustainability.

The California Department of Fish and Game's recovery objectives for Sacramento River spring-run chinook salmon are (1) the protection and enhancement of the existing natural populations; (2) the re-establishment of additional, viable native populations; and (3) the restoration and protection of natal, rearing, and migratory streams within the Sacramento River basin (California Department of Fish and Game 1998).

The U.S. Fish and Wildlife Service (1996) has recommended restoration objectives and criteria for Sacramento River spring-run chinook salmon based on the objective of establishing self-sustaining populations which will persist indefinitely for each species addressed. Additionally, the population goals for chinook salmon runs include extra adult production for allowing sustained limited harvests of each run. The plan states that restoration will be measured by three interacting criteria: (1) presence of self-sustaining spawning populations in Mill and Deer creeks; (2) total number of spawners in Mill, Deer, Antelope, Butte, Big Chico, Beegum, South Fork Cottonwood, and Clear creeks (if the Yuba River proves to still have a natural run of spring-run chinook, the population goal should be raised by whatever number of spawners the stream can support); and (3) smolt survival through the Delta.

Spring-run chinook salmon populations will be considered healthy when the average number of spawners in tributary streams to the Sacramento River exceeds 5,000 fish each year over a 15-year period (five generations times 3 years per generation), with 3 of the 15 years being dry or critically dry. The average number of natural, wild spawners over the 15-year period must not be fewer than 8,000 fish (USFWS 1996).

SACRAMENTO LATE-FALL-RUN CHINOOK SALMON

SPECIES TARGETS: Achieve species recovery by 1) increasing the number of wild spawning fish in the Sacramento River to a mean number of 22,000 fish and maintain the population such that it does not drip below 15,000 fish for 15 years, 3 of which are dry or critical and 2) achieving juvenile survival rates that approach pre-CVP and SWP levels following years when the adult populations are fewer that 15,000 fish in the Sacramento River (U.S. Fish and Wildlife Service 1996).

Note: The Central Valley fall/late fall-run ESU is a candidate species, not a threatened or endangered species, under the ESA. The NMFS recovery plan for Central Valley salmonids will therefore not include formal recovery goals for populations in this ESU. The recovery plan for Central Valley salmonids will identify factors of concern and measures to ensure the long-term conservation of the Central Valley fall/late fall-run ESU and recovery actions proposed for listed ESUs will be evaluated to ensure that they do not place non-listed species at significant risk. CALFED, DFG and the NMFS will work together to identify restoration goals following the VSP framework in a process separate from the NMFS recovery planning process. These goals will aim to ensure the long-term viability of Sacramento and San Joaquin fall-run and Sacramento late fall-run chinook salmon.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Coordinate protection, enhancement, and restoration of occupied and historic chinook salmon habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, the Anadromous Fish Restoration Program, the U.S. Fish and Wildlife Service recovery plans, the SB 1086 Program, and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Implement applicable management measures identified in the restoration plan for the Anadromous Fish Restoration Program and the recovery plan for the native fishes of the Sacramento/San Joaquin Delta.
- Operate hatcheries such that the maintenance, and expansion of natural populations are not threatened by the release of hatchery fish.
- To the extent consistent with CALFED objectives, manage operations at the Red Bluff diversion dam to improve fish passage, reduce the level of predation on juvenile fish, and increase fish survival.
- To the extent consistent with CALFED objectives, manage export flows from the San Joaquin River to improve conditions for upstream migration of adult fish (i.e., attraction flows).
- To the extent consistent with CALFED objectives, operate physical barriers in the Delta in a manner to assist in achieving recovery goals.
- Continue research to determine causes for low outmigration survival of fish from the San Joaquin River in the south Delta and identify and implement measures to improve outmigration survival.

RATIONALE: *Presently, late-fall-run chinook salmon have no special protection. The great majority of late-fall-run chinook appear to spawn in the mainstem Sacramento River during January, February, and March. Late-fall-run chinook abundance has declined due to passage problems at Red Bluff Diversion Dam, loss of habitat, poor survival of emigrating smolts, sport and commercial harvest, and other factors, such as disease and pollutants.*

FALL-RUN CHINOOK SALMON ESU

MSCS SPECIES GOAL PRESCRIPTION:

San Joaquin Fall Run: Achieve species recovery by 1) increasing the number of naturally spawning fish in the Stanislaus, Tuolumne, and Merced rivers to a median number of 20,000 fish and maintaining a three-year running average that does not drop below 3,000 fish for 15 years, three of which are dry and critical and 2) achieving smolt survival rates that approach pre-CVP and SWP levels when adult numbers decline to fewer that 3,000 natural spawning fish.

Sacramento Fall Run: Restore self-sustaining populations to all their native streams.

Note: The Central Valley fall/late fall-run ESU is a candidate species, not a threatened or endangered species, under the ESA. The NMFS recovery plan for Central Valley salmonids will therefore not include formal recovery goals for populations in this ESU. The recovery plan for Central Valley salmonids will identify factors of concern and measures to ensure the long-term conservation of the Central Valley fall/late fall-run ESU and recovery actions proposed for listed ESUs will be evaluated to ensure that they do not place non-listed species at significant risk. CALFED, DFG and the NMFS will work together to identify restoration goals following the VSP framework in a process separate from the NMFS recovery planning process. These goals will aim to ensure the long-term viability of Sacramento and San Joaquin fall-run and Sacramento late fall-run chinook salmon.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Coordinate protection, enhancement, and restoration of occupied and historic chinook salmon habitats with other federal, state, and regional programs (e.g., the San Francisco Bay

Area Wetlands Ecosystem Goals Project, the Anadromous Fish Restoration Program, the U.S. Fish and Wildlife Service recovery plans, the SB 1086 Program, and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.

- Implement applicable management measures identified in the restoration plan for the Anadromous Fish Restoration Program and the recovery plan for the native fishes of the Sacramento/San Joaquin Delta.
- Operate hatcheries such that the maintenance, and expansion of natural populations are not threatened by the release of hatchery fish.
- To the extent consistent with CALFED objectives, manage operations at the Red Bluff diversion dam to improve fish passage, reduce the level of predation on juvenile fish, and increase fish survival.
- To the extent consistent with CALFED objectives, manage export flows from the San Joaquin River to improve conditions for upstream migration of adult fish (i.e., attraction flows).
- To the extent consistent with CALFED objectives, operate physical barriers in the Delta in a manner to assist in achieving recovery goals.
- Continue research to determine causes for low outmigration survival of fish from the San Joaquin River in the south Delta and identify and implement measures to improve outmigration survival.

RATIONALE: *Because of their life-history requirements, typical of all Pacific salmon, Central Valley chinook salmon require high-quality habitats for migration, holding, spawning, egg incubation, emergence, rearing, and emigration to the ocean. These diverse habitats are still present throughout the Central Valley and are successfully maintained to varying degrees by existing ecological processes. Even though the quality and accessibility of the habitats have been diminished by human-caused actions, these habitats can be restored through a comprehensive program that strives to restore or reactivate ecological processes, functions, and habitat elements on a systematic basis, while reducing or eliminating known sources of mortality and other stressors that impair the survival of chinook salmon.*

There are three major programs to restore chinook salmon populations in the Central Valley. The Secretary of the Interior is required by the Central Valley Project Improvement Act (PL 102-575) to double the natural production of Central Valley anadromous fish stocks by 2002 (USFWS 1995). The National Marine Fisheries Service is required under the federal ESA to develop and implement a recovery plan for the endangered winter-run chinook salmon and to restore the stock to levels that will allow its removal from the list of endangered species (NMFS 1996). The California Department of Fish and Game is required under state legislation (the Salmon, Steelhead Trout and Anadromous Fisheries Program Act of 1988) to double the numbers of salmon that were present in the Central Valley in 1988 (Reynolds et al. 1993).

Each of the major chinook salmon restoration /recovery programs has developed specific goals for Central Valley chinook salmon stocks. ERPP embraces each of the restoration/recovery goals and will contribute to each agency's program by restoring critical ecological processes, functions, and habitats, and by reducing or eliminating stressors. ERPP's approach is to contribute to managing and restoring each stock with the goal of maintaining cohort replacement rates of much greater than 1.0 while the individual stocks are rebuilding to desired levels. When the stocks approach the desired population goals, ERP will contribute to maintaining a cohort replacement rate of 1.0.

CENTRAL VALLEY STEELHEAD ESU

MSCS SPECIES GOAL PRESCRIPTION: The Central Valley steelhead Evolutionarily Significant Unit (ESU) will be regarded as restored when the ESU meets specific viability criteria to be established in the NMFS recovery plan for Central Valley salmonids. Viability of the Central Valley steelhead ESU will be assessed according to the "Viable Salmonid Populations" (VSP) framework developed by the NMFS (in review). The framework deals with four population characteristics:

1. **ABUNDANCE:** populations are large enough to resist extinction due to random environmental, demographic and genetic variation.

2. **PRODUCTIVITY:** populations have enough reproductive capacity to ensure resistance to episodes of poor freshwater or ocean conditions and the ability to rebound rapidly during favorable periods, without the aid of artificial propagation.

3. **SPATIAL DISTRIBUTION:** populations are distributed widely and with sufficient connectivity such that catastrophic events do not deplete all populations and stronger populations can rescue depleted populations.

4. **DIVERSITY:** populations have enough genetic and life history diversity to enable adaptation to long-term changes in the environment. Populations achieve sufficient expression of historic life history strategies (migration timing, spawning distribution), are not negatively impacted by outbreeding depression resulting from straying of domesticated hatchery fish, and are not negatively impacted by inbreeding depression due to small population size and inadequate connectivity between populations.

The NMFS recovery planning for Central Valley salmonids will proceed in two phases. The first phase will be conducted by a technical recovery team (TRT) that will produce numeric recovery criteria for populations and the ESU following the VSP framework, factors for decline, early actions for recovery, and provide plans for monitoring and evaluation. The TRT will review existing salmonid population recovery goals and management programs being implemented by federal and State agencies and will coordinate with agency scientists, CALFED staff and Central Valley science/restoration teams such as the Interagency Ecological Program work teams during this first phase. TRT products will be peer-reviewed and made available for public comment.

The second phase will be identification of recovery measures and estimates of cost and time required to achieve recovery. The second phase will involve participation by agency and CALFED staff as well as involvement by a broad range of stakeholders, including local and private entities, with the TRT providing technical guidance on biological issues.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Coordinate protection, enhancement, and restoration of occupied and historic Central Valley steelhead ESU habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, the Anadromous Fish Restoration Program, the U.S. Fish and Wildlife Service recovery plans, the SB 1086 Program, and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Implement applicable management measures identified in the restoration plan for the Anadromous Fish Restoration Program and the recovery plan for the native fishes of the Sacramento/San Joaquin Delta.
- Implement management measures as recommended by DFG that are applicable to CALFED actions and achieving CALFED objectives.
- Minimize flow fluctuations to reduce or avoid stranding of juveniles.

RATIONALE: *NMFS has identified steelhead populations in the Central Valley as composing a single evolutionarily significant unit (ESU) based on a variety of physical and biological data. These data include the physical environment (geology, soil type, air temperature, precipitation, riverflow patterns, water temperature, and vegetation); biogeography (marine, estuarine, and freshwater fish distributions); and life history traits (age at smolting, age at spawning, river entry timing, spawning timing, and genetic uniqueness).*

The Central Valley steelhead ESU encompasses the Sacramento River and its tributaries and the San

Joaquin River and its tributaries downstream of the confluence with the Merced River (including the Merced River). Recent data from genetic studies show that samples of steelhead from Deer and Mill creeks, the Stanislaus River, Coleman National Fish Hatchery on Battle Creek, and Feather River Hatchery are well differentiated from all other samples of steelhead from California Busby et al. 1996; NMFS 1997).

Within the broad context of ecosystem restoration, steelhead restoration will include a wide variety of efforts, many of which are being implemented for other ecological purposes, or that are nonspecific to steelhead trout. For example, restoration of riparian woodlands along the Sacramento River between Keswick Dam and Verona will focus on natural stream meander, flow, and natural revegetation/successional processes. These will be extremely important in providing shaded riverine aquatic habitat, woody debris, and other necessary habitats required by lower trophic organisms and juvenile and adult steelhead populations.

Operation of the water storage and conveyance systems throughout the Central Valley for their potential ecological benefits can be one of the more important elements in restoring a wide spectrum of ecological resources, including steelhead trout. Inadequate connectivity between upstream holding, spawning, and rearing habitat in certain tributary streams has impaired or reduced the reproductive potential of most steelhead stocks. Providing stream flows, improving fish ladders, and removing dams will contribute greatly to efforts to rebuild steelhead populations.

MASON'S LILAEOPSIS

MSCS SPECIES GOAL PRESCRIPTION: Expand suitable and occupied habitat by 100 linear miles and protect at least 90% of the currently occupied habitat including 90% of high quality habitat occurrences in the North, South, and East Delta and Napa River Ecological Management Units.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Maintain processes that support the dynamic habitat distributed throughout the species range and associated with existing source populations (species occurs on eroding margins of levees).
- To the extent practicable, design restoration of tidal habitats to create unvegetated, exposed substrate habitat at tidal margins of tidal fresh emergent wetland and riparian habitat.
- To the extent consistent with CALFED objectives, incorporate sufficient edge habitat to support the species in levee set back and channel island habitat restoration designs.
- To the extent practicable, maximize sinuosity of restored and created slough channels to increase water-land edge habitat.
- To the extent consistent with CALFED objectives, maintain and restore habitat and populations throughout the species' geographic ranges and expand habitat and populations to their historical and ecological ranges based on hydrologic, salinity and other habitat requirements of the species.
- Consistent with CALFED objectives, incorporate suitable habitat for these species in band protection designs used in CALFED actions.
- Monitor status and distribution of the species at five-year intervals and document expansion of the species into restored habitat for the duration of the Program.

RATIONALE: *Mason's lilaeopsis is dependent on saturated clay soils that are regularly inundated by waves and tidal action. Proposed habitat restoration action in the Sacramento-San Joaquin Delta and Suisun Marsh/North San Francisco Bay Ecological Management Zones will contribute to the recovery of this species.*

SUISUN MARSH ASTER

MSCS SPECIES GOAL PRESCRIPTION: Expand suitable and occupied habitat by 100 linear miles and protect at least 90% of the currently occupied habitat including 90% of high quality habitat occurrences in the North, South, and East Delta and Napa River Ecological Management Units.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the

Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Maintain processes that support the dynamic habitat distributed throughout the species range and associated with existing source populations (species occurs on eroding margins of levees).
- To the extent practicable, design restoration of tidal habitats to create unvegetated, exposed substrate habitat at tidal margins of tidal fresh emergent wetland and riparian habitat.
- To the extent consistent with CALFED objectives, incorporate sufficient edge habitat to support the species in levee set back and channel island habitat restoration designs.
- To the extent practicable, maximize sinuosity of restored and created slough channels to increase water-land edge habitat.
- To the extent consistent with CALFED objectives, maintain and restore habitat and populations throughout the species' geographic ranges and expand habitat and populations to their historical and ecological ranges based on hydrologic, salinity and other habitat requirements of the species.
- Consistent with CALFED objectives, incorporate suitable habitat for these species in band protection designs used in CALFED actions.
- Monitor status and distribution of the species at five-year intervals and document expansion of the species into restored habitat for the duration of the Program.

RATIONALE: *Suisun Marsh aster has habitat requirements similar to those described for Mason's lilaeopsis. Proposed habitat restoration action in the Sacramento-San Joaquin Delta and Suisun Marsh/North San Francisco Bay Ecological Management Zones will contribute to the recovery of this species.*

SUISUN THISTLE

MSCS SPECIES GOAL PRESCRIPTION: Maintain the current distribution and existing populations of Suisun thistle, establish 10 new populations, and increase overall population size ten-fold.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Identify opportunities for establishing new populations or expanding existing populations and habitat.
- Control and reduce populations of non-native marsh species with potential effects on Suisun thistle and potential Suisun thistle habitat.
- Monitor the population size and vigor of all extant occurrences at a two-year interval for the duration of the Program.
- Modify conservation measures according to the adaptive management process as more understanding is developed of recovery needs.

RATIONALE: *Suisun thistle is known from only two location in Suisun Marsh. It occurs on the edges of salt and brackish marsh habitat that are periodically inundated during high tides. Proposed habitat restoration action in the Suisun Marsh/North San Francisco Bay Ecological Management Zone will contribute to the recovery of this species.*

SOFT BIRD'S-BEAK

MSCS SPECIES GOAL PRESCRIPTION: Maintain the current distribution and existing populations of soft bird's-beak and reestablish and maintain viable populations throughout its historic range.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Expand potential habitat by improving tidal circulation to diked wetlands that sustain some existing exchange.
- Identify opportunities for establishing new populations or expanding existing populations and habitat.
- Establish soft bird's-beak populations to existing and restored suitable habitat.

- Control and reduce populations of non-native marsh species with potential effects on soft bird's beak and potential soft bird's-beak habitat.
- Monitor the populations size and vigor of all extant occurrences at two-year interval for the duration of the Program and design and implement remediation measures if the recovery goal is not met.
- Modify conservation measures according to the adaptive management process as more understanding is developed of recovery needs.

RATIONALE: *Soft bird's-beak inhabits the upper reaches of salt grass-pickleweed marshes at or near the limit of tidal action. Proposed habitat restoration action in the Suisun Marsh/North San Francisco Bay Ecological Management Zone will contribute to the recovery of this species.*

ANTIOCH DUNES EVENING-PRIMROSE AND CONTRA COSTA WALLFLOWER

MSCS SPECIES GOAL PRESCRIPTION: Continue protection of and expand the size of these species' Antioch Dunes populations; enhance and restore suitable habitat at and in the vicinity of the Antioch Dunes; and achieve recovery goals identified in the USFWS recovery plan.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Coordinate protection and restoration of inland dune scrub habitats with other programs (e.g., U.S. Fish and Wildlife Service recovery plans and management of the Antioch Dunes Preserve) that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Conduct surveys to locate potential habitat restoration sites on Tinnin soils and identify opportunities for and implement permanent protection, restoration, and management of these habitat areas to enhance habitat conditions for these species.
- Enhance and maintain existing populations.
- Annually monitor establishment success and modify establishment and management techniques as needed using adaptive management.

RATIONALE: *Protection and restoration of these two species at the Antioch Dunes is a major objective of efforts to improve and expand suitable dune habitat. Although the species distribution is limited, the species appear stable.*

LANGE'S METALMARK BUTTERFLY

MSCS SPECIES GOAL PRESCRIPTION: Continue protection of and expand the size of the Antioch Dunes population of the Lange's metalmark butterfly; enhance and restore suitable habitat at and in the vicinity of the Antioch Dunes; and achieve recovery goals identified in the USFWS recovery plan.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Coordinate protection, enhancement, and restoration of inland dune scrub habitat with other federal and state programs (e.g., U.S. Fish and Wildlife Service species recovery plans and management of the Antioch Dunes Preserve) that could affect management of current and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Conduct surveys to locate potential habitat restoration sites on Tinnin soils and identify opportunities for and implement permanent protection, restoration, and management of these habitat areas to enhance habitat conditions for the Lange's metalmark.
- Monitor enhanced and restored habitat areas to determine the success of enhancement and restoration methods, and to determine the response of Lange's metalmark populations and management.

RATIONALE: *Protection and restoration of Lange's metalmark habitat at the Antioch Dunes is a major objective of the species recovery plan (U.S. Fish and Wildlife Service 1984c).*

VALLEY ELDERBERRY LONGHORN BEETLE

MSCS SPECIES GOAL PRESCRIPTION: Maintain and restore connectivity among riparian habitats occupied by the valley elderberry longhorn beetle and within its historic range along the Sacramento and San Joaquin rivers and their major tributaries.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Coordinate protection and restoration of riparian habitats with other federal and state programs (e.g., U.S. Fish and Wildlife Service recovery plans, the SB 1086 program, and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of occupied and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Within the species current range, design ERP riparian habitat enhancements and restorations to include suitable riparian edge habitat, including elderberry savanna.
- Initially direct ERP riparian habitat actions towards enhancement and restoration of habitat areas located near occupied habitat to encourage the natural expansion of the species range.
- Include sufficient buffer habitat around suitable restored and enhanced habitat areas within the species' range to reduce potential adverse effects associated with pesticide drift.
- To the extent consistent with CALFED objectives, implement levee maintenance guidelines to protect suitable habitat.
- To the extent consistent with CALFED objectives, design levees to encourage the establishment and long-term maintenance of suitable habitat.

RATIONALE: *The primary reason attributable to the decline in numbers and distribution of the valley elderberry longhorn beetle populations is the extensive loss or degradation of its historical riparian habitats in the Central Valley to urban and agricultural uses, and flood control and water supply projects to support those uses (U.S. Fish and Wildlife Service 1984b). Protection, restoration, and enhancement of large expanses of suitable riparian habitat within the species historical and current range, therefore, will protect existing populations from future decline and provide habitat area necessary for existing populations to expand.*

SUISUN ORNATE SHREW

MSCS SPECIES GOAL PRESCRIPTION: Maintain the current distribution and existing populations of the Suisun ornate shrew and reestablish and maintain viable species' populations throughout its historic range in the portion of the Bay Region within the ERP focus area.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- The geographic priorities for implementing actions to protect, enhance, and restore saline emergent wetlands and associated habitats for the Suisun ornate shrew should be: 1) western Suisun Marsh, 2) Napa Marshes, and eastern Suisun Marshes, 3) Sonoma Marshes and Highway 37 marshes west of Sonoma Creek.
- Coordinate protection, enhancement, and restoration of saltmarsh and associated habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, and USFWS species recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Initial species recovery efforts should be directed to locations where there are immediate

opportunities for protection, enhancement, or restoration of suitable habitat.

- To the extent practicable, direct ERP salt marsh enhancement efforts towards existing degraded marshes that are of sufficient size and configuration to develop fourth order tidal channels (marshes would likely need to be at least 1,000 acres in size).
- Restore wetland and perennial grassland habitats adjacent to occupied habitats to create a buffer of natural habitat to protect populations from adverse affects that could be associated with future changes in land use on nearby lands and to provide habitat suitable for the natural expansion of populations.
- To the extent practicable, design salt marsh enhancements and restorations to provide low-angle upland slopes at the upper edge of marshes to provide for the establishment of suitable and sufficient wetland to upland transition habitat. Transition habitat zones should be at least 0.25 mile in width.
- Manage enhanced and restored habitat areas to avoid or minimize impacts on the Suisun ornate shrew associated with recreational uses on lands acquired or managed under conservation easements.
- Direct salt marsh habitat enhancements and restorations towards increasing habitat connectivity among existing and restored tidal marshes within the range of the Suisun ornate shrew.
- To the extent practicable, design dikes constructed in enhanced and restored saline emergent wetlands to provide optimal wetland to upland transitional habitat.
- Identify and implement feasible methods for controlling invasive non-native marsh plants.
- To the extent practicable, control non-native predator populations in occupied habitat and saltmarshes enhanced and restored under the ERP.
- Provide interim management of occupied salt marshes to maintain source populations until restored habitats have developed sufficiently to provide suitable habitat.
- Acquire conservation easements to adjust grazing regimes to enhance wetland to upland transition habitat conditions in occupied habitat areas.
- Conduct research to determine use of restored salt marsh habitats by Suisun ornate shrews and the rate at which restored habitats are colonized.

RATIONALE: *The Suisun ornate shrew is a listed as a species of special concern by the California Department of Fish and Game, but its limited habitat and distribution indicate it may qualify as a threatened species. Long-term survival of this subspecies is dependent upon tidal wetland, as opposed to diked wetlands, and has to have adequate physical structures and plant communities for survival. Its tidal marsh habitat has to have adjacent upland habitat for survival of the species during periods when the marsh is inundated. The upland habitat has to have relatively low densities of exotic predators. Restoring habitat would not only benefit the Suisun ornate shrew but other species, such as the salt marsh harvest mouse, that also use tidal marsh and upland marsh habitats.*

SUISUN SONG SPARROW

MSCS SPECIES GOAL PRESCRIPTION: Maintain the current distribution and existing populations of the Suisun song sparrow and reestablish and maintain viable species' populations throughout its historic range in portions of the Bay and Delta Regions within the ERP focus areas.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- The geographic priorities for implementing ERP actions to protect, enhance, and restore saline emergent wetlands and associated habitats for the Suisun song sparrow should be: 1) western Suisun Marsh, 2) eastern Suisun Marsh, and 3) the Contra Costa County shoreline.
- Coordinate protection, enhancement, and restoration of saltmarsh and associated habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands

Ecosystem Goals Project, and USFWS species recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.

- Restore wetland and perennial grassland habitats adjacent to occupied nesting habitats to create a buffer of natural habitat to protect nesting pairs from adverse affects that could be associated with future changes in land use on nearby lands and to provide suitable foraging habitat and nesting habitat area suitable for the natural expansion of populations.
- Initial species recovery efforts should be directed to locations where there are immediate opportunities for protection, enhancement, or restoration of suitable habitat.
- To the extent practicable, design dikes constructed in enhanced and restored saline emergent wetlands to provide optimal wetland to upland transitional habitat.
- To the extent practicable, direct ERP salt marsh enhancement efforts towards existing degraded marshes that are of sufficient size and configuration to develop fourth order tidal channels (marshes would likely need to be at least 1,000 acres in size).
- To the extent practicable, design salt marsh enhancements and restorations to provide low-angle upland slopes at the upper edge of marshes to provide for the establishment of suitable and sufficient wetland to upland transition habitat. Transition habitat zones should be at least 0.25 mile in width.
- Control non-native plants in existing salt marshes where non-native plants have degraded habitat quality and in salt marshes restored under the ERP.
- Manage enhanced and restored habitat areas to avoid or minimize impacts on the Suisun song sparrow associated with recreational uses on lands acquired or managed under conservation easements.
- Direct salt marsh habitat enhancements and restorations towards increasing habitat connectivity among existing occupied and restored tidal marshes.
- To the extent practicable, direct ERP restorations to improve tidal circulation to diked wetlands that currently sustain partial tidal exchange.
- To the extent practicable, control non-native predator populations in occupied habitat areas and salt marshes enhanced and restored under the ERP.
- Identify and implement feasible methods for controlling invasive non-native marsh plants.
- Conduct research to determine use of restored salt marsh habitats by Suisun song sparrows and the rate at which restored habitats are colonized.
- Acquire conservation easements to adjust grazing regimes to enhance wetland to upland transition habitat conditions.

RATIONALE: *The Suisun song sparrow occurs only in and near Suisun Marsh, in about 13 isolated populations. Populations of this unusual subspecies are declining for a variety of reasons but mainly the degradation of their habitat. Reductions in fresh water outflow from the Sacramento-San Joaquin Rivers and diking and channelization of marsh lands have contributed to their decline. Restoration of their populations is likely to be a good indicator of the success of restoration of brackish tidal marshes in the Suisun Marsh area.*

SAN PABLO SONG SPARROW

MSCS SPECIES GOAL PRESCRIPTION: Maintain the current distribution and existing populations of the San Pablo song sparrow and reestablish and maintain viable species' populations throughout its historic range in the portion of the Bay Region within the ERP focus area.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- The geographic priorities for implementing ERP actions to protect, enhance, and restore saline emergent wetlands and associated habitats for the San Pablo song sparrow should be: 1) Gallinas/Ignacio marshes and Napa Marshes, 2)

Sonoma Marshes, Petaluma Marshes, and Highway 37 marshes west of Sonoma Creek, 3) Point Pinole Marshes, 4) Highway 37 marshes east of Sonoma Creek,

- Coordinate protection, enhancement, and restoration of saltmarsh and associated habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, and USFWS species recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Restore wetland and perennial grassland habitats adjacent to occupied nesting habitats to create a buffer of natural habitat to protect nesting pairs from adverse affects that could be associated with future changes in land use on nearby lands and to provide suitable foraging habitat and nesting habitat area suitable for the natural expansion of populations.
- Initial species recovery efforts should be directed to locations where there are immediate opportunities for protection, enhancement, or restoration of suitable habitat.
- Design dikes constructed in enhanced and restored saline emergent wetlands to provide optimal wetland to upland transitional habitat.
- To the extent practicable, direct ERP salt marsh enhancement efforts towards existing degraded marshes that are of sufficient size and configuration to develop fourth order tidal channels (marshes would likely need to be at least 1,000 acres in size).
- To the extent practicable, design salt marsh enhancements and restorations to provide low-angle upland slopes at the upper edge of marshes to provide for the establishment of suitable and sufficient wetland to upland transition habitat. Transition habitat zones should be at least 0.25 mile in width.
- Manage enhanced and restored habitat areas to avoid or minimize impacts on the San Pablo song sparrow associated with recreational uses on lands acquired or managed under conservation easements.
- To the extent practicable, control non-native predator populations in occupied habitat areas and salt marshes enhanced and restored under the ERP.
- Identify and implement feasible methods for controlling invasive non-native marsh plants.
- Conduct research to determine use of restored salt marsh habitats by San Pablo song sparrows and the rate at which restored habitats are colonized.

RATIONALE: *The San Pablo song sparrow occupies habitat only in the North San Francisco Bay Region and is dependent on saline emergent wetland habitat. Recover of this species may depend on the success of restoring additional saline emergent wetlands and associated transitional habitats.*

Species with the designation "Contribute to Recovery".

CALIFORNIA CLAPPER RAIL

MSCS SPECIES GOAL PRESCRIPTION: Maintain the current distribution and existing populations of the California clapper rail and reestablish and maintain viable species' populations throughout its historic range in the portion of the Bay Region within the ERP focus area.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- The geographic priorities for implementing actions to protect, enhance, and restore saline emergent wetlands and associated habitats for the California clapper rail should be: 1) Gallinas/Ignacio marshes and Napa Marshes, 2) Sonoma Marshes, Petaluma Marshes, and Highway 37 marshes west of Sonoma Creek, 3) Point Pinole Marshes, 4) Highway 37 marshes west of Sonoma Creek, and 5) the Contra Costa County shoreline.

- Coordinate protection, enhancement, and restoration of saltmarsh and associated habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, and USFWS species recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Restore wetland and perennial grassland habitats adjacent to occupied nesting habitats to create a buffer of natural habitat to protect nesting pairs from potential adverse affects that could be associated with future changes in land use on nearby lands and to provide suitable foraging habitat and nesting habitat area suitable for the natural expansion of populations.
- Initial species recovery efforts should be directed to locations where there are immediate opportunities for protection, enhancement, or restoration of suitable habitat.
- To the extent practicable, design dikes constructed in enhanced and restored saline emergent wetlands to provide optimal wetland to upland transition habitat.
- Direct ERP salt marsh enhancement efforts towards existing degraded marshes that are of sufficient size and configuration to develop fourth order tidal channels (marshes would likely need to be at least 1,000 acres in size).
- To the extent practicable, design salt marsh enhancements and restorations to provide low-angle upland slopes at the upper edge of marshes to provide for the establishment of suitable and sufficient wetland to upland transition habitat. Transition habitat zones should be at least 0.25 mile in width.
- Manage enhanced and restored habitat areas to avoid or minimize impacts on the California clapper rail associated with recreational uses on lands acquired or managed under conservation easements.
- Direct ERP restoration actions towards improving tidal circulation to dikes wetlands that currently sustain partial tidal exchange.
- Direct some habitat enhancements and restorations towards increasing habitat connectivity among existing and restored tidal marshes.
- To the extent practicable, control non-native predator populations in occupied habitat areas and salt marshes enhanced and restored under the ERP.
- Identify and implement feasible methods for controlling invasive non-native marsh plants.
- Monitor to determine use of restored salt marsh habitat by California clapper rails and the rate at which restored habitats are colonized.

RATIONALE: *The primary reason attributable to the decline in California clapper rail populations is the extensive loss of its historical salt marsh habitat to urban, industrial, and agricultural uses (U.S. Fish and Wildlife Service 1984a). Restoration of large expanses of suitable salt marsh habitat within the species historical and current range, therefore, will provide habitat area necessary for populations to expand.*

CALIFORNIA BLACK RAIL

MSCS SPECIES GOAL PRESCRIPTION: Maintain the current distribution and existing populations of the California black rail and reestablish and maintain viable species' populations throughout its historic range in portions of the Delta and Bay Regions within the ERP focus area.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- The geographic priorities for implementing actions to protect, enhance, and restore saline emergent wetlands and associated habitats for the California black rail should be: 1) western Suisun Marsh, 2) Gallinas/Ignacio marshes, Napa Marshes, and eastern Suisun Marshes, 3) Sonoma Marshes, Petaluma Marshes, and Highway 37 marshes west of Sonoma Creek, 4) Point Pinole Marshes, 4) Highway 37 marshes west of Sonoma Creek, and 6) the Contra Costa County shoreline.

- Coordinate protection, enhancement, and restoration of saltmarsh and associated habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, and USFWS species recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Restore wetland and perennial grassland habitats adjacent to occupied nesting habitats to create a buffer of natural habitat to protect nesting pairs from potential adverse affects that could be associated with future changes in land use on nearby lands and to provide suitable foraging habitat and nesting habitat area suitable for the natural expansion of populations.
- Initial species recovery efforts should be directed to locations where there are immediate opportunities for protection, enhancement, or restoration of suitable habitat.
- To the extent practicable, design dikes constructed in enhanced and restored saline emergent wetlands to provide optimal wetland to upland transition habitat.
- Direct ERP salt marsh enhancement efforts towards existing degraded marshes that are of sufficient size and configuration to develop fourth order tidal channels (marshes would likely need to be at least 1,000 acres in size).
- To the extent practicable, design salt marsh enhancements and restorations to provide low-angle upland slopes at the upper edge of marshes to provide for the establishment of suitable and sufficient wetland to upland transition habitat. Transition habitat zones should be at least 0.25 mile in width.
- Manage enhanced and restored habitat areas to avoid or minimize impacts on the California black rail associated with recreational uses on lands acquired or managed under conservation easements.
- Direct ERP restoration actions towards improving tidal circulation to dikes wetlands that currently sustain partial tidal exchange.
- Direct some habitat enhancements and restorations towards increasing habitat connectivity among existing and restored tidal marshes.
- To the extent practicable, control non-native predator populations in occupied habitat areas and salt marshes enhanced and restored under the ERP.
- Identify and implement feasible methods for controlling invasive non-native marsh plants.
- Monitor to determine use of restored salt marsh habitat by California clapper rails and the rate at which restored habitats are colonized.
- Acquire conservation easements in occupied habitat areas to adjust grazing regimes to enhance wetland to upland transition habitat conditions.

RATIONALE: *The primary reason attributable to the decline in California black rail populations is the extensive loss of its historical tidal marsh habitat to urban, industrial, and agricultural uses. Restoration of large expanses of suitable tidal marsh habitat within the species historical and current range, therefore, will provide habitat area necessary for populations to expand.*

SWAINSON'S HAWK

MSCS SPECIES GOAL PRESCRIPTION: Protect, enhance, and increase habitat sufficient to support a viable breeding population. The interim prescription is to increase the current estimated population of 1,000 breeding pairs in the Central Valley to 2,000 breeding pairs. This prescription will be modified based on results of a population viability analysis being conducted by the California Department of Fish and Game.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Proposed ERP actions designed to restore valley/foothill riparian habitat should initially be implemented in the Delta.
- To the extent practicable, design restored seasonal wetlands in occupied habitat areas to

provide overwinter refuge for rodents to provide source prey populations during spring and summer.

- To the extent consistent with CALFED objectives, enhance at least 10% of agricultural lands to be enhanced under the ERP in the Delta, Sacramento River, and San Joaquin River Regions to increase forage abundance and availability within 10 miles of occupied habitat areas.
- To the extent consistent with CALFED objectives, manage lands purchased or acquired under conservation easements that are occupied by the species to maintain or increase their current population levels.
- To the extent practicable, manage restored or enhanced habitats under the ERP to maintain desirable rodent populations and minimize potential impacts associated with rodent control.

RATIONALE: *Historically, Swainson's hawk foraging habitat consisted of large expanses of open grasslands that supported abundant prey species. Swainson's hawks typically nest in riparian forests, small groves of trees, or lone trees within open habitats. Today, as a result of conversion of large expanses of historic grassland to urban, industrial, and agricultural uses, agricultural lands are major foraging habitat areas for Swainson's hawks. Some types of agriculture, however, are unsuitable because they do not support sufficient prey populations or because prey is unavailable as a result of dense vegetation (e.g., rice and vineyards). Over 85% of nesting territories in the Central Valley are associated with riparian systems adjacent to suitable foraging habitats (California Department of Fish and Game 1992). Consequently, improving prey abundance and availability on agricultural lands adjacent to restored riparian habitats will provide important elements of the specie's habitat necessary for the population to expand.*

SALT MARSH HARVEST MOUSE

MSCS SPECIES GOAL PRESCRIPTION: Maintain the current distribution and existing populations of salt marsh harvest mouse and establish and maintain viable species' populations throughout its historic range in the portion of the Bay Region within the ERP focus area.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- The geographic priorities for implementing actions to protect, enhance, and restore saline emergent wetlands and associated habitats for the salt marsh harvest mouse should be: 1) western Suisun Marsh, 2) Gallinas/Ignacio marshes, Napa Marshes, and eastern Suisun Marshes, 3) Sonoma Marshes, Petaluma Marshes, and Highway 37 marshes west of Sonoma Creek, 4) Point Pinole Marshes, 5) Highway 37 marshes west of Sonoma Creek, and 6) the Contra Costa County shoreline.
- Coordinate protection, enhancement, and restoration of saltmarsh and associated habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, and USFWS species recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Restore wetland and perennial grassland habitats adjacent to occupied nesting habitats to create a buffer of natural habitat to protect nesting pairs from adverse affects that could be associated with future changes in land use on nearby lands and to provide suitable foraging habitat and nesting habitat area suitable for the natural expansion of populations.
- Initial species recovery efforts should be directed to locations where there are immediate opportunities for protection, enhancement, or restoration of suitable habitat.
- To the extent practicable, design dikes constructed in enhanced and restored saline emergent wetlands to provide optimal wetland to upland transition habitat.
- To the extent practicable, direct ERP salt marsh enhancement efforts towards existing degraded marshes that are of sufficient size and configuration to develop fourth order tidal

channels (marshes would likely need to be at least 1,000 acres in size).

- To the extent practicable, design salt marsh enhancements and restorations to provide low-angle upland slopes at the upper edge of marshes to provide for the establishment of suitable and sufficient wetland to upland transition habitat. Transition habitat zones should be at least 0.25 mile in width.
- Manage enhanced and restored habitat areas to avoid or minimize impacts on the salt marsh harvest mouse associated with recreational uses on lands acquired or managed under conservation easements.
- Direct restoration efforts towards restoration of lands adjacent to occupied habitat areas.
- Direct restoration efforts towards improving tidal circulation to diked wetlands that currently sustain partial tidal exchange.
- Direct some habitat enhancements and restorations towards increasing habitat connectivity among existing and restored tidal marshes.
- To the extent practicable, control non-native predator populations in occupied habitat areas and salt marshes enhanced and restored under the ERP.
- Control non-native invasive plants in existing salt marshes where non-native plants have degraded habitat quality and in salt marshes restored under the ERP.
- Monitor the use of restored salt marsh habitats by salt marsh harvest mice and the rate at which restored habitats are colonized.
- Acquire conservation easements to adjust grazing regimes to enhance wetland to upland transition habitat conditions.
- To the extent consistent with CALFED objectives, manage lands purchased or acquired under conservation easements that are occupied by the species to maintain or increase their current population levels.

RATIONALE: *The primary reason attributable to the decline in salt marsh harvest mouse populations is the extensive loss of its historical high tidal salt marsh and adjacent upland habitats to urban, industrial, and agricultural uses (U.S. Fish and Wildlife Service 1984a). Restoration of large expanses of suitable salt marsh habitat adjacent to uplands within the species historical and current range, therefore, will provide habitat area necessary for populations to expand.*

SAN PABLO CALIFORNIA VOLE

MSCS SPECIES GOAL PRESCRIPTION: Maintain the current distribution and existing populations of San Pablo California vole and establish and maintain viable species' populations throughout its historic range in portions of the Delta and Bay Regions within the ERP focus area.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Coordinate protection, enhancement, and restoration of saltmarsh and associated habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, and USFWS species recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Restore wetland and perennial grassland habitats adjacent to occupied habitats to create a buffer of natural habitat to protect populations from potential adverse affects that could be associated with future changes in land use on nearby lands and to provide habitat suitable for the natural expansion of populations.
- Manage enhanced and restored habitat areas to avoid or minimize impacts on the San Pablo California vole associated with recreational uses on lands acquired or managed under conservation easements.
- To the extent practicable, acquire, restore and manage historic tidal salt marshes and surrounding lands occupied by the San Pablo California vole along the west side of Point

Pinole to tidal marsh with sufficient wetland to upland transition and adjacent upland habitat to improve habitat conditions for the San Pablo California vole.

- To the extent practicable, control non-native predator populations in occupied habitat areas and salt marshes enhanced and restored under the ERP.
- Identify and implement feasible methods for controlling invasive non-native marsh plants.
- To the extent consistent with CALFED objectives, manage land purchases or acquired under conservation easement that are occupied by the species to maintain or increase their current population levels.

RATIONALE: *The San Pablo vole is a California Department of Fish and Game Special Concern species. Although little is known about its distribution, biology, or taxonomy, it appears to be a distinct form that is confined to salt marshes and adjoining grasslands in Contra Costa County. To limit the decline of the populations even further, salt marsh and adjoining grassland habitats in Contra Cosa County need to be protected and further degradation and loss of habitat halted.*

SACRAMENTO PERCH

MSCS SPECIES GOAL PRESCRIPTION: Establish multiple self-sustaining populations of Sacramento perch within the Central Valley.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Coordinate protection and restoration of Sacramento perch and its habitats with other federal and state programs (e.g., U.S. Fish and Wildlife Service species recovery plans) that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Implement reintroductions into suitable habitat areas and manage habitat areas to maintain introduced populations.

RATIONALE: *The Sacramento perch was once one of the most abundant fish in lowland habitats of the Central Valley. With the exception of a small population in Clear Lake, it has been extirpated from natural habitats within its native range due to competition and predation from introduced centrarchid fishes, such as black bass. It would certainly be formally listed as an endangered species except that it has been widely introduced into reservoirs, lakes, and ponds outside its native habitats in California and other western states.*

RIPARIAN BRUSH RABBIT

MSCS SPECIES GOAL PRESCRIPTION: Protect the Caswell Memorial State Park population; protect, enhance, and expand the species' Caswell Memorial Park population; and restore four additional self-sustaining populations in the Delta and along the San Joaquin River by 2020.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Coordinate protection and restoration of riparian brush rabbit populations and its habitats with other federal and state programs (e.g., U.S. Fish and Wildlife Service species recovery plans) that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Conduct surveys to identify suitable habitat areas for establishment of additional populations in the Delta and along the San Joaquin River and implement introductions to establish four additional populations in these areas aby 2020.
- Direct ERP actions proposed for the Stanislaus River towards protecting, enhancing, and restoring suitable riparian and associated flood refuge habitats in and adjacent to occupied habitat at Caswell Memorial State Park.

- Develop and implement a monitoring plan to assess populations status and trends.

RATIONALE: *Protection and restoration of existing occupied riparian brush rabbit habitat at Caswell Memorial State Park and actions to reduce the probability for mortality as a result of flooding, fire, and predation are major objectives of the species recovery plan (U.S. Fish and Wildlife Service 1997).*

SAN JOAQUIN VALLEY WOODRAT

MSCS SPECIES GOAL PRESCRIPTION: Protect the Caswell Memorial State Park Population; protect, enhance, and expand the species' Caswell Memorial Park population; and improve habitat connectivity and genetic interchange among isolated populations.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Coordinate protection and restoration of San Joaquin Valley woodrat populations and its habitats with other federal and state programs (e.g., U.S. Fish and Wildlife Service species recovery plans and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Direct ERP actions proposed for the Stanislaus River towards protecting, enhancing, and restoring suitable riparian and associated flood refuge habitats in and adjacent to occupied habitat at Caswell Memorial State Park.
- Direct ERP actions proposed for the San Joaquin River and its major tributaries within the current range of the species towards protecting and enhancing existing occupied habitat areas; restoring suitable habitat adjacent to occupied habitat areas; and restoring suitable riparian habitat to create habitat corridors linking isolated populations.

RATIONALE: *The primary reason attributable to the decline in numbers and distribution of the San Joaquin Valley woodrat populations is the extensive loss and fragmentation of its historical riparian habitats in the San Joaquin Valley urban and agricultural uses, and flood control and water supply projects to support those uses (U.S. Fish and Wildlife Service 1997). Protection, restoration, and enhancement of large expanses of suitable riparian habitat within the species historical and current range, therefore, will protect existing populations from future decline and provide habitat area necessary for existing populations to expand.*

GREATER SANDHILL CRANE

MSCS SPECIES GOAL PRESCRIPTION: Achieve recovery objectives identified in the Pacific Flyway Management Plan for the Central Valley population of greater sandhill cranes and Assembly Bill (AB) 1280 legislation that applicable to CALFED problem area, the Butte Sink, and other species' use areas consistent with CALFED's mission.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- To the extent consistent with CALFED objectives, implement ERP actions in concert with the species recovery strategies identified in AB 1280 and the Pacific Flyway Plan.
- Implementation of proposed ERP actions to enhance agricultural habitats should give priority to improving the abundance and availability of upland agricultural forage (e.g., corn and winter wheat) in the core use area centered around Bract Tract.
- Implementation of proposed ERP actions to restore wetlands should give priority to restoring and managing wetland habitat area within the core use area centered on Bract Tract that would provide suitable roosting habitat.
- Avoid or minimize recreational uses in the core area centered on Bract Tract that could disrupt crane habitat use patterns from October-March.
- To the extent consistent with CALFED objectives, at least 10% of agricultural lands to be enhanced under the ERP in the Delta and the Butte Sink should be managed to increase forage

abundance and availability for cranes. Priority should be given to implementing these habitat improvements within 10 miles of core habitat area centered on Bract Tract.

- Monitor to determine use of protected, restored, and enhanced habitats by sandhill cranes in core wintering areas.

RATIONALE: *Suitable shallow-water roosting habitat used by greater sandhill cranes during winter in the Delta is limited. Restoration and management of seasonal wetlands specifically to provide suitable roosting habitat free from disturbance near suitable foraging habitats will increase the area of available roosting habitat and may improve distribution of wintering cranes. Increases in food availability and abundance on agricultural lands will also be likely to improve distribution and winter survival of cranes in the Delta.*

CALIFORNIA YELLOW WARBLER

MSCS SPECIES GOAL PRESCRIPTION: Maintain and enhance suitable riparian corridor migration habitats and restore suitable breeding habitat within the historic breeding range of this species in the Central Valley.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Coordinate protection and restoration of riparian habitat areas with other federal and state programs (e.g., the Riparian Habitat Joint Venture, the SB 1086 Program, and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.

- To the extent consistent with CALFED objectives, protect existing suitable riparian habitat corridors from potential future changes in land use or other activities that could result in the loss or degradation of habitat

- A portion of restored riparian habitat area should be designed to include riparian scrub communities.

- To the extent practicable, restore riparian habitat in patch sizes sufficient to discourage nest parasitism by brown-headed cowbirds..

RATIONALE: *Neotropical migratory birds constitute a diverse group of largely passerine songbirds that overwinter in the tropics but breed in or migrate through the Central Valley and Bay-Delta region. As a group, they are in decline because of loss of habitat on their breeding grounds, in their migratory corridors, and in their wintering grounds. The species within this group are good indicators of habitat quality and diversity and their popularity with birders means that populations are tracked and have high public interest. They can also be good indicators of contaminant levels, by monitoring reproductive success and survival in areas near sources of contamination. Riparian forests are particularly important to this group because they are major migration corridors and breeding habitat for many species. By providing improved nesting and migratory habitat, it may be possible to partially compensate for increased mortality rates in the wintering grounds. Improved habitat for songbirds also provides habitat for many other species of animals and plants.*

LEAST BELL'S VIREO

MSCS SPECIES GOAL PRESCRIPTION: Achieve recovery objectives identified in the least Bell's vireo recovery plan applicable to the ERP focus study area.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Coordinate protection and restoration of riparian habitat areas with other federal and state programs (e.g., the least Bell's vireo recovery plan team, Riparian Habitat Joint Venture, and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.

- To the extent consistent with CALFED objectives, protect existing riparian habitat areas from potential future changes in land use or other activities that could result in the loss or degradation of habitat areas that would be suitable for reintroductions or natural colonization of the species.
- A portion of restore riparian habitat area should be designated to include riparian scrub communities.
- To the extent practicable, restore riparian habitats in patch sizes sufficient to discourage nest parasitism by brown-headed cowbirds.

RATIONALE: *A major reason attributable to the extirpation of the least Bell's vireo from its historical range in the Central Valley is the extensive loss and fragmentation of its historical riparian habitats to urban and agricultural uses, and flood control and water supply projects to support those uses (U.S. Fish and Wildlife Service 1998). Protection, restoration, and enhancement of large expanses of suitable riparian habitat within the species historical range is an objective of the least Bell's vireo recovery plan (U.S. Fish and Wildlife Service 1998) and will provide habitat area necessary for existing populations to expand.*

WESTERN YELLOW-BILLED CUCKOO

MSCS SPECIES GOAL PRESCRIPTION: Protect existing suitable riparian forest habitat areas within the species' historic range and increase the areas of suitable riparian forest habitat sufficiently to allow the natural expansion of the Sacramento Valley population.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Coordinate protection and restoration of riparian habitat areas with other federal and state programs (e.g., the Riparian Habitat Joint Venture, the SB 1086 Program, and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Initially direct ERP actions to restore suitable valley/foothill riparian forest and woodland along at least 10 contiguous miles of channels in the Delta to create a riparian forest corridor at least 200 meters in width.
- Restore large contiguous blocks of suitable valley/foothill riparian forest and woodland at least 200 meters in width and 500 acres in size along reaches of the Sacramento River adjacent to occupied habitat areas (Red Bluff to Chico).

RATIONALE: *The primary reason attributable to the decline in numbers and distribution of the western yellow-billed cuckoo is the extensive loss or degradation of its historical riparian forest habitats in the Central Valley to urban and agricultural uses, and flood control and water supply projects to support those uses (California Department of Fish and Game 1992). Protection, restoration, and enhancement of large expanses of suitable riparian habitat within the species historical and current range, therefore, will protect existing populations from future decline and provide habitat area necessary for existing populations to expand.*

BANK SWALLOW

MSCS SPECIES GOAL PRESCRIPTION: Allow reaches of the Sacramento River and its tributaries that are unconfined by flood control structures (i.e., bank revetment and levees) to continue to meander freely, thereby creating suitable bank nesting substrates through the process of bank erosion.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Coordinate protection and restoration of channel meander belts and existing bank swallow colonies with other federal and state programs (e.g., the SB 1086 Program and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.

- Proposed ERP actions designed to protect or restore stream meander belts should initially be implemented along reaches of the Sacramento River and its tributaries that support nesting colonies or potential nesting habitat.
- Monitor to determine the response of bank swallows to restoration of stream meander belts and riparian habitat.
- Coordinate with BOR and DWR to_phase spring-summer reservoir releases in a manner that would reduce the potential for adverse effects on nesting colonies that could result from large, pulsed, releases.
- To the extent consistent with CALFED objectives, protect all known nesting colonies from potential future changes in land use or activities that could adversely affect colonies.

RATIONALE: *The decline in numbers and distribution of bank swallow populations is attributable to the loss of the natural depositional and erosional processes of rivers that create and sustain the types of channel bank nesting substrates required by the species largely as a result of flood control projects that have impeded the ability of rivers to erode their banks (California Department of Fish and Game 1992). Restoration of the ability of channels of major rivers in the Central Valley to erode their banks will increase the availability of suitable nesting habitat, providing the additional habitat area necessary for existing populations to expand.*

LITTLE WILLOW FLYCATCHER

MSCS SPECIES GOAL PRESCRIPTION: Maintain and enhance suitable riparian corridor migration habitats and restore suitable breeding habitat within the historic breeding range of this species in the Central Valley.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Coordinate protection and restoration of riparian habitat areas with other federal and state programs (e.g., the Riparian Habitat Joint Venture, the SB 1086 Program, and the Corps' Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- To the extent consistent with CALFED objectives, protect existing suitable riparian habitat corridors from potential future changes in land use or other activities that could result in the loss or degradation of habitat
- A portion of restored riparian habitat area should be designed to include riparian scrub communities.
- To the extent practicable, restore riparian habitat in patch sizes sufficient to discourage nest parasitism by brown-headed cowbirds..

RATIONALE: *A major reason attributable to the extirpation of the little willow flycatcher as a breeding species from its historical range in the Central Valley is the extensive loss and fragmentation of its historical riparian habitats to urban and agricultural uses, and flood control and water supply projects to support those uses (Zeiner et al. 1990, California. Department of Fish and Game 1992). Consequently, the protection, restoration, and enhancement of large expanses of suitable riparian habitat within the species historical range will provide habitat area necessary for existing populations to expand.'*

GIANT GARTER SNAKE

MSCS SPECIES GOAL PRESCRIPTION: Protect the existing population and habitat within the Delta Region and restore, enhance, and manage suitable habitat areas adjacent to known populations to encourage the natural expansion of the species.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- A substantial portion of tidal wetlands to be restored under the ERP should be restored in the North Delta (the Yolo Basin and Bypass)
- To the extent consistent with CALFED objectives, protect existing and restore additional habitat in the east Delta to create a corridor of suitable habitat linking Stone Lakes, the Cosumnes River, and White Slough.
- To the extent practicable, design setback levees in the restored Stone Lakes/Cosumnes River/White Slough habitat corridor to include a mosaic of habitats.
- Identify opportunities for implementing levee maintenance practices in the Delta that will maintain suitable levee habitat or minimize the impacts of necessary maintenance on the species and its habitat.
- Incorporate restoration of permanent or seasonal flooded (April-October) suitable habitat areas as part of a mosaic of the seasonal wetland and agricultural land enhancements to be implemented under the ERP.
- To the extent consistent with CALFED objectives, locate ERP nontidal marsh restorations near existing occupied habitat areas and design restorations to include suitable upland habitat areas at least 200 feet around restored wetlands.
- Include improvements to and maintenance of suitable agricultural infrastructure habitat (i.e., ditches, drains, canals, and levees) as part of ERP actions to improve wildlife habitat values associated with agricultural lands.
- To the extent consistent with CALFED objectives, manage lands purchased or acquired under conservation easements that are occupied by the species to maintain or increase their current population levels.
- Monitor suitable wetlands restored in the Delta Region adjacent to or near occupied habitats to assess if and when (relative to habitat maturity) giant garter snake occupy restored habitat or to identify reasons they are not using restored and apparently suitable habitat.

RATIONALE: *The giant garter snake is listed by both state and federal governments as a threatened species. Most of the original giant garter snake habitat, freshwater marshes, has been lost to agriculture. This snake resides in marsh habitat where there are pools and sloughs that exist year round to provide the frogs and invertebrates on which they feed. This snake survives today because small numbers live in rice fields and along irrigation ditches. Survival of the species, however, is likely to depend upon increasing its natural habitat through marsh restoration combined with special protection measures on the agricultural land it currently inhabits.*

DELTA GREEN GROUND BEETLE

MSCS SPECIES GOAL PRESCRIPTION: Protect all known occupied habitat areas from potential adverse affects associated with current and potential future land uses and establish three additional populations of the delta green ground beetle within its current and/or historic range.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Coordinate protection, enhancement, and restoration of delta green ground beetle populations and its habitat with other federal and state programs (e.g., U.S. Fish and Wildlife Service species recovery plans and management of the Jepson Prairie Preserve) that could affect management of current and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Direct ERP actions towards protecting, enhancing, and restoring suitable vernal pool and associated grassland habitat within the species historic range, including expansion of Jepson Prairie Preserve westward to Travis Air Force Base.
- To the extent consistent with ERP objectives, direct ERP actions towards protection of the Davis Antenna Site population.

- Conduct surveys to identify suitable habitat areas, including enhanced and restored habitats, for establishment of additional populations in the Delta and Bay Regions and implement species introductions to establish three additional populations.
- To the extent consistent with CALFED objectives, manage lands purchased or acquired under conservation easements that are occupied by the species to maintain or increase current population levels and enhance occupied habitat areas.

RATIONALE: *The Delta green ground beetle is federally listed as a threatened species that is currently known only from Jepson Prairie Preserve (Solano County). Habitat requirements for this species are not clearly understood but the beetles seem to require open places near vernal pools. A better knowledge would help restoration efforts.*

SALTMARSH COMMON YELLOWTHROAT

MSCS SPECIES GOAL PRESCRIPTION: Maintain the current distribution and existing populations of the saltmarsh common yellowthroat and reestablish and maintain viable species' populations throughout its historic range in the portion of the Bay Region within the ERP focus area.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- The geographic priorities for implementing ERP actions to protect, enhance, and restore saline emergent wetlands and associated habitats for the saltmarsh common yellowthroat should be: 1) Gallinas/Ignacio marshes and Napa Marshes, 2) Sonoma Marshes, Petaluma Marshes, and Highway 37 marshes west of Sonoma Creek, 3) Point Pinole Marshes, 4) Highway 37 marshes east of Sonoma Creek, and 5) the Contra Costa County Shoreline.
- Coordinate protection, enhancement, and restoration of saltmarsh and associated habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, and USFWS species recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Restore wetland and perennial grassland habitats adjacent to occupied nesting habitats to create a buffer of natural habitat to protect nesting pairs from potential adverse affects that could be associated with future changes in land use on nearby lands and to provide suitable foraging habitat and nesting habitat area suitable for the natural expansion of populations.
- Initial species recovery efforts should be directed to locations where there are immediate opportunities for protection, enhancement, or restoration of suitable habitat.
- To the extent practicable, design dikes constructed in enhanced and restored saline emergent wetlands to provide optimal wetland to upland transitional habitat.
- To the extent practicable, direct ERP salt marsh enhancement efforts towards existing degraded marshes that are of sufficient size and configuration to develop fourth order tidal channels (marshes would likely need to be at least 1,000 acres in size).
- To the extent practicable, design salt marsh enhancements and restorations to provide low-angle upland slopes at the upper edge of marshes to provide for the establishment of suitable and sufficient wetland to upland transition habitat. Transition habitat zones should be at least 0.25 mile in width.
- Manage enhanced and restored habitat areas to avoid or minimize impacts on the saltmarsh common yellowthroat associated with recreational uses on lands acquired or managed under conservation easements.
- Direct some habitat enhancements and restorations towards increasing habitat connectivity among existing and restored tidal marshes.
- To the extent practicable, control non-native predator populations in occupied habitat areas

and salt marshes enhanced and restored under the ERP.

- Identify and implement feasible methods for controlling invasive non-native marsh plants.
- Monitor to determine use of restored salt marsh habitats by saltmarsh common yellowthroat and the rate at which restored habitats are colonized.

RATIONALE: *Saltmarsh common yellowthroat occupies habitat year round in the Suisun Marsh/North San Francisco Bay Ecological Management Zone. Contributions to the recovery of this species will include the consideration and integration of this species's needs into the design and implementation of habitat restoration projects in the region.*

BRISTLY SEDGE

MSCS SPECIES GOAL PRESCRIPTION: Research habitat requirements and use knowledge gained to develop and implement specific recovery measures.

MSCS CONSERVATION MEASURE: The following conservation measure is included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Identify and implement opportunities to restore suitable wetland habitat within ERP nontidal freshwater marsh restoration actions.

RATIONALE: *Bristly sedge is dependent on non-tidal perennial aquatic habitats such as lakes and ponds. This species will benefit from the restoration of habitats in the Suisun Marsh/North San Francisco Bay Ecological Management Zone.*

POINT REYES BIRD'S-BEAK

MSCS SPECIES GOAL PRESCRIPTION: Maintain, enhance and restore suitable high marsh and high marsh-upland transition habitat around San Pablo Bay.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Identify and implement restoration of suitable habitat in high marsh and marsh/upland transition areas. Incorporate high marsh and margin suitable habitat in ERP salt marsh restoration programs.
- Maintain and restore Point Reyes bird's-beak around San Pablo Bay in conjunction with restoration of saline emergent wetlands.
- Prepare and implement a management plan to control and reduce non-native weeds near existing and new populations.

RATIONALE: *Point Reyes bird's-beak occurs or has the potential to occur in the Suisun Marsh/North San Francisco Bay Ecological Management Zone. Program to restore saltmarshes in this Zone will contribute to the recovery of this species.*

CRAMPTON'S TUCTORIA

MSCS SPECIES GOAL PRESCRIPTION: Review and update recovery plan targets, protect all extant occurrences, and manage habitat to benefit Crampton's tuctoria (e.g., manage grazing).

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Establish three new self-sustaining populations in conjunction with establishment of Delta green ground beetle populations.
- Maintain existing populations.

RATIONALE: *Crampton's tuctoria occurs only in Solano and Yolo counties and is dependent on the clay bottoms of drying vernal pools and lakes. Actions to contribute to the recovery of this species will also benefit the Delta green ground beetle.*

DELTA MUDWORT AND DELTA TULE PEA

MSCS SPECIES GOAL PRESCRIPTION: Protect at least 90% of occupied habitat including 90% of high quality habitat throughout the range of the species to protect geographic diversity, and expand suitable and occupied habitat by 100 linear miles.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Maintain process that support the dynamic habitat of Delta mudwort and Delta tule pea throughout the species range and associated with existing source populations.
- To the extent consistent with CALFED objectives, create unvegetated, exposed substrate at tidal margins of restored and created tidal fresh emergent wetland and riparian habitat.
- To the extent consistent with CALFED objectives, incorporate suitable habitat for these species into levee designs.
- Incorporate sufficient edge habitat to support the species in levee setback and channel island habitat restoration.
- Maximize sinuosity of restored and created slough channels to increase water-land edge habitat.
- Maintain and restore habitat and populations throughout the species geographic ranges and expand the species ranges to the historical and ecological ranges based on hydrological, salinity, and other habitat attributes.
- Monitor existing populations and their habitat at five year intervals

RATIONALE: *These two species inhabit freshwater and brackish marshes. Actions to enhance existing marsh habitats and to restore tidal marsh areas will contribute to the recovery of delta tule pea and delta mudwort.*

DELTA COYOTE-THISTLE

MSCS SPECIES GOAL PRESCRIPTION: Survey all extant populations and suitable habitat and update status and ownership information. Bring at least 10 of the largest extant, naturally occurring populations found during surveys into permanent protected status and bring at least 50% of all extant populations and individuals under permanent protected status. Manage protected populations for long-term viability. Increase suitable habitat by 50% over existing extent. Increase population and individually by 25% over present existing conditions.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Survey all extant population and suitable habitat and update ecological, population, and ownership information.
- Bring at least 10 of the largest, extant, naturally occurring populations found during surveys into permanent protected status.
- Manage the protected populations for long-term viability. This measure includes research into appropriate management strategies.
- Establish and protect new populations in newly created floodplain habitat along the San Joaquin River and associated sloughs in Merced and Stanislaus Counties.
- Restore, enhance, and protect suitable habitat near existing populations and avoid impacts on existing populations to the greatest extent practicable during restoration activities.
- Monitor the status and distribution of all (natural and restored) populations at two-year intervals for the duration of CALFED and evaluate methods for active reintroduction into restored and enhanced habitat when natural colonization does not occur. Evaluate appropriate habitat management measures for maintaining suitable habitat.

RATIONALE: *Delta coyote-thistle occurs on clay soils on sparsely vegetated margins of seasonally flooded floodplains and swales, freshwater marshes and riparian areas. Actions to enhance and restore those habitat types will contribute to the recovery of Delta coyote-thistle.*

ALKALI MILK-VETCH

MSCS SPECIES GOAL PRESCRIPTION: Protect extant populations and reintroduce species near extirpated populations.

MSCS CONSERVATION MEASURES: The following conservation measures are included in the

Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Monitor status and distribution of populations and design and implement conservation measures if a decline in population size or vigor is observed.
- Protect extant populations and reintroduce species near extirpated populations.

RATIONALE: *Alkali milk-vetch is dependent on vernal pool habitat. Actions to protect, enhance, and restore vernal pools will contribute to the recovery of this species.*

Species with the designation "Maintain.

NOTE: The following species designated as "Maintain" all share the following common species goal prescription: **An increase in or no discernable adverse effect on the size or distribution of species populations.** Additionally, these species are covered by general conservation measures which broadly apply to each. A few species have specific conservation measures and they have been included.

GENERAL CONSERVATION MEASURES

- Conduct surveys in suitable habitat areas within portions of the species' range that could be affected by CALFED actions to determine the presence and distribution of the species before implementing actions that could result in take or loss or degradation of occupied habitat.
- Avoid or minimize (except as noted in specific species conservation measures) implementing CALFED actions that could result in or take of evaluated species or the loss or degradation of habitat occupied by evaluated species.
- Coordinate CALFED actions with U.S. Fish and Wildlife Service, National Marine Fisheries Service and/or California Department of Fish and Game to avoid potential conflicts with existing and potential future CALFED actions that may be implemented to recover evaluated species.
- Coordinate CALFED actions with other federal, state, and regional programs (e.g., the San Francisco Bay Wetlands Ecosystem Goals Project, the Anadromous Fish Restoration Program, the Senate Bill (SB) 1086 program, the Corps' Sacramento and San Joaquin River Basins Comprehensive Study, the Riparian Habitat Joint Venture, the Central Valley Habitat Joint Venture, and the Grassland Bird Conservation plan) that could affect management of evaluated species to avoid potential conflicts among management objectives.
- Avoid implementing CALFED actions that could result in the substantial loss or degradation of suitable habitat in areas that support core populations of evaluated species and that are essential to maintaining the viability and distribution of evaluated species.
- CALFED actions that potentially could mobilize large quantities of toxic materials from the soil should include an analysis to determine the amount of contaminants that could be mobilized and, if released and contaminant loadings could be harmful to evaluated species, modify actions to the extent practicable to reduce loadings of mobilized contaminants.
- To the extent consistent with CALFED objectives, manage lands purchased or acquired under conservation easements to maintain or increase current population levels of resident evaluated species.

MAD-DOG SKULLCAP

MSCS CONSERVATION MEASURE: Conduct surveys in suitable habitat areas that could be affected by CALFED actions to determine whether species are present before implementing actions that could result in the loss or degradation of occupied habitat.

RATIONALE: *Mad-dog skullcap inhabits mesic meadows and marshes and is known only from two locations in San Joaquin County. Actions to protect, enhance, or restore wet meadows or marshes can provide a means to maintain this native species in the ERP ecological management zones.*

Rose-Mallow

MSCS Conservation Measures:

- Avoid or minimize adverse effect on the ecological processes that support the dynamic habitat of rose mallow throughout the species' range and associated with existing source populations.
- Conduct research to determine the extent and physical and biological qualities of existing habitat and populations before implementing actions to rehabilitate or restore levees.
- To the extent consistent with ERP objectives, create unvegetated, exposed substrate at tidal margins of restored and created tidal fresh emergent wetland and riparian habitats.
- To the extent consistent with CALFED objectives, incorporate suitable habitat for this species into levee improvement, levee setbacks, and channel island habitat restoration designs.
- To the extent consistent with ERP objectives, maximize sinuosity of restored and created slough channels to increase water-land edge habitat.

Rationale: *Rose-mallow is dependent on open, freshwater marsh habitats along the lower portions of the Sacramento and San Joaquin rivers. Action to improve and restore floodplain habitats and freshwater marshes will contribute to the recovery of this species.*

Eel-Grass Pondweed

MSCS Conservation Measure: Conduct surveys in suitable habitat areas that could be affected by CALFED actions to determine whether species are present before implementing actions that could result in the loss or degradation of occupied habitat.

Rationale: *Eel-grass pondweed is dependent on ditches, ponds, lakes, and slow-moving streams. Actions to protect, enhance and restore these aquatic habitats can assist in maintaining this native species.*

Colusa Grass

MSCS Conservation Measure: To the extent consistent with ERP objectives, enhance or restore suitable habitats to benefit Colusa grass in occupied habitat.

Rationale: *Colusa grass is dependent on large or deep vernal pools with substrates of adobe mud. Actions to protect, restore, and enhance vernal pools will help maintain this native species.*

Contra Costa Goldfields

MSCS Conservation Measure: Conduct surveys in suitable habitat areas that could be affected by CALFED actions to determine whether species are present before implementing actions that could result in the loss or degradation of occupied habitat.

Rationale: *Contra Costa goldfields is a vernal pool dependent species. Action to protect, enhance, and restore vernal pool will contribute to efforts to maintain self-sustaining populations of this native species.*

Boggs Lake Hedge-Hyssop and Green's Legenere

MSCS Conservation Measure: To the extent consistent with ERP objectives, enhance or restore suitable habitats to benefit these species in occupied habitat areas.

Rationale: *Actions to protect and restore vernal pool will help to maintain viable populations of these two vernal pool species*

Recurved Larkspur and Heartscale

MSCS Conservation Measures:

- Develop a seedbank from all populations affected by implementation of CALFED actions and use the collected seed for inoculating unoccupied suitable habitat.
- To the extent consistent with ERP objectives, enhance or restore suitable habitats to benefit these species in occupied habitat areas.

Rationale: *These two species will be maintain through action of protect and restore perennial grasslands.*

California Freshwater Shrimp

MSCS Conservation Measure: To the extent consistent with ERP objectives, enhance or restore suitable habitats near occupied habitat areas.

Rationale: *The recovery objectives for California freshwater shrimp are: (1) to recover and delist the shrimp when viable, self-sustaining populations and their habitat are secured an managed within all watershed harboring shrimp, and (2) to enhance habitat conditions for aquatic organisms that currently coexist or have occurred historically with the California freshwater shrimp.*

Downlisting from endangered to threatened will be considered when: (1) a watershed plan has been implemented for each of four drainage units, (2) long-term protection is assured for at least one shrimp stream in each of the four drainage units, and (3) the abundance of California freshwater shrimp increases to over 2,000 individuals per stream in each of 16 streams harboring shrimp.

Delisting of California freshwater shrimp will be considered when: (1) a watershed plan has been implemented for each of four drainage units, (2) long-term protection is assured for at least eight shrimp stream with at least one in each of the four drainage units, (3) populations of California freshwater shrimp maintain stable or increasing populations of at least 2,000 individuals for at least 10 years in each of 16 streams harboring shrimp, and (4) at least 50 percent of shrimp-bearing streams have shrimp distributed over 8 kilometers (5 miles) or more (U.S. Fish and Wildlife Service 1997b).

Hardhead

MSCS Conservation Measure: No additional conservation measures are required to maintain this species.

Rationale: *Actions to protect, enhance, and restore aquatic habitats throughout the ERP ecological management zones will improve conditions for the native hardhead and contribute to maintaining existing populations.*

Western Least Bittern

MSCS Conservation Measures:

- To the extent consistent with ERP objectives, design and manage wetland habitat restorations and enhancements to provide suitable nesting and foraging habitat conditions.
- To the extent consistent with ERP objectives, restore wetland habitats adjacent to occupied nesting habitats to create a buffer zone of natural habitat to protect nesting pairs from potential adverse effects that could be associated with future changes in land use on nearby lands and to provide foraging and nesting habitat areas suitable for the natural expansion of populations.
- Avoid or minimize disturbances that could be associated with implementing CALFED actions near active nest sites during the nesting period (April-August).

Rationale: *The western least bittern, a California Department of Fish and Game Species of Special Concern nests in emergent wetlands of cattails and tules in the upper and lower reaches of the Central Valley and winters in marshlands along the main rivers and in the Delta. Least bitterns were apparently once a common wintering bird in the Central Valley but are now scarce. The loss of wintering habitat as a result of channelization and reclamation of marsh lands along the major rivers and Delta has been a major factor in their decline.*

California Red-legged Frog

MSCS Conservation Measures:

- To the extent consistent with ERP objectives, enhance or restore suitable habitats near occupied habitat areas.
- Avoid or minimize CALFED actions that could increase or attract non-native predator populations to occupied habitat.

Rationale: *Red-legged frogs are virtually extinct in the region, with just a handful of tenuous populations remaining in the Central Valley and bay region (none near the estuary). Their inability to recover from a presumed major population crash in the 19th century (due to overexploitation) has been the result of a combination of factors (in approximate order of importance): (1) predation and competition from introduced bullfrogs and fishes; (2) habitat loss, (3) pesticides and other toxins, (4) disease, and (5) other factors. Because of the poor condition of the few remaining frog populations and the continued existence of major causes of their decline, this* *objective may not be achievable in either the short or long term.*

CALIFORNIA TIGER SALAMANDER

MSCS CONSERVATION MEASURES:

- To the extent consistent with ERP objectives, enhance or restore suitable habitats near occupied habitat areas.
- Avoid or minimize CALFED actions that could increase or attract non-native predator populations to occupied habitat.

RATIONALE: *California tiger salamander populations are disappearing rapidly in the Bay-Delta watershed because of habitat alteration, especially urban development, and introductions of non-native fishes into their breeding ponds. They require fish-free breeding ponds next to upland habitat containing rodent burrows in which they can over-summer. Patches of suitable habitats are naturally somewhat isolated from one another, promoting genetic diversity within the species which presumably reflects adaptations to local conditions. Long-term survival of these diverse populations depends on numerous protected areas containing both breeding ponds and upland habitats.*

WESTERN POND TURTLE

MSCS CONSERVATION MEASURE: To the extent practicable, capture individuals from habitat areas that would be affected by CALFED actions and relocate them to nearby suitable existing, restored, or enhanced habitat areas.

***RATIONALE**: The western pond turtle is the only turtle native to the Central Valley region and to much of the western United States. Although considered to be just one widely distributed species, it is likely that the pond turtle is a complex of closely related species, each adapted for a different region. The Pacific pond turtle is still common enough in the Bay-Delta watershed so that it is not difficult to find them in habitats ranging from sloughs of the Delta and Suisun Marsh to pools in small streams. The problem is that most individuals seen are large, old individuals; hatchlings and small turtles are increasingly rare. The causes of the poor reproductive success are not well understood but factors that need to be considered include elimination of suitable breeding sites, predation on hatchlings by non-native predators (e.g., largemouth bass, bullfrogs), predation on eggs by non-native wild pigs, diseases introduced by non-native turtles, and shortage of safe upland over-wintering refuges. If present trends continue, the western pond turtle will deserve listing as a threatened species (it may already).*

WESTERN SPADEFOOT

MSCS CONSERVATION MEASURES:

- To the extent consistent with ERP objectives, enhance or restore suitable habitats near occupied habitat areas.
- Avoid or minimize CALFED actions that could increase or attract non-native predator populations to occupied habitat.

***RATIONALE**: Spadefoot toad populations are disappearing rapidly in the Bay-Delta watershed because of habitat alteration, especially urban development, and introductions of non-native fishes into their breeding ponds. They require fish-free breeding ponds next to upland habitat in which they can burrow for over summering. These habitats are naturally somewhat isolated from one another, promoting genetic diversity within the species which presumably reflects adaptations to local habitat conditions. Long-term survival of spadefoot toad populations depends on protected areas containing both breeding ponds and upland habitats.*

Species with the designation "Enhance and/or Conserve Biotic Communities."

NOTE: The following species are designated in the ERP as "Enhance and/or Conserve." These species are not covered by the MSCS and thus do not have MSCS species goal prescription or MSCS conservation measures.

LAMPREY FAMILY

POPULATION TARGET: Evaluate the status and life history requirements of Pacific lamprey and river lamprey in the Central Valley and determine their use of the Delta and Suisun Bay for migration, breeding, and rearing.

RATIONALE: *Lampreys are anadromous species that clearly have declined in the Central Valley although the extent of the decline has not been documented. Pacific lamprey probably exist in much of the accessible habitat available today but this is not known. The decline of lampreys is presumably due to deterioration of their spawning and rearing habitat, to entrainment in diversions, and to other factors affecting fish health in the system.*

NATIVE RESIDENT FISHES

POPULATION TARGET: Maintain self-sustaining populations of all native resident fishes throughout their native ranges in the ERP Ecological Management Zones.

RATIONALE: *The Central Valley has a native resident fish fauna that is largely endemic to the region. Some species are extinct (thicktail chub) or nearly extinct (Sacramento perch) in the wild. While some native species (e.g., Sacramento pikeminnow [squawfish], Sacramento sucker) are clearly thriving under altered conditions, others are not (e.g., hitch, Sacramento blackfish, hardhead). There is a need to determine if some have unique problems or requirements that will prevent them from responding to general habitat improvements.*

NATIVE ANURAN AMPHIBIANS

POPULATION TARGET: Maintain self-sustaining populations of all native anuran amphibians throughout their native ranges in the ERP Ecological Management Zones.

RATIONALE: *The native frogs and toads in the ERP focus area are in a general state of decline. Actions to reduce pesticide use and control or eliminate introduced frogs such as the bullfrog, will help maintain the diversity of these species in the ERP Ecological Management Zones.*

WATERFOWL

POPULATION TARGET: Improve populations and distribution of waterfowl.

RATIONALE: *Waterfowl resources will be enhanced by protecting existing and restoring additional seasonal, permanent, and tidal wetlands. Improved management of agricultural lands using wildlife friendly methods will contribute to sustaining waterfowl resources in the Bay-Delta. The focus for seasonal wetlands should be in areas that may be too deep for tidal marsh restoration over the next 20 years. In concert with efforts to reduce or reverse subsidence, selected areas or islands would be managed as waterfowl habitat. Besides increasing waterfowl resources, efforts to sustain waterfowl and their habitat will help offset some of the effects of converting agricultural or seasonal wetlands to tidal action when such actions may reduce the value of an area to waterfowl such as white-fronted geese or mallard. Efforts should also be focused on improving waterfowl nesting success by improving nesting and brood habitat. Improving waterfowl populations will be done in a manner that reduces conflict with broader ecosystem restoration goals or with goals to recover endangered species. For example: Flooding of rice fields for waterfowl in late winter may require water needed by migratory salmon. Careful management of the amount and timing of those diversions and the manner in which the diversions occur (e.g. through screened diversions) can help reduce conflicts. Management of waterfowl areas will occur using management strategies developed for existing and new waterfowl areas that provide benefits to at-risk species.*

SHOREBIRD GUILD

POPULATION TARGET: Improve populations and distribution of shorebirds birds.

RATIONALE: *Loss and degradation of wetland and aquatic habitats used by wintering and migrant shorebirds in the Central Valley is a factor limiting populations of these species. Large-scale restorations of these habitats will increase the available foraging habitat area to better accommodate existing populations and potential future expansions of shorebird populations.*

WADING BIRD GUILD

POPULATION TARGET: Improve populations and distribution of wading birds.

RATIONALE: *Substantial loss and degradation of aquatic, wetland and riparian habitats used by wintering and resident wading birds in the Central Valley is a factor limiting populations of these species. Large-scale restorations of these habitats will increase the available foraging, roosting, and nesting habitat area to better accommodate existing* *populations and future potential expansions of wading bird populations.*

Neotropical Migratory Birds

Population Target: Increase the abundance and distribution of neotropical migratory birds in the Central Valley.

Rationale: *Neotropical migratory birds constitute a diverse group of largely passerine songbirds that overwinter in the tropics but breed in or migrate through the Central Valley and Bay-Delta region. As a group, they are in decline because of loss of habitat on their breeding grounds, in their migratory corridors, and in their wintering grounds. The species within this group are good indicators of habitat quality and diversity and their popularity with birders means that populations are tracked and have high public interest. They can also be good indicators of contaminant levels, by monitoring reproductive success and survival in areas near sources of contamination. Riparian forests are particularly important to this group because they are major migration corridors and breeding habitat for many species. By providing improved nesting and migratory habitat, it may be possible to partially compensate for increased mortality rates in the wintering grounds.*

Bay-Delta Foodweb Organisms

Population Target: Increase populations and distribution of important foodweb organisms in Delta channels and reduce competition with invasive non-native species.

Rationale: *The population target is quite likely impossible to achieve because recent invading species, from the Asiatic clam to various crustacean zooplankters, will continue to play major ecological roles in the system, to the detriment of native organisms. However, at the very least it is possible to stop further introductions of non-native species which have the potential to further change the system unpredictably. This target is also a call to develop a thorough understanding of the planktonic portion of the Bay-Delta system to predict and understand the impacts of large-scale ecosystem alteration projects on the plankton.*

Plant Communities

Population Target: For all plant communities, maintain the present distribution and abundance and ensure self-sustaining communities in the long-term.

Rationale: *Native plant communities are composed of a diversity of groups including aquatic habitat, tidal brackish and freshwater habitat, seasonal wetland habitat, inland dune habitat, and tidal riparian habitat plant communities. Overall, actions in the ERP Ecological Management Zones to improve ecological process and protect, enhance or restore habitats will contribute to maintaining the diversity and abundance of plant community groups.*

Species with the designation "Maintain and/or Enhance Harvested Species."

NOTE: The following species are designated and "maintain and/or enhance harvested species" in the ERP. These species are not covered in the MSCS and thus do not have MSCS species goal prescriptions or MSCS conservation measures.

White Sturgeon

Population Target: Meet Native Fish Recovery Plan goals (U.S. Fish and Wildlife Service 1996), which include 100,000 white sturgeon and 2,000 green sturgeon greater than 100 centimeters long as measured in the DFG mark-recapture program.

Rationale: *White sturgeon represent an unusual situation: a success story in the management of the fishery for a native species. Numbers of sturgeon today are probably nearly as high as they were in the nineteenth century before they were devastated by commercial fisheries. The longevity and high fecundity of the sturgeon, combined with good management practices of the California Department of Fish and Game, have allowed it to sustain a substantial fishery since the 1950s, without a major decline in numbers. Numbers of white sturgeon could presumably be increased if the San Joaquin River once again contained suitable habitat for spawning and rearing.*

STRIPED BASS

POPULATION TARGET: Restore the adult population (greater than 18 inches total length) to 1.1 million fish within the next 10 years. In addition, all measures will be taken to assure that striped bass restoration efforts do not interfere with the recovery of threatened and endangered species and other species of special concern covered under public trust responsibilities.

RATIONALE: *The striped bass is a non-native species that is a favorite sport fish in the estuary. It is also the most abundant and voracious piscivorus fish in the system and it has the potential to limit the recovery of native species, such as chinook salmon and steelhead. Therefore, the management for striped bass must juggle the objectives of providing opportunities for harvest while not jeopardizing recovery of native species. An appropriate policy may be to allow striped bass to increase in numbers as estuarine conditions permit but not to take any extraordinary measures to enhance its populations, especially artificial propagation. Artificially reared bass have the potential to depress not only native fish populations but also populations of wild striped bass, because larger juveniles (of hatchery origin) may prey on smaller juveniles (of wild origin). If increases in bass numbers appear to adversely affect recovery of native species, additional management measures may be required to keep bass numbers below the level that pose a threat to native species.*

AMERICAN SHAD

POPULATION TARGET: The target for American shad is to maintain production of young as measured in the fall midwater trawl survey and targets of the Anadromous Fish Restoration Program (US Fish and Wildlife Service 1997, in preparation). Specifically, the index of young American shad production should increase, especially in dry water years.

RATIONALE: *The American shad is a non-native species that is an important sport fish in the estuary and its spawning streams, although less seems to be known about its life history in the estuary than any other major game fish. It is a common planktivore and occasional piscivore in the system and it may have the potential to limit the recovery of native species, such as chinook salmon. Therefore, the management for American shad must juggle the objectives of providing opportunities for harvest without jeopardizing recovery of native species. An appropriate policy may be to allow American shad to increase in numbers as estuarine conditions permit but not to take any extraordinary measures to enhance its populations, especially flow releases specifically to favor shad reproduction. If increases in shad numbers appear to adversely affect recovery of native species, additional management measures may be required to keep shad numbers below the level that pose a threat to native species.*

NON-NATIVE WARMWATER GAMEFISH

POPULATION TARGET: Increase our knowledge about warmwater sport fishes in the Delta, Suisun Marsh, riverine backwaters, and elsewhere to find out their interactions with native fishes, limiting factors, and their contaminant loads (for both fish and human health).

RATIONALE: *White catfish, channel catfish, brown and black bullhead, largemouth bass, and various sunfishes are among the most common fishes caught in the sport fishery in the Delta, Suisun Marsh, riverine backwaters, reservoirs, and other lowland waters. Although this fishery is poorly documented, it is probably the largest sport fishery in central California in terms of people engaged in it and in terms of numbers of fish caught. There is no sign of overexploitation of the fishes, although some (e.g., white catfish) have remarkably slow growth rates, indicating vulnerability to overexploitation. The fishes and the fishers are always going to be part of the lowland environment and deserve support of the management agencies. However, habitat improvements that favor native fishes, especially improvements that increase flows or decrease summer temperatures, may not favor these game fishes. The effects of the various CALFED actions on these fish and fisheries need to be understood, as do the interactions among the non-native fishes and the native fish CALFED is trying to protect.*

PACIFIC HERRING

POPULATION TARGET: Increase abundance of marine/estuarine fish and large invertebrates, particularly in dry years.

RATIONALE: *Pacific herring support the most valuable commercial fishery in San Francisco Bay. This seasonal, limited-entry fishery focuses on spawning fish, for the fish themselves, their roe, and* kazunoko kombu (herring eggs on eel grass). It seems to be an example of successful fishery management because it has been able to sustain itself through a series of years with highly variable ocean and bay conditions. An important connection to the ERP is that highest survival of herring embryos (which are attached to eel grass and other substrates) occurs during years of high outflow during the spawning period; the developing fish seem to require a relatively low-salinity environment. There is also some indication that populations have been lower since the invasion of the Asiatic clam into the estuary, with the subsequent reduction in planktonic food organisms. Given the frequent collapse of commercial fisheries (including those for herring) in the modern world, it is best to manage this fishery very cautiously to make sure it can continue indefinitely.*

GRASS SHRIMP

POPULATION TARGET: Maintain grass shrimp populations at present levels as a minimum to support the existing commercial fisheries. Determine factors regulating their populations in order to discover if the fisheries conflict with other ecosystem restoration objectives.

RATIONALE: *Grass shrimp are a mixture of native and introduced species that support a small commercial fishery in San Francisco Bay, largely for bait. The relative abundance of the various species as well as their total abundance appears to be tied in part to outflow patterns. It is likely that these abundant shrimp are important in Bay-Delta food webs leading to many other species of interest. The role of these shrimp in the Bay-Delta system and the effects of the fishery on that role need to be investigated.*

SIGNAL CRAYFISH

POPULATION TARGET: Maintain signal crayfish populations at present levels, in order to support the existing fisheries.

RATIONALE: *The signal crayfish is an introduced species that supports a small commercial fishery, as well as a recreational fishery, in the Delta. It has been established in the Delta for nearly a century and appears to be integrated into the Bay-Delta system, appearing as a major food item for otters and some fish. The signal crayfish has fairly high water quality requirements so its populations will presumably increase as water quality in the freshwater portions of the Delta improves. Its role in the ecosystem and the effects of the fishery on that role need to be investigated.*

UPLAND GAME

POPULATION TARGET: Increase the populations and distribution of upland game.

RATIONALE: *Upland game are supported by diverse agricultural and upland habitats. The key to maintaining these species is by maintaining the habitats upon which they depend.*

Table 4. Ecological Management Zones in which programmatic actions are proposed that will assist in the recovery of species and species groups.

Species and Species Group Visions	Ecological Management Zone[1]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Species with the Designation "Recover"														
Delta Smelt	●	●												
Longfin Smelt	●	●										●		
Green Sturgeon	●	●	●					●						
Sacramento Splittail	●	●	●					●	●		●	●		
Winter-run Chinook Salmon	●	●	●	●	●		●	●	●	●	●	●	●	
Spring-run Chinook Salmon	●	●	●								●	●	●	
Fall-run Chinook Salmon (including late-fall-run)	●	●	●	●	●		●	●	●	●	●	●	●	
Steelhead Trout	●	●	●	●	●		●	●	●	●	●	●	●	
Mason's Lilaeopsis	●	●							●	●				●
Suisun Marsh Aster	●	●												
Suisun Thistle		●												
Soft Bird's-Beak		●												
Antioch Dunes Evening-Primrose and Contra Costa Wallflower		●												
Lange's Metalmark butterfly	●	●												
Valley Elderberry Longhorn Beetle	●	●	●	●	●									
Suisun Ornate Shrew		●												

Table 4. Ecological Management Zones in which programmatic actions are proposed that will assist in the recovery of species and species groups (continued).

Species and Species Group Visions	Ecological Management Zone[1]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Suisun Song Sparrow		●												
San Pablo Song Sparrow		●												
Species with the Designation "Contribute to Recovery"														
California Clapper Rail		●		—										
California Black Rail	●	●												
Swainson's Hawk	●	●							●	●	●	●	●	
Salt Marsh Harvest Mouse		●												
San Pablo California Vole		●												
Sacramento Perch	●	●	●	●							●	●	●	●
Riparian Brush Rabbit	●												●	
San Joaquin Valley Woodrat	●												●	
Greater Sandhill Crane	●													
California Yellow Warbler	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Least Bell's Vireo	●	●	●	●								●		
Western Yellow-Billed Cuckoo	●		●									●	●	
Bank Swallow			●	●										
Little Willow Flycatcher				●					●		●	●	●	

Table 4. Ecological Management Zones in which programmatic actions are proposed that will assist in the recovery of species and species groups (continued).

Species and Species Group Visions	Ecological Management Zone[1]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Giant Garter Snake	●	●				●	●		●		●	●	●	
Delta Green Ground Beetle	●	●												
Saltmarsh Common Yellowthroat		●												
Bristly Sedge		●												
Point Reyes Bird's-Beak		●												
Crampton's Tuctoria	●									●				
Delta Mudwort and Delta Tule Pea	●	●												
Alkali Milk-Vetch		●	●			●				●	●	●	●	●
Delta Coyote-Thistle	●		●									●		
Species with the Designation "Maintain"														
Mad-dog Skullcap											●			
Rose-Mallow		●	●									●		
Eel-grass Pondweed	●					●	●	●	●	●	●		●	
Colusa Grass		●	●			●				●	●	●	●	●
Boggs Lake Hedge Hyssop and Green's Legenere		●	●	●	●	●	●	●	●	●	●			
Contra Costa Goldfields		●								●				●

Table 4. Ecological Management Zones in which programmatic actions are proposed that will assist in the recovery of species and species groups (continued).

Species and Species Group Visions	Ecological Management Zone[1]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Recurved Larkspur and Heartscale	●	●				●	●	●		●		●	●	●
California Freshwater Shrimp		●												
Hardhead	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Western Least Bittern	●	●	●	●								●		
California Red-Legged Frog	●	●				●	●		●		●	●	●	●
Western Pond Turtle	●	●				●	●		●		●	●	●	
California Tiger Salamander	●													
Western Spadefoot	●													
Species with the Designation "Enhance and/or Conserve Biotic Communities"														
Lamprey	●	●	●	●	●		●	●	●	●	●	●	●	
Native Resident Fish Species	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Native Anuran Amphibians	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Waterfowl	●	●	●	●	●	●	●	●	●		●	●	●	●
Shorebird and Wading Bird Guild	●	●											●	
Neotropical Migratory Bird Guild	●	●	●	●						●	●	●	●	●

Table 4. Ecological Management Zones in which programmatic actions are proposed that will assist in the recovery of species and species groups (continued).

Species and Species Group Visions	Ecological Management Zone[1]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Bay-Delta Foodweb Organisms	●	●												
Plant Communities	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Species with the Designation "Maintain and/or Enhance Harvested Species"														
White Sturgeon	●	●	●					●				●		
Striped Bass	●	●	●					●	●			●		
American Shad	●	●	●					●	●			●		
Non-native Warmwater Gamefish	●	●	●							●	●	●	●	●
Pacific Herring		●												
Grass Shrimp		●												
Signal Crayfish	●		●											
Upland Game	●		●	●						●	●	●	●	●

[1] 1 = Sacramento-San Joaquin Delta
2 = Suisun Marsh/North San Francisco Bay
3 = Sacramento River
4 = North Sacramento Valley
5 = Cottonwood Creek
6 = Colusa Basin
7 = Butte Basin
8 = Feather River/Sutter Basin
9 = American River Basin
10 = Yolo Basin
11 = Eastside Delta Tributaries
12 = San Joaquin River
13 = East San Joaquin Basin
14 = West San Joaquin Basin

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◆ Ecological Management Zones

Introduction

The following section provides the ecological management zone visions for the 14 areas that compose the ERPP study area. These include the following ecological management zones:

- Sacramento-San Joaquin Delta
- Suisun Marsh/North San Francisco Bay
- Sacramento River
- North Sacramento Valley
- Cottonwood Creek
- Colusa Basin
- Butte Basin
- Feather River/Sutter Basin
- American River Basin
- Yolo Basin
- Eastside Delta Tributaries
- San Joaquin River
- East San Joaquin
- West San Joaquin.

Distinguishing Characteristics

Understanding the structure, function and organization of ecosystems is necessary for planning and implementing environmental restoration, rehabilitation and protection projects. Such understanding enables managers to assess, during planning phases of a program, the degree to which prospective restoration sites diverge from a "healthy" or "natural" condition, as well as to evaluate, after actions have been undertaken, project progress and effectiveness. In a management context, perhaps the most practical means of summarizing the most relevant existing information on ecosystems is to develop, over an appropriate hierarchy of spatial and ecological scales, a list of key system attributes - those fundamental natural ecological characteristics that together define and distinguish these systems, their status, and/or their interrelationships. Such lists of attributes may serve as a convenient and necessary "check list" of environmental factors that might be addressed in an ecological restoration/rehabilitation context. At sites for which comprehensive restoration is the goal, a full suite of applicable attributes would presumably be addressed. More commonly, at sites where partial restoration (rehabilitation) is the goal, actions and efforts would be focused upon an appropriate subset of attributes.

Some individual system attributes - such as water temperature - may be evaluated directly. Others, such as "habitat continuity," are more nebulous, and must be evaluated by developing appropriate "indicators" - measurable parameters that provide a means to objectively (preferably quantitatively) evaluate individual attributes that in themselves are not readily measured. The term indicators is also used in a broader context to refer to a *subset* of system attributes (or their measurable parameters) that are derived and used *as a group* to provide a convenient way to evaluate *overall* system status. Thus, the term "indicator" is commonly used in two somewhat different ecosystem management/restoration contexts, representing two differing scales of resolution: that of *individual* attributes, or alternately, that of *groups* of attributes. In either case, "indicators" are simply a convenient way of measuring or evaluating that which is of primary concern - system attributes. An additional, and most useful tool in understanding and describing fundamental characteristics of complex systems is the use of conceptual models that integrate and diagrammatically represent the three basic *kinds* of system components: elements (attributes), their states, and the relationships that affect attribute states.

Ecosystem Typology

The ERPP study area is divided into four ecological zones, based on similarities and differences in their respective attributes. (Refer to the Key Ecological Attributes of the San Francisco Bay-Delta Watershed section of ERPP Volume I for additional details regarding the ecosystem typology.) The ecological zone designations follow:

- Upland River-Floodplain Ecological Zone
- Alluvial River-Floodplain Ecological Zone
- Delta Ecological Zone
- Greater San Francisco Bay Ecological Zone

Each of the 14 ecological management zone is contained within one or more ecological zones. The following tables display the distribution of ecological managements zones within each ecological zone.

Table 5. Distribution of Ecological Management Zones within the Ecological Zone Typology.

Ecological Management Zone	Ecological Zone			
	Upland River-Floodplain	Alluvial River-Floodplain	Delta	Greater San Francisco Bay
Sacramento San Joaquin Delta			●	
Suisun Marsh/North San Francisco Bay	○			●
Sacramento River		●		
North Sacramento Valley	●	○		
Cottonwood Creek	●			
Colusa Basin	●	●		
Butte Basin	●	○		
Feather River/Sutter Basin	○	●		
American River Basin	●	●		
Yolo Basin	●	●		
Eastside Delta Tributaries	○	●		
San Joaquin River		●		
East San Joaquin		●		
West San Joaquin	●			

● Denotes primary ecological zone, ○ Denotes secondary or less prevalent ecological zone.

◆ SACRAMENTO-SAN JOAQUIN DELTA ECOLOGICAL MANAGEMENT ZONE

INTRODUCTION

The Sacramento-San Joaquin River Delta (Delta) is the tidal confluence of the Sacramento and San Joaquin rivers. Between the upper extent of tidewater (i.e., near the city of Sacramento on the Sacramento River and Mossdale on the San Joaquin River) and the confluence of the two rivers near Collinsville is a maze of tidal channels and sloughs known as the Delta. Once a vast maze of interconnected wetlands, ponds, sloughs, channels, marshes, and extensive riparian strips it is now islands of reclaimed farmland protected from flooding by hundreds of miles of levees. Remnants of the tule marshes are found on small "channel" islands or shorelines of remaining sloughs and channels.

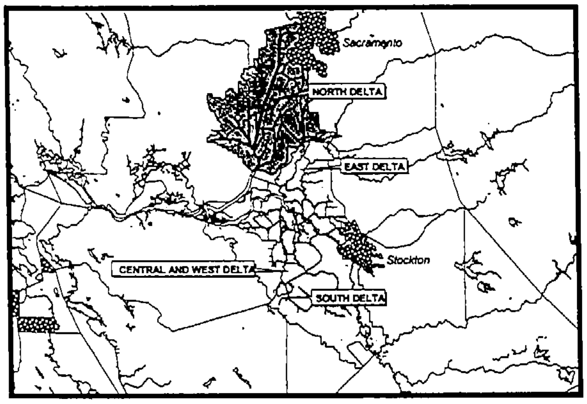
The Delta is home to many species of native and non-native fish, waterfowl, shorebirds, and wildlife. All anadromous fish of the Central Valley either migrate through the Delta or spawn in, rear in, or are dependent on the Delta for some critical part of their life cycle. Many of the Pacific Flyway's waterfowl and shorebirds pass through or winter in the Delta. Many migratory song birds and raptors migrate through the Delta or depend on it for nesting or wintering habitat. Despite many changes, the Delta remains a productive nursery grounds and migratory route for many species. Four runs of chinook salmon, steelhead, green sturgeon, white sturgeon, lamprey, striped bass, and American shad migrate through the Delta on their journey between the Pacific Ocean and Central Valley spawning rivers. Native resident fish including delta smelt and splittail spend most of their lives within the Delta. Considerable areas of waterfowl and wildlife habitat occur along the channels and sloughs and within the leveed agricultural lands.

The Delta also supports many plants with restricted distribution and some important plant communities. Special status plant species include Mason's lilaeopsis, rose-mallow (hibiscus), eel-grass pondweed, Delta tule pea, and Delta mudwort. Important plant groups or communities include pondweed with floating or submerged leaves, bulrush series, cattail series, common reed series, vernal pool communities, black willow series, narrowleaf willow series, white alder series, buttonbush series, Mexican elderberry series, and valley oak series.

Ecological factors having the greatest influence on Delta fish and wildlife include freshwater inflow from rivers, water quality, water temperature, channel configuration and hydraulics, wetlands, riparian vegetation, and diversity of aquatic habitat. Stressors include water diversions, channelization, levee maintenance, flood protection, placement of rock for shoreline protection, poor water quality, legal and illegal harvest, wave and wake erosion, agricultural practices, conversions of agricultural land to vineyards, urban development and habitat loss, pollution, and introductions of non-native plant and animal species.

DESCRIPTION OF THE MANAGEMENT ZONE

The Sacramento-San Joaquin Delta Ecological Management Zone is defined by the legal boundary of the Sacramento-San Joaquin River Delta. It is divided into four regional Ecological Management Units: North Delta, East Delta, South Delta, and Central and West Delta Ecological Management Units.



Location Map of the Sacramento-San Joaquin Delta Ecological Management Zone and Units.

The Delta is the easternmost portion of the estuary, and today is clearly delineated by a legal boundary that includes the areas that historically were intertidal, along with supratidal portions of the floodplains of the Sacramento and San Joaquin rivers. Today's legal Delta extends between the upper extent of the tidewater (near the city of Sacramento on the Sacramento River and Mossdale on the San Joaquin River) and Chipps Island to the west, and encompasses the lower portions of the Sacramento and San Joaquin river-floodplain systems as well as those of some lesser tributaries (e.g., Mokelumne River, Calaveras River).

The Sacramento-San Joaquin Delta Ecological Management Zone is characterized by a mosaic of habitats that support the system's fish, wildlife, and plant resources. Instream and surrounding topographic features influence ecological processes and functions and are major determinants of aquatic community potential. Both the quality and quantity of available habitat affect the structure and composition of the Delta's biological communities. Currently, much of the remaining natural habitats consists of small, scattered, and degraded parcels. Other, more common wildlife habitats on agricultural lands are at risk of loss because of levee failures. Important aquatic habitats are severely limited by levees and flood control systems.

Important aquatic habitats in the Delta include shaded riverine aquatic (SRA) habitat; vegetated and non-vegetated shallow shoal areas; open-ended sloughs, both large and small; and small dead-end sloughs. The large, open river channels of the Sacramento and San Joaquin rivers in the central and western Delta are more like the tidal embayments of Suisun Bay to the west of the Delta. Areas with SRA habitat are fragmented and subject to excessive erosion from wind- and boat-generated waves. Shallow shoal areas are small and fragmented and are subject to excessive water velocities and periodic dredging that degrade or scour them.

In many areas, agricultural lands have become surrogate habitat for wildlife, partially replacing native habitats. For example, natural wetlands have been replaced by rice fields as habitat for waterfowl and natural grasses have been replaced by agricultural grains, corn, and alfalfa which provide food for geese and cranes. Agricultural lands have important benefits for wildlife in the Delta, but are not a substitute for natural habitat.

Remaining channels and sloughs have been modified to become water conveyance "facilities" and flood control features. These modifications resulted in elevated water velocities and loss of structural diversity. The few remaining small dead-end sloughs have lost their SRA habitat, are choked with water hyacinth, and have poor water quality from agricultural and dairy runoff. Reclamation of Delta islands has cut off miles of dead-end sloughs that once drained extensive tidal wetlands and has significantly reduced the amount of land-water interface.

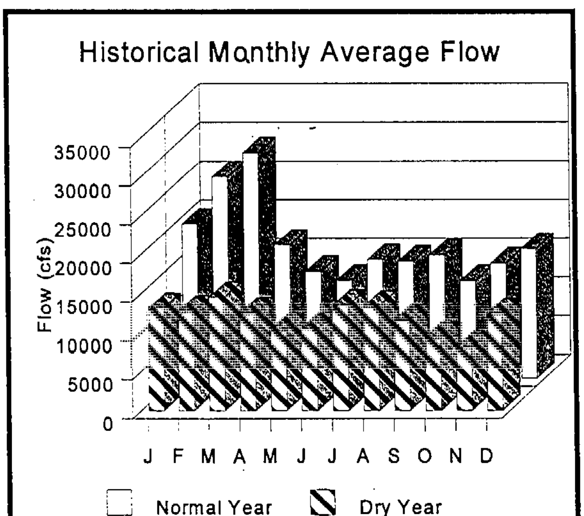
Geographic Information System (GIS) program analysis of 1906 U.S. Geological Survey maps by the California Department of Fish and Game (CDFG) provided estimates of the historical wetted perimeter in Delta sloughs and channels and tidal wetlands. *[Note: Wetted perimeter is the linear measurement of shoreline. Total wetted perimeter is compared to the total acreages of related dry land within a defined area to calculate a ratio of wetted perimeter to land acreage. Higher ratios of wetted perimeter indicate a more extensive mosaic of habitats (e.g., backwaters, sloughs, floodplains, marshes, and islands).]* The 1906 maps were the earliest available, and even then many Delta levees had already been constructed. These perimeter calculations were compared to similar data from GIS mapping by Pacific Meridian for CDFG using 1993 satellite imagery. That comparison indicated that there have been wetted perimeter reductions in three of the four Delta Ecological Management Units since 1906. Wetted perimeter reductions ranged from 25.2% to 44.7%.

Change in Ratio of Wetted Perimeter
1906 to 1993
(Ratio of water to land acreage)

Ecological Unit	1906	1993	Percentage of change
North Delta	3.4	4.5	+32.3%
East Delta	10.5	7.1	-32.4%
South Delta	11.9	8.9	-25.2%

Central Valley water supply and hydroelectric projects have had a large effect on the freshwater flow through the Delta. Spring flows that, before water projects, averaged 20,000 to 40,000 cubic feet per second (cfs) in dry years and 40,000 to 60,000 cfs in normal years have, in recent decades, averaged only 6,000 to 10,000 cfs in dry years and 15,000 to 30,000 cfs in normal years. In the driest years, spring flows were once 8,000 to 14,000 cfs, while under present conditions they average only 2,500 to 3,000 cfs.

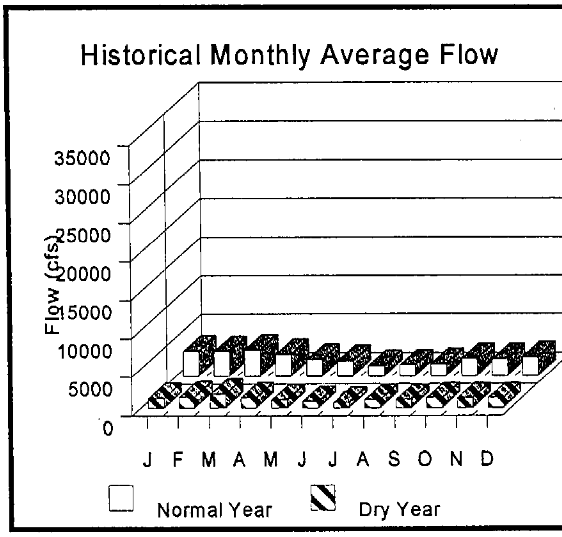
In dry and normal years, summer outflow from the Delta has remained in the 4,000 to 8,000 cfs range because water is released from reservoirs to keep saltwater from entering the Delta. Summer inflows that were only 4,000 to 8,000 cfs in dry and normal years now exceed 10,000 cfs as water is released from reservoirs to satisfy demands for water diversions.



Historical Delta Inflow from Sacramento River measured at Freeport, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Winter flows have fallen from the 15,000- to 60,000-cfs range to the 7,000- to 35,000-cfs range because much runoff from winter rains is now stored in foothill reservoirs. Flows in years with the highest rainfall are relatively unchanged, although short-term peaks are attenuated by flood control storage in the larger foothill reservoirs.

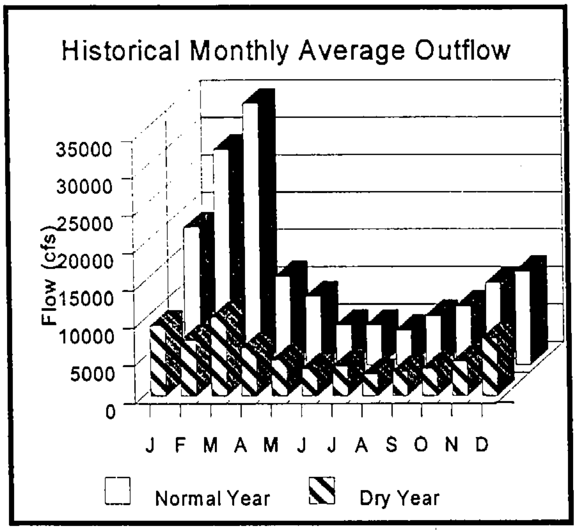
Much of the Delta outflow is made up of Sacramento River flow entering the Delta near Sacramento. Although inflows through the Sacramento River channel reach 60,000 to 80,000 cfs in winter and spring of wet years, inflows are generally less than 30,000 cfs. In the driest years, inflows range from 5,000 to 9,000 cfs through the entire year, while in dry years they range from 8,000 to 15,000 cfs. In wet years, floodflows that average up to 130,000 cfs per month enter the Delta from the Yolo Bypass through Cache Slough.



Historical Delta Inflow from San Joaquin River Flow measured at Vernalis, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

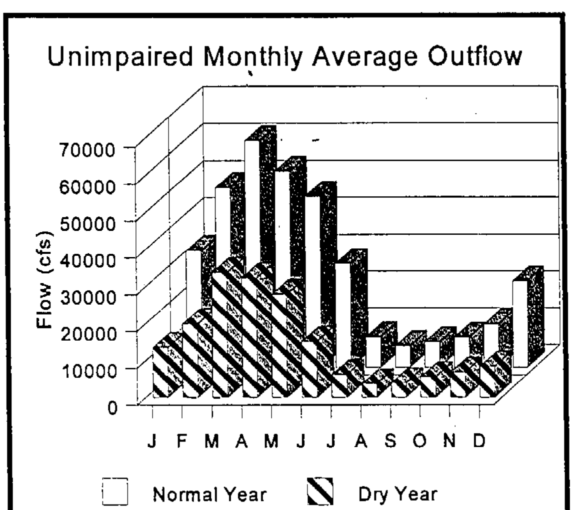
Most of the remaining inflow to the Delta comes from the Mokelumne River and the San Joaquin River. The Mokelumne River contributes only 100 to 300 cfs in dry and normal years. The San Joaquin River flows make up most of the remainder with average monthly flows of 500 to 1,500 cfs in dry years, 1,500 to 3,500 cfs in normal years, and up to 20,000 to 40,000 cfs in wet years.

Water diversions from the Delta may reduce outflows by as much as 14,000 cfs. Of that total, small Delta agriculture diversions combine to divert up to approximately 3,000 cfs during peak irrigation seasons. State Water Project (SWP) and Central Valley Project (CVP) pumping plants in the southern Delta can divert up to 11,000 cfs.



Historical Delta Outflow for 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Natural floodplains and flood processes are the periodic flooding of the floodplain during peak flow events that would typically occur in late winter and spring of all but the driest years. Land reclamation and levee construction have eliminated much of the natural Delta floodplain, forcing waters rapidly to exit the Delta through confined channels. Only the Yolo Bypass and adjoining leveed islands are periodically flooded to help carry large flows coming down the Sacramento River.



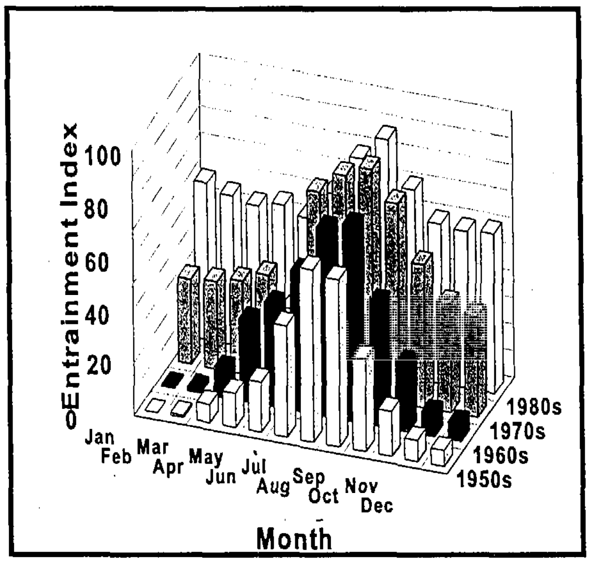
Unimpaired Delta Outflow Estimated for Period 1972-1992 (Dry year is the 20th percentile; normal year is the 50th percentile or median year.)

Reductions in spring freshwater flow into the Delta and the loss of riparian vegetative cover have led to slightly increased water temperatures in the Delta. Agricultural and other discharges into the Delta including power plant cooling water have also increased Delta water temperatures. Maintaining water temperatures in the Delta during the transitions in spring and fall is necessary to meet the needs of migrating salmon and steelhead passing through the Delta. Reduced March to May inflows and loss of riparian (waterside) and SRA habitats in the Delta have also contributed to higher water temperatures in the Delta.

Changes in Delta channel hydraulics (water flows) began in the mid-19th century with land reclamation that restricted flows to narrow channels of levees. Floodflows that once spilled into a vast floodplain are now confined to narrow channels. These same channels later became conduits for carrying water to water-export facilities in the central and south Delta. In 1951, the CVP began to transport water from the south Delta at Tracy to the Delta-Mendota Canal. That same year, operation of the Delta Cross Channel (DCC) began to allow Sacramento River water to flow through interior Delta channels to the south Delta export facilities at Tracy. South Delta export facilities were increased with the addition of the SWP pumping plant at Byron in the late 1960s. In 1968, the SWP began to transport Delta water through the California Aqueduct to southern California.

Existing hydraulic conditions inhibit the function of Delta channels as migration corridors and rearing habitat for salmon and other anadromous fish, including steelhead, striped bass, American shad, white sturgeon, and green sturgeon. Native resident fish such as delta smelt and splittail also depend on natural hydraulic processes, as hydraulic conditions determine physical habitat characteristics and foodweb (all of the food chains) production (i.e., by controlling the residence time of water in Delta channels). Natural hydraulic conditions benefit other resident freshwater and estuarine fish, including longfin smelt, tule perch, threadfin shad, white catfish, largemouth bass, and starry flounder. Low residence time in Delta channels and sloughs decreases biological productivity and habitat value.

Channel hydraulics once were relatively unaltered in the Delta. In November through March, an important period for aquatic species, hydraulic changes were insignificant in the 1950s and 1960s, as measured using an indicator of hydraulic conditions provided by output from a particle transport model (DeltaMOVE). However, by the 1980s, there had been a dramatic increase in unhealthy channel hydraulic conditions in locations such as the Central and West Delta. Aquatic foodweb productivity in the Delta has declined over the past several decades and is the subject of ongoing focused research activities. The decline was caused by changes in freshwater inflow, Delta channel hydraulics (i.e., water residence time), water diversions, water quality, and the species composition of aquatic organism communities. Foodweb productivity, beginning at the primary production (i.e., plant cell production) level, is essential to provide enough food to maintain populations of important fish. Primary productivity in the Delta depends on spring flow events in dry and normal years. Spring flows deliver essential nutrients, increase residence time in channels and sloughs, and increase shallow water and wetland habitat.



Historic Calculated Entrainment Indices of the Central and West Delta Ecological Management Unit.

The loss of tidal marshes (historic tule marshes) to agricultural conversion probably constituted one of the greatest causes of loss of productivity and a change in the nature of the aquatic foodweb (i.e., a change from a detritus-based food web characteristic of marshes to a more phytoplankton-based food web). Along with the loss of tidal marshes in the Delta to land reclamation came the loss of shallow-water aquatic habitats (e.g., small sloughs, ponds). Many native resident and anadromous fish and estuarine

Species-Habitat Associations

Species	*Habitats*
Swainson's hawk	*Riparian/Agricultural*
Clapper rail	*Tidal emergent wetland*
Black rail	*Tidal Emergent wetland*
Sandhill crane	*Seasonal aquatic and wetland, agricultural, and grassland*
Riparian brush rabbit	*Contiguous riparian woodland*
Shore and wading birds	*Aquatic and wetland, seasonal aquatic, and agricultural*
Upland game birds	*Agricultural, riparian, and upland*
Waterfowl	*Tidal perennial aquatic, seasonal aquatic, riparian, agricultural, and wetland*
Neotropical migratory birds	*Riparian, grassland, agricultural land*
Delta smelt	*Shallow water, sloughs, bays*
Splittail	*Marsh, floodplain, sloughs*
Striped bass	*Shallow water, sloughs*

invertebrates depend on these habitats. Shallow-water habitats around the Delta provide spawning and rearing habitats for many native resident Delta fishes. They also provide important rearing and migratory habitats for many Central Valley chinook salmon and steelhead. Tidal perennial aquatic habitat benefits native waterfowl, wading and shorebirds, and wildlife, as well as native plants that depend on such habitats.

Lakes and ponds support simple invertebrate communities, riparian habitat, and wintering waterfowl. Examples of nontidal perennial aquatic habitats include the Stone Lakes in the North Delta Ecological Management Unit near Sacramento and the "blow out ponds," or ponds remaining after levee breaks on islands such as Venice Island and Webb Tract. Most ponds also support introduced species such as the bullfrog and largemouth bass, which reduce the value of these ponds to special-status species such as the red-legged frog. Introduced species also reduce the habitat's value as brood water for nesting waterfowl. Such habitats within the Delta also benefit waterfowl, as well as many plant and wildlife species, including many rare or declining special status species.

After more than 100 years of land reclamation activities in the Delta, many linear miles of natural sloughs have been lost. Sloughs are important spawning and rearing areas for many native Delta fish species, as well as waterfowl and wildlife. Of those natural sloughs that remain, most have been severely degraded by dredging, levee confinement, loss of riparian vegetation, high water flow, infestation of water hyacinth, and poor water quality (i.e., many receive agricultural drain water).

Shoals are simple underwater islands or shallows in otherwise deeper channels of the Delta. Channel islands and shoals provide valuable fish and wildlife habitat within the confined reaches of Delta channels. Only "tule islands" or "berm islands" contain some original native Delta habitats. These islands are found in Delta channels where the distance between levees is wide enough that past dredging activities left a remnant strip where soils were deposited at an elevation high enough to support tules and cattails. Such islands generally have shallow water and SRA habitats, as well as tidal marsh and riparian habitats. The number and acreage of channel islands have declined over the past several decades from dredging, wave and wake erosion, and levee maintenance.

Tidal marshes, once the most widespread habitat in the Delta, are now restricted to remnant patches. A GIS analysis of 1906 U.S. Geological Survey maps determined the extent of change in tidal wetland since 1906. Extensive losses of tidal wetland habitats in three of the four Delta Ecological Management Units have exceeded 87,000 acres from 1906 to 1993. These losses represent only a portion of the change that have taken place since reclamation began in the mid-nineteenth century. It has been estimated that circa 1850, about 310,000 acres of the Delta consisted of tidal wetlands in a mosaic dominated by emergent vegetation, and included smaller tidal marsh drainage channels and open-water lakes and ponds (Atwater and Belknap 1980).

Nearly two-thirds of the reclamation of the Sacramento-San Joaquin Delta Ecological Management Zone for farmland occurred before 1906. Thirty percent of the lands reclaimed before 1900 were in the North Delta and East Delta Ecological Management Units, 38% in the South Delta Ecological Management Unit, and only 2% in the Central and West Delta Ecological Management Unit. Most of the remaining tidal wetlands lack adjacent upland transition habitat and other attributes of fully functioning tidal wetlands. This was caused by upstream water development, in-Delta export facilities, adjacent levee maintenance practices, agricultural practices, and urban and industrial development.

Tidal wetlands provide important habitats for many species of plants, waterfowl, and wildlife. In addition, wetlands provide an important contribution of plant (dead material) and nutrient recycling to the aquatic foodweb of the Bay-Delta estuary, as well as important habitat to some species of fish and aquatic invertebrates.

Seasonal wetlands include vernal pools, wet meadows or pastures, and other seasonally wetted habitats such as managed duck clubs in the Delta floodplain. Most of this habitat is located on leveed lands or in floodplain bypasses such as the Yolo Bypass. Such habitats were once very abundant during the winter rainy season or after seasonal flooding of the Delta. With reclamation, flooding occurs primarily from accumulation of rainwater behind levees, from directed overflow of flood waters to bypasses, or from flooding leveed lands (e.g., managed wetlands). Seasonal wetlands are important habitat to many species of fish, waterfowl, shorebirds, and wildlife.

Acres of Tidal Fresh Emergent Wetland (Marsh)

Ecological Managemen t Unit	1906	1993	Percentage of change
North Delta	53,660	4,640	-91.3
East Delta	7,600	1,270	-83.3
South Delta	470	650	+38.3
Central and West Delta	37,170	5,040	-86.4
Total	98,900	11,600	-88.6

Upland habitats are found mainly on the outer edges of the Delta and consist primarily of grasslands and remnant oak woodland and oak savanna. Of these, perennial grasslands are an important transition habitat for many Delta wildlife species. They are also buffers to protect wetland and riparian habitats. Much of the grassland habitat adjacent to the Delta has been lost to agriculture (e.g., grain, vineyards, and orchards) and development (e.g., home construction, golf courses). Grasslands provide habitats for many Delta plant and animal species.

Riparian habitat, both forest and shrub, is found on the water and land side of levees, berms, berm islands, and in the interior of some Delta islands. This habitat ranges in value from disturbed (i.e., sparse, low value) to relatively undisturbed (i.e., dense, diverse, high value). The highest value riparian habitat has a dense and diverse canopy structure with abundant leaf and invertebrate biomass. The canopy and large woody debris in adjacent aquatic habitats provide shaded riverine aquatic habitats on which many important fish and wildlife depend during some portion of the life cycles. The lower value riparian habitat is frequently mowed, disced, or sprayed with herbicides, resulting in a sparse, habitat structure with low diversity.

Riparian habitat is used by more terrestrial wildlife species than any other Delta habitat type. From about 1850 to the turn of the century most of the riparian forests in the Delta were decimated for fuelwood as a result of the gold rush, river navigation, and agricultural clearing. Remnant patches are found on levees, channel islands, and along the margins of the Delta. Riparian habitats and their adjacent shaded riverine aquatic habitat benefit many species of fish and wildlife.

Inland dune scrub habitat is found in the south and west portions of the Delta in areas where wind-blown sand is deposited along margins of the Delta. Inland dune habitat has unique native plant communities including two special-status species. Much of the dune habitat has been lost to industrial and urban development.

Agricultural habitats also support populations of small animals, such as rodents, reptiles, and amphibians, and provide opportunities for foraging raptors. Nonflooded fields and pastures are also habitats for pheasant, quail, and dove. The Delta supports a variety of wintering and breeding raptors. Preferred habitat consists of tall trees for nesting and perching near open agricultural fields that support small rodents and insects for prey. Both pasture land and alfalfa fields support abundant rodent populations.

The Swainson's hawk, a raptor species listed by the State as threatened, breeds and occasionally winters in the Delta. One of the highest breeding densities of Swainson's hawks in the Central Valley is found on the eastern edges of the Delta, primarily along the upland margins in areas adjacent with pastures, alfalfa croplands, and grasslands. The present-day Delta is mostly farmland, occupying over 86% of the dry-land area. The wildlife habitat value of these lands depends on crop types and agricultural practices employed, including flooding and tillage regimes. The farmed "wetlands" of the Delta are important for wintering water birds, including shorebirds, geese, swans, ducks, and sandhill cranes, supporting 10% of all waterfowl wintering in the State. The value of agricultural lands to other migratory birds is much greater. For example, the Delta is extremely important for tundra swans and greater sandhill cranes. In average years, 70% to 85% of the tundra swans in the Pacific Flyway winter in the Central Valley; 90% of this use occurs in just eight counties with the Delta being a major use area.

Water diversions in the Delta divert up to 14,000 cfs of the freshwater inflow to the Delta. Though diversions vary seasonally, relatively high rates can occur in any month. Water diverted from the Delta is used throughout much of the central and southern portion of the State.

With many diversions unscreened or poorly screened great numbers of fish and aquatic invertebrates are entrained with the water. Lack of adequate screening and location of water diversions in sensitive areas of the Delta contribute to the loss of important fish and aquatic foodweb organisms.

Levee construction and bank protection have led to the loss of riparian, wetland, and shallow-water habitat throughout the Delta. Habitat on levees and shorelines needs improvement to restore the variety of species and ecological functions needed for aquatic and wildlife resources of the Delta.

Dredging and disposal of dredge materials have contributed to the loss and degradation of important aquatic habitat and vegetated berm islands in the Delta.

Over the past several decades, the accidental introduction of many marine and estuarine organisms from the ballast waters of ships from the Far East has greatly changed the plankton and benthic (bottom and shore dwelling) invertebrates of the Delta with further effects up the foodweb. Further changes can be expected if restrictions are not made on ballast water releases into the San Francisco Bay and Delta. Other important routes for the introduction of invasive species include overland at border crossings, aquaculture operations, and commercial bait dealers.

The numbers of predatory fish have increased at certain locations in the Delta (e.g., Clifton Court Forebay, docks, piers, etc.) and losses of some resident and anadromous fish to predation may limit their recovery. Predators may reduce populations of important fish, including chinook salmon, steelhead, and delta smelt.

Large amounts of toxins continue to enter the Delta from municipal, industrial, and agricultural discharges. The toxins have demonstrated in bioassay potential adverse effect on the health, survival, and reproduction of many important Delta fish and their foodweb organisms. Toxins in the tissues of the fish are also a human health risk to people who eat Delta fish. Continued reductions of toxins from discharges and from releases of toxins from the sediment (e.g., those disturbed by natural forces and dredging) are essential to the restoration program.

The legal and illegal harvest of fish may limit recovery of some populations in the Delta and its watersheds. Harvest of chinook salmon, steelhead, and sturgeon in the Delta may affect recovery of these populations. Harvest enforcement and management help sustain important fish populations from overharvest.

Boat traffic in the Delta contributes to the erosion of remaining shallow water, riparian, and wetland habitat along Delta channels and degrades water quality from fuel and oil spills. High boat speeds and traffic endanger remnant habitat and limit the success of habitat restoration.

The delta smelt population of the Bay-Delta estuary is a federally listed threatened species. It depends on the Delta for spawning and rearing habitat. It lives in fresh and brackish bays and sloughs of the Delta. Delta smelt decline is related to poor habitat conditions during periods of drought, but are also adversely affected by water diversions throughout the Delta. Delta smelt benefit from high freshwater inflow, particularly during the late winter and spring of dry years. Their recovery depends on adequate slough and shallow water habitat, reduced effects of water diversions, and increased productivity of the aquatic foodweb.

The longfin smelt populations of the Bay-Delta live within the brackish water and saltwater of northern San Francisco Bay and migrate upstream into the Delta to spawn. The decline in the longfin smelt population has coincided with a number of changes in the estuary including: low flows in late winter and spring, reduced freshwater flows through the Delta and into Suisun Bay, water diversion (particularly in drier years), and contaminants.

Like delta smelt, splittail are a native resident species of the Delta and Bay that depend on the Delta for spawning, rearing, and feeding. The Delta splittail population declined during droughts but has rebounded in recent years. Splittail depend primarily on shallow water habitats for spawning including shorelines, sloughs, and aquatic habitats associated with wetlands and seasonal floodplains (e.g., the Yolo Bypass in the north Delta). The splittail population will benefit from improved wetland and slough habitat, a more productive aquatic foodweb, reduced loss to predation, improved estuarine hydraulics, and higher late-winter and spring freshwater flows during dry years.

White sturgeon and green sturgeon populations in the Central Valley use the Delta for migrating, feeding, and as a nursery area. Populations appear to be stable. Do to lack of specific data for green sturgeon, however, the implication that this species is stable may be inaccurate. Sturgeon benefit from high late-winter and spring freshwater inflow, a productive aquatic foodweb, and slough habitats in the Delta. Legal and illegal harvest and losses to water diversions may be limiting their abundance.

Four runs of chinook salmon use Central Valley waterways. All four runs depend on the Delta during at least a portion of their life cycle. The Delta provides migratory and rearing habitat for salmon in all but the warmest summer months. Tidal perennial marsh habitat and adjoining sloughs and aquatic habitats in the Delta are important fry rearing habitats.

Many populations of chinook salmon have declined in recent decades. The decline was caused by a combination of ocean, river, and Delta factors. Reductions in freshwater flow through the Delta and increases in water diversions have led to declines in salmon populations. Improving late-winter and spring freshwater flows through the Delta and reducing losses to diversions are essential to the recovery of salmon. Chinook salmon also benefit from lower water temperatures in spring and fall, adequate aquatic habitats, and high foodweb productivity. Many juvenile chinook salmon are lost to water diversions and predators.

Steelhead usage of the delta-estuary is not well known and has not been studied. At the very least, they utilize the delta waterways for migration to and from the spawning and rearing tributaries. Generally, estuaries provide important - and on some small coastal tributaries, essential - rearing habitat for steelhead, but usage of the Sacramento-San Joaquin delta-estuary by steelhead for this purpose is unknown. Occurrences of juvenile steelhead are not uncommon at the CVP and SWP fish salvage facilities, but they are not salvaged in as great a number as are chinook salmon. This could reflect a much lower abundance of steelhead in the Central Valley system or it could be the result of the larger size of steelhead smolts, compared to salmon smolts, when they are emigrating to the ocean (larger fish are better able to avoid entrainment).

The striped bass population of San Francisco Bay and the Sacramento and San Joaquin rivers depends on the Delta for much of its life cycle. The Delta provides important spawning and rearing habitat for striped bass. Reductions in freshwater flow and increases water diversions have resulted in striped bass population declines over the past several decades. Poor water quality in the Delta may also be limiting the survival of young and adults. Striped bass also benefit from high aquatic foodweb productivity. Loss of tidal perennial aquatic, wetland, and slough habitats may also limit production of striped bass. Many striped bass young are lost in water exported through water diversions. Artificially rearing young striped bass salvaged at the south Delta pumping plant fish facilities or supplementing production with hatchery-reared fish may be necessary to sustain the population under present limiting factors.

American shad is an anadromous fish that spawns in the Sacramento River and its major tributaries. They pass through the Delta on their upstream spawning migration in spring. In the fall, young migrate through the Delta on their way to the ocean. A portion of the population spawns and rears in the Delta. Low productivity in periods of drought is a concern. American shad production increases with higher late-winter and spring freshwater flow through the Delta in dry and normal rainfall years. Improved aquatic foodweb production and lower relative export rates at water diversions will benefit American Shad.

Many native and non-native fish species are residents of the Delta. Resident fish populations, like delta smelt and splittail, will benefit from improved aquatic habitats and foodweb production. Many native fish species have declined gradually over the past century from loss of habitats and introductions of non-native fishes. More recently, native resident species have further declined from changes in freshwater flow, water diversions, poor water quality, and further non-native species introductions and habitat degradation. For many of these species, improvements in their native habitats such as sloughs and tidal marshes, is essential to their restoration. Native residents will also benefit from more natural freshwater flow patterns, improved water quality, and reduced losses to water diversions.

Bay-Delta aquatic foodweb organisms include bacteria, algae, zooplankton (e.g., copepods and cladocerans), epibenthic invertebrates (e.g., crayfish, Neomysis and Crangon shrimp), and benthic invertebrates (e.g., clams). Foodweb organisms are essential for the survival and productivity of fish, shorebird and other higher order animal populations in the Bay-Delta estuary. Some organisms are non-native species (e.g., certain zooplankton and Asian clams) that may be detrimental to native species and the foodweb in general. Recent declines in aquatic foodweb organisms of the Bay-Delta, particularly in drier years, has caused a reduction in overall Bay-Delta productivity. Important aquatic foodweb organisms include algae, bacteria, rotifers, copepods, cladocera, and mysid shrimp.

The western spadefoot and California tiger salamander occur throughout much of the Central Valley, San Francisco Bay, and coast ranges and foothills below 3,000 feet, as well as along the coast in the southern portion of the State. Declining populations have warranted their designation as species of special concern and species of concern by the California Department of Fish and Game (DFG) and U.S. Fish and Wildlife Service, respectively. Major factors that limit these resources' contribution to the health of the Delta are related to adverse effects of conversion of seasonal wetlands and adjacent uplands to other land uses and excessive mortality resulting from introduction of non-native predators and some land use practices.

The California red-legged frog is California's largest native frog. Its habitat is characterized by dense, shrubby riparian vegetation associated with deep, still, or slow-moving water that supports emergent vegetation. The distribution and population of this species has declined substantially, primarily as a result of habitat loss or degradation and excessive predation. The loss of habitat and declining condition of the species' population have warranted its listing as threatened under the federal Endangered Species Act and a Species of Special Concern by DFG. Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of the loss or degradation of critical wetland and riparian habitats and the introduction of non-native predators.

Once possibly abundant in the Delta, the giant garter snake and western pond turtle are now rare there. Improvements in wetland, riparian, and grassland habitats around the margins of the Delta could greatly benefit these species.

Once abundant in the Delta, Swainson's hawk is now rare. Improvements in agricultural and riparian habitats will aid in the recovery of the Swainson's hawk.

A long-term decline in emergent wetlands has reduced the population of California black rail in the Delta. Restoring emergent wetlands in the Delta should aid in the recovery of the California black rail.

The population of greater sandhill crane in the Central Valley has declined over the past century with the loss of permanent and seasonally flooded wetlands. Improvements in seasonally flooded wetlands and agricultural habitats should help toward recovery of the greater sandhill crane population.

Herons, egrets, and other shorebirds and wading birds breed and winter throughout the Central Valley and the Delta. Their populations depend on aquatic and wetland habitats. Shorebirds and wading birds will benefit from restoration of wetland, riparian, aquatic, and agricultural habitats.

The riparian brush rabbit is associated with riparian habitats of the Central Valley floodplain. It has been eliminated from the Delta from loss of riparian habitat. Elsewhere, the population and distribution of this species have declined substantially, primarily as a result of the loss or degradation of its habitat. The loss of habitat and declining populations have warranted its listing as endangered under the California Endangered Species Act.

The major factor that limits this resource's contribution to the health of the Delta is related to adverse effects of the historical loss and degradation of the mature riparian forests, on which the riparian brush rabbit depends, in the Delta and San Joaquin River floodplain.

Many species of waterfowl overwinter in the Delta and depend on high-quality foraging habitats to replenish their energy reserves. They depend on wetland, riparian, aquatic, and agricultural habitats. Many species of resident and migratory waterfowl will benefit from improved aquatic, wetland, riparian, and agricultural habitats.

Upland game species are of high interest to recreational hunters in the Bay-Delta and contribute to California's economy through the sale of hunting-related equipment and hunting-related expenditures. Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of conversion of native upland habitats for agricultural, industrial, and urban uses, and land use practices that degrade habitats used by these species.

Neotropical bird species breed in North America and winter in Central and South America. Many species of neotropical migratory birds migrate through or breed in the Bay-Delta. These species are a significant component of the ecosystem. These species are of high interest to recreational bird watchers, and contribute to California's economy through sales of equipment and other bird-watching-related expenditures. There have been substantial losses of historic habitat used by these species and available information suggests that population levels for many of these species is declining.

Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of conversion of native habitats for agricultural, industrial, and urban uses, and land use practices that degrade habitats used by these species.

The Lange's metalmark and the delta green ground beetle, both federally listed endangered species, and the valley elderberry longhorn beetle (VELB), a federally listed threatened species, are respectively associated with inland dune, vernal pool, and riparian habitats. The distribution and populations of these species have declined substantially, primarily as a result of the loss or degradation of these habitats within their range. The loss of habitat and declining condition of these species populations have warranted their listing as threatened or endangered under the federal Endangered Species Act.

Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of conversion of native habitats for agricultural, industrial, and urban uses, and land and water management practices that degrade habitats used by these species.

Once abundant in riparian woodlands of the Delta, yellow-billed cuckoo have declined with the loss of riparian habitats there. The yellow-billed cuckoo will benefit from improvements in habitat that result from efforts to protect, maintain, and restore riparian and riverine aquatic habitats throughout the Delta.

List of Species to Benefit from Restoration Actions in the Delta Ecological Management Zone

- delta smelt
- longfin smelt
- green sturgeon
- Sacramento splittail
- chinook salmon (all runs)
- steelhead trout
- lamprey (all species)
- California black rail
- Swainson's hawk
- special status plant species
- Sacramento perch
- riparian brush rabbit
- greater sandhill crane
- western yellow-billed cuckoo
- California red-legged frog
- western pond turtle
- Lange's metalmark butterfly
- native resident fishes
- migratory waterfowl
- shorebird guild
- wading bird guild
- neotropical migratory bird guild
- Bay-Delta foodweb organisms
- white sturgeon
- striped bass
- American shad
- non-native warmwater gamefish
- upland game

Descriptions of Ecological Management Units

North Delta Ecological Management Unit

The North Delta Ecological Management Unit is bounded on the south and east by the Sacramento River. Notable features are the Yolo Bypass, the Sacramento deep water channel, the Cache Slough complex, the Sacramento River and adjoining sloughs, the Snodgrass Slough and Stone Lakes complex, and the Delta Cross Channel (DCC) gates which, when open, allow Sacramento River water to flow into the forks of the lower Mokelumne River. Land elevations generally range from 5 feet below to 10 feet above mean sea level.

The size of the unit is approximately 235,000 acres. As with the Delta's other units, the primary land use is agriculture with more than 60% or 141,000 acres in field crops, orchards, and vineyards. Approximately 5% of the unit consists of riparian, oak woodland, freshwater marsh, and seasonal wetland. (See tables in this section.) Much of the permanent and seasonal wetland habitat is found in the Yolo Bypass, Cosumnes River Preserve, and Stone Lakes area.

Hydraulic processes in the North Delta Ecological Management Unit are influenced by tides, upstream water releases, weather, channel diversions, and river inflow. Unimpeded tidal action into tidal wetlands affects sediment and nutrient supplies into those wetlands and natural marsh successional processes. Tidal action and floodwater discharges from the rivers and Yolo Bypass transport nutrients and organic carbon into aquatic habitats of the Delta and San Francisco Bay.

Hydraulic processes have been modified in the North Delta Ecological Management Unit since the 1890s. Reductions in flow from the Mokelumne River began in the early 1890s with diversions by the Woodbridge Irrigation District. Further diversions began with the completion of the Mokelumne River Aqueduct in the 1930s. Additional agricultural diversions from the river were developed in the 1960s when the present level of diversions from the Mokelumne River was reached. The construction of the Yolo Bypass significantly altered hydraulic patterns during above normal and wet water years. The DCC gates began operation in 1951 and increased the flow of Sacramento River water into the East Delta Ecological Management Unit and away from the mainstem Sacramento River below Walnut Grove.

Hydraulic patterns have been further modified by the significant export pumping beginning in 1951 for the CVP and in 1968 for the SWP. The Barker Slough pumping plant at the east end of Lindsey Slough in the Cache Slough complex was completed in 1988; it exports water directly from the North Delta Ecological Management Unit to the North Bay Aqueduct.

Current hydraulic conditions in the North Delta Ecological Management Unit affect the ability of this Ecological Management Unit to support channels with suitable residence times and natural net flows; to provide adequate transport flows to the lower estuary; and to support high-quality rearing and spawning habitat, nutrient cycling, and foodweb integrity.

The effects of many small unscreened diversions in the North Delta Ecological Management Unit are undocumented.

EAST DELTA ECOLOGICAL MANAGEMENT UNIT

The East Delta Ecological Management Unit is bounded on the northwest by the Sacramento River; on the northeast by the Mokelumne and Cosumnes rivers; and on the south by Highway 12, the South Fork of the Mokelumne River, White and Disappointment Sloughs, and the San Joaquin River. Notable features are Georgiana Slough, the DCC, the Cosumnes River Preserve, and the Woodbridge Ecological Reserve.

North Delta Ecological Management Unit Land Use

Land use	Acres
Non-flooded Ag	118,011
Flooded Ag	14,528
Orchard	2,832
Vines	5,805
Total cultivated	141,176
Grass	42,194
Other	52,480
Total	235,850

Land elevations in this unit generally range from 10 feet below to 10 feet above mean sea level with the western half of the unit ranging from 10 feet below to 5 feet below mean sea level and the eastern half ranging from 5 feet below to 10 feet above mean sea level. These elevations are generally higher that elevations in other regions of the Delta. Elevation is an important factor in evaluating the quality of habitats and in designing habitat restoration projects.

This Ecological Management Unit consists of more than 100,000 acres. It contains both forks of the Mokelumne River, the Cosumnes River, three dead-end sloughs (Beaver, Hog, and Sycamore), and important waterfowl wintering and sandhill crane foraging and roosting areas. As with the Delta's other units, the primary land use is agriculture with more than 68% in field crops, orchards, and vineyards. (See the table in this section for land use acreage.)

East Delta Ecological Management Unit Habitat Acreage

Habitat	Acres
Riparian scrub	714
Riparian woodland	2,201
Fresh emergent wetland (marsh)	1,270
Seasonal wetland	635
Total	4,820

Less than 5% of the east Delta consists of riparian, oak woodland, fresh emergent wetland, and seasonal wetland habitats. Much of the riparian and permanent and seasonal wetland habitats are found along the Cosumnes and Mokelumne rivers and in the White Slough Wildlife Area.

Hydraulic processes in the east Delta are influenced by tides, river inflow, weather, channel diversions, and upstream water releases. Unimpeded tidal action into tidal wetlands affects the habitat's sediment and nutrient supplies. These supplies influence the natural marsh successional processes. Tidal outflows transport nutrients and carbon into Bay-Delta aquatic habitats. Hydraulic processes have been modified in the east Delta since the 1800s. Reductions in flow from the Mokelumne River began in the late 1800s and continued to decline into the 1960s. The DCC gates began operating in 1951 and increased the flow of Sacramento River water into the East Delta Ecological Management Unit. Hydraulic patterns have been further modified by the significant export pumping, which began in 1951 for the CVP and in 1968 for the SWP.

East Delta Ecological Management Unit Land Use

Land Use	Acres
Non-flooded Ag	58,937
Flooded Ag	6,054
Orchard	870
Vines	2,653
Total cultivated	68,514
Grass	10,906
Other	21,152
Total	100,572

Current hydraulic conditions in the east Delta are unhealthy. These conditions reduce the ability of this Ecological Management Unit to provide suitable residence times and more natural net flows, to provide adequate transport flows to the central and west Delta, and to support high-quality rearing and spawning habitat, nutrient cycling, and foodweb integrity.

The effects of the many small unscreened diversions in the east Delta are unknown.

South Delta Ecological Management Unit

The South Delta Ecological Management Unit is bounded on the north by the San Joaquin River, Turner Cut, Whiskey Slough, Trapper Slough, Victoria Canal, and Italian Slough. Notable features are the San Joaquin, Old, and Middle rivers; Clifton Court Forebay; and the State and federal fish protection and export facilities. Land elevations generally range from 10 feet below to 10 feet above mean sea level. Only about half of the unit is at or slightly higher than sea level.

This Ecological Management Unit consists of more than 177,000 acres. The primary land use is agriculture with more than 60% in field crops, orchards, and vineyards. Less than 2% of this Ecological Management Unit consists of riparian, oak woodland, fresh emergent wetland, and seasonal wetland habitats. Much of the riparian and wetland habitat is found in narrow bands along the San Joaquin River and on small channel islands in Old River. (See tables in this section for acreages.)

Hydraulic processes in the south Delta are influenced by tides, river inflow, weather, channel diversions, temporary rock barriers in Middle River, Old River at Tracy, head of Old River, Grantline Canal, and water releases from upstream reservoirs. Unimpeded tidal action into tidal wetlands affects sediment and nutrient supplies. These supplies influence the natural marsh successional processes. Outflows from tidal wetlands transport nutrients and carbon into aquatic habitats of the Bay-Delta.

Hydraulic processes have been modified in the south Delta since the 1800s. Further reduction in flow started in the 1930s with the completion of the Hetch Hetchy Aqueduct from the Tuolumne River. In the early 1940s, construction of Friant Dam began to alter hydraulic patterns significantly, particularly during drier water years. The South Bay Aqueduct began diversions directly from the South Delta Ecological Management Unit starting in 1962. Hydraulic patterns were further modified by the significant export pumping near Tracy, which began in 1951 for the CVP and in 1968 near Byron for the SWP.

South Delta Ecological Management Unit Habitat Acreage

Habitat	Acres
Riparian scrub	899
Riparian woodland	263
Fresh emergent wetland (marsh)	650
Seasonal wetland	430
Total	2,242

Current hydraulic conditions in the south Delta are unhealthy and affect the ability of this Ecological Management Unit to support channels with suitable residence times and more natural net flows; to provide adequate transport flows to the entrapment zone; and to support high-quality rearing and spawning habitat, nutrient cycling, and foodweb integrity.

While the effects of many small unscreened diversions in the south Delta are undocumented, effects of the two large export facilities on nearly all Delta anadromous and resident fishes have been well described and are very significant (See Water Diversions Vision in Volume I: Ecological Attributes of the San Francisco Bay-Delta Watershed.)

South Delta Ecological Management Unit Land Use

Land Use	Acres
Nonflooded Ag	98,269
Flooded Ag	1,909
Orchard	3,668
Vines	3,466
Total cultivated	107,312
Grass	40,483
Other	29,434
Total	177,229

CENTRAL AND WEST DELTA ECOLOGICAL MANAGEMENT UNIT

The Central and West Delta Ecological Management Unit is bounded on the west and north by Suisun Bay, the Sacramento River, Highway 12, the South Fork of the Mokelumne River, and White and Disappointment Sloughs; and on the south by the San Joaquin River, Turner Cut, Whiskey Slough, Trapper Slough, Victoria Canal, and Italian Slough. Notable features are the San Joaquin and Sacramento rivers, Frank's Tract, the channel islands in Middle and Old rivers, and Potato and Disappointment Sloughs. Land elevations generally range from 10 feet below to as deep as 21 feet below mean sea level. This Ecological Management Unit consists of more than 200,000 acres. It contains most of the mainstem of the San Joaquin River in the Delta. Agricultural uses account for 48% of the area and include field crops, orchards, and vineyards. Approximately 3% of the area consists of riparian, oak woodland, fresh emergent wetland, and seasonal wetland. Much of the riparian and wetland habitat is found on the extensive network of small channel islands in Old and Middle rivers; on White, Potato, and Disappointment Sloughs; along the edges of Big Break and Frank's Track; on the Lower Sherman Island Wildlife Area; and on adjacent tide lands on both sides of the Sacramento River channel between Collinsville and Rio Vista, including Decker Island and adjacent channels. (See the table in this section for habitat acreage.)

The central and west Delta contains most of the heavily subsided (sunken) islands in the Delta. Although nearly 98% of this unit was not reclaimed until after 1900, the highly organic soils of this unit have oxidized at an accelerated rate. This has resulted in subsidence (sinking) of 20 to 30 feet in many places. The subsidence has led to serious potential erosion of the levees around the islands and numerous levee breaks in the last several decades.

Central and West Delta
Ecological Management Unit
Habitat Acreage

Habitat	*Acres*
Riparian scrub	*1,004*
Riparian Woodland	*248*
Fresh emergent wetland	*5,040*
Seasonal wetland	*544*
Total	*6,836*

The central and west Delta has some of the highest levels of wintering waterfowl within the Delta. They use seasonally flooded croplands on the deeper islands in this unit. The California Department of Water Resources is one of the most significant landowners in this unit owning most of Twitchell and Sherman islands.

Hydraulic processes in the central and west Delta are influenced by tides, river inflow, weather, channel configuration, water diversions, and river inflow. Unimpeded tidal action into tidal wetlands affects sediment and nutrient supplies into those wetlands to complement natural marsh successional processes. Tidal action associated with flows out of tidal wetlands transport nutrients and organic carbon into aquatic habitats of the Bay-Delta.

Hydraulic processes have been modified in the central and west Delta since the 1800s. The South Bay Aqueduct began diversions directly from the south Delta starting in 1962. Deliveries to the Contra Costa Canal began in 1962 directly from Rock Slough in the western portion of this unit. Hydraulic patterns were further modified by the significant export pumping, which began in 1951 for the CVP and in 1968 for the SWP.

Current hydraulic conditions in the central and west Delta are unhealthy. The ability of this Ecological Management Unit to maintain suitable residence times and provide more natural flows are restricted. These restrictions inhibit adequate transport flows to the entrapment zone and reduce high-quality rearing and spawning habitat, nutrient cycling, and foodweb integrity.

In addition to many small unscreened agricultural diversions (e.g., siphons and pumps), electric generating stations divert up to 1,500 cfs of Delta water. The water is diverted at Antioch, along the San Joaquin River channel, for cooling purposes. Some juvenile Delta fish are stressed or killed in the water diverted for plant cooling. Though the amount of heat added to the Delta is small, it is locally measurable. This combined with other heated discharges contributes to significant seasonal warming of Delta waters.

VISION FOR THE ECOLOGICAL MANAGEMENT ZONE

The vision for the Sacramento-San Joaquin Delta Ecological Management Zone is to achieve a healthier system that better provides for the ecological needs of plants and animals using the system. A healthy ecosystem will have more natural freshwater flow and channel hydraulic patterns. A more natural channel configuration with greater amounts of slough and permanent and seasonal wetland habitats will provide more habitat for fish, waterfowl, and wildlife, and improve aquatic foodweb production and water quality. Improvements in riparian vegetation along waterways will reduce heating of the water and provide habitat for fish and wildlife. A healthy Delta ecosystem will lead to improved survival of anadromous fish that depend on the Delta for a portion of their life cycles, including chinook salmon and steelhead, striped bass, white and green sturgeon, and American shad. A healthy Delta will also help toward improving the native resident fish community including delta smelt and splittail, as well as resident wildlife, migratory waterfowl, neotropical birds, and special-status plants and plant communities.

A restored Delta ecosystem will have improved ecological processes and habitats and reduced stressors. Ecological processes that will be improved include freshwater inflow and outflow, Delta hydraulics, channel configuration, water temperature, floodplain processes, and aquatic and terrestrial foodweb productivity. There will be substantial increases in the acreage of tidal emergent wetlands, seasonal and permanent nontidal wetlands, and shallow water, riparian, and tidal slough habitats. Stresses from land use, urban and industrial development, contaminants, land reclamation, water diversions, flood control (i.e., levees and bank protection), non-native plant and animal species, recreational activity (e.g., boating), water conveyance structures, livestock grazing, and agricultural practices will be reduced.

Following restoration, the Delta will be a better fish spawning, rearing, and migration habitats. A healthy Delta will be more effective in nutrient cycling and will increase primary (plant) and secondary (animal) productivity. Productivity will increase through improved freshwater inflow and outflow, longer hydraulic residence time in Delta channels, and an increase in the amount of tidal wetlands. Improved Delta productivity will also improve the productivity of northern San Francisco Bay.

Both the endangered winter-run chinook salmon and the threatened delta smelt will benefit from improved Delta inflow and outflow during the late winter and spring, greater estuary (river mouth) foodweb productivity, riparian and wetland habitat improvements, and improved screening systems at water diversions.

Much of the new fish and wildlife habitats will come from agricultural lands that are either no longer productive or too expensive to maintain (e.g., levee maintenance costs are too high). These lands will be purchased from willing sellers. Productive agricultural lands will continue to be an integral part of the Delta habitat mosaic and will be protected by upgrading channel configurations and levees.

The Delta's levee system will be effectively maintained to reduce the risk of failure. This will also minimize loss of water quality (e.g., saltwater intrusion) and loss of high-value wildlife habitat and agricultural land. Riparian, wetland, and aquatic habitats along the levees will be improved where possible. In those areas where leveed lands can eventually be restored to tidal action, the exterior levees will be maintained until the island interiors are restored to the proper elevations necessary to support the desired habitats.

A basic restoration strategy is to protect and enlarge areas of remaining native habitats and establish the connectivity of these areas. For example, the Cosumnes River Preserve (Badger Creek Marsh) supports a sizable population of giant garter snake. Caldoni Marsh (White Slough Wildlife Area) west of Lodi is also an area of several recent and historical giant garter snake sightings. Stone Lakes Refuge-Morrision Creek drainage and the Yolo Basin also contain suitable garter snake habitat, though population sizes are thought to be quite small. Restoring connectivity of these areas would benefit giant garter snakes and contribute to their recovery by providing corridors for the reestablishment of historic population. Such areas in the Delta include:

- the Cache Slough complex,
- Stone Lakes,
- the Cosumnes River Preserve in the north Delta, and
- the Sherman Island Wildlife Area in the western Delta.

Benefits to species and habitats will come predominantly through changes to important physical processes. These processes include:

- freshwater flow into and through the Delta
- hydraulic conditions within Delta channels, and
- the channel configuration of the Delta.

Increasing the amount of the floodplain that is inundated by flood waters and tides, and increasing the amount of shallow water and shorelines will increase tidal aquatic, wetland, and riparian habitats. Habitat improvements will be made in concert with floodplain and levee improvements. Levees will be rebuilt and maintained to include shallow water and riparian habitats that not only protect the integrity of the levees, but also provide valuable fish and wildlife habitats. Agricultural lands on Delta islands will be managed to support waterfowl and wildlife better. Tidal sloughs and creeks will be restored to their former health from improved channel hydraulics, water quality, and riparian vegetation, and reductions in non-native aquatic plants (e.g., water hyacinth).

To ensure this recovery, it will be necessary to reduce stressors. Examples of stressors include the alteration of Delta hydraulic patterns by pumping in the South Delta, unscreened or poorly screened diversions, non-native invasive plant species (e.g., water hyacinth), toxic substances, and human disturbance such as erosion of sensitive habitats from boat wakes. In some cases, fish and wildlife may need temporary or even long-term support through artificial habitat construction, reductions in legal and illegal harvest, or artificial reproduction (e.g., hatcheries).

Improvements to restore the health of the estuary need to be made in a way that contribute to the quality of life for Delta fish and wildlife populations, while protecting the region's agricultural economy and preserving landowner property rights. Rebuilt levees will protect valuable agricultural lands and other properties. Improved fish and wildlife populations will benefit recreation. Greater areas of wetlands and riparian habitats will benefit water quality. With restoration, the Delta would provide improved educational and recreational opportunities. The Delta will provide increased public opportunities for wildlife observation, photography, nature study and wildlife interpretation, fishing, hunting, picnicking, and other activities in a manner that is consistent with maintaining the fish and wildlife values of the Delta and protecting adjacent private properties.

Attaining this vision requires extensive efforts in the Delta, and in watersheds above the Delta. For this reason, this Delta vision is closely tied to the visions for the other 13 Ecological Management Zones. Important ecological processes such as streamflow are controlled by upstream reservoirs and watersheds to the Delta. Delta habitat and the productivity of that habitat are greatly dependent on physical, chemical, and biological processes upstream of the Delta.

A focus on natural processes may reduce the need for measures that artificially maintain habitat and plant and animal populations (e.g., hatcheries). It may be necessary, however, to artificially sustain habitats, severely inhibit stressors, and increase population abundance until such time when natural ecological processes and functions are restored. This will be particularly true during the recovery period.

INTEGRATION OF ACTIONS FOR STAGE 1 IMPLEMENTATION

Stage 1 actions are those actions to be implemented during the first 7 years of the program. The selection of Stage 1 actions is guided by the Strategic Plan for Ecosystem Restoration (2000). The Strategic Plan identifies 12 important issues related to substantial uncertainties about Bay-Delta ecosystem dynamics that should be addressed by adaptive management and adaptive probing early in Stage 1. Many of the issues address the uncertainty resulting from incomplete information and unverified conceptual models, sampling variability, and highly variable system dynamics.

Relevant issues in the Sacramento-San Joaquin Delta Ecological Management Zone that need resolution during Stage 1 include:

- The impact of introduced species and the degree to which they may pose a significant threat to reaching restoration objectives.
- Recognition that channel dynamics, sediment transport, and riparian vegetation are important elements in a successful restoration program and the need to identify which parts of the system can be restored to provide the desired benefits.
- Development of an alternative approach to manage floods by allowing rivers access to more of their natural floodplains and integrating ecosystem restoration activities with the Army Corps of Engineers' Comprehensive Study of Central Valley flood management programs.
- Increasing the ecological benefits from existing flood bypasses, such as the Yolo Bypass, so that they provide improved habitat for waterfowl, fish spawning and rearing, and possibly as a source of food and nutrients for the estuarine foodwebs.
- Thoroughly testing the assumptions that shallow water tidal and freshwater marsh habitats are limiting the fish and wildlife populations of interest in the Delta.
- A better understanding of the underlying mechanisms of the X2 salinity standard in the Delta and the resultant effects on aquatic organisms.

- A need to better understand the linkage between the decline at the base of the estuarine foodweb and the accompanying decline of some, but not all, species and trophic groups.
- Clarifying the extent to which entrainment at the CVP and SWP pumping plants affects the population size of species and invertebrates.
- Clarifying the suitability and use of the Delta for rearing by juvenile salmon and steelhead.

The proposed Stage 1 approach for the Sacramento-San Joaquin Delta Ecological Management Zone is to broadly design and implement actions that will make a substantial contribution to developing aquatic and terrestrial habitat corridors through the Delta which connect with upstream areas. In addition to the focus on the corridor concept, a variety of general actions will be implemented. Implementation of these actions and linking their implementation with adaptive management through the Comprehensive Monitoring, Research and Monitoring Program will be major steps toward resolving the important Stage 1 issues and will set the direction for subsequent implementation stages.

The three major habitat corridors envisioned include the following:

- **THE NORTH DELTA HABITAT CORRIDOR** will provide a large, contiguous habitat corridor connecting the mosaic of tidal marsh, seasonal floodplain, riparian and perennial grassland habitats in the Yolo Bypass, Cache Slough Complex, Jepson Prairie Preserve, Prospect Island, Little Holland Tract, Liberty Island, and Steamboat Slough.
- **THE EAST DELTA HABITAT CORRIDOR** will restore a large, contiguous corridor containing a mosaic of habitat types including tidal perennial aquatic, riparian and riverine aquatic habitat, freshwater fish habitat, essential fish habitat, and improved floodplain-stream channel interactions along the Cosumnes River. The focus area includes the South Fork Mokelumne River, East Delta dead-end sloughs, Georgiana Slough, Snodgrass Slough, and the Cosumnes River.
- **THE SAN JOAQUIN RIVER HABITAT CORRIDOR** will provide a contiguous habitat corridor of tidal perennial aquatic habitats, riparian and riverine aquatic habitat, freshwater fish habitat, essential fish habitat, and improve river-floodplain interactions.

In addition to the three habitat corridors, many other restoration actions are proposed for implementation during Stage 1. These additional actions range from conversion of Frank's Tract to shallow water habitats to developing a ballast water management program to halt the accidental introductions of invasive aquatic organisms.

VISIONS FOR ECOLOGICAL MANAGEMENT UNITS

NORTH DELTA ECOLOGICAL MANAGEMENT UNIT

Habitat restoration, fish passage improvement, and floodplain modifications are the primary focus of the restoration program in the North Delta Ecological Management Unit Restoring a mosaic of tidal emergent wetland and SRA habitat at the ecological-unit level should provide essential resources for all species, particularly communities or assemblages of species that have declined significantly within the Delta.

Habitat restoration will focus on four areas:

- the Yolo Bypass including shallow agricultural islands at the south end of the bypass (i.e., Prospect, Little Holland, and Liberty)
- tidal sloughs between the Sacramento Ship Channel and the Sacramento River (i.e., Steamboat, Miner, Oxford, and Elk)
- the Stone Lakes-Cosumnes Preserve complex, and
- the main channel of the Sacramento River from Sacramento to Rio Vista.

Seasonal patterns of freshwater inflow from the Sacramento River, Yolo basin (Cache and Putah creeks), and the Cosumnes and Mokelumne rivers would be improved. Fish passage problems in the Yolo Bypass, DCC, Sacramento Ship Channel, and Snodgrass Slough should be resolved. Unscreened diversions in important habitat and migration pathways should be screened. Non-native plants will be controlled.

The vision for the North Delta Ecological Management Unit focuses heavily on habitat restoration in the major subunits and the creation of a North Delta habitat corridor. In the Yolo Bypass, channels should be constructed to connect to channel improvements in the Yolo basin (i.e., connections with Putah and Cache creeks, the Colusa drain, and the Sacramento River through the Sacramento and Fremont weirs). These channels should be constructed as permanent sloughs along either side of the bypass.

The sloughs will feed permanent tidal wetlands constructed along the bypass and connected with existing wetlands within the Yolo Basin Wildlife Area. The sloughs would provide rearing and migrating habitat for juvenile and adult salmon, and other native fishes. The sloughs would drain into extensive marsh-slough complexes developed in shallow islands (i.e., Liberty, Little Holland, and Prospect) at the lower end of the bypass. These changes, in conjunction with structural improvements to the bypass floodway (e.g., reducing the hydraulic impedance of the railroad causeway paralleling Interstate 80, and removing levees along the lower Sacramento Ship Channel (see below), will retain and possibly increase the flood bearing capacity of the Yolo Bypass.

To the east of the Yolo Bypass, the vision includes some improvements to the Sacramento Ship Channel. Fish passage problems at the gate structure on the Sacramento River at the north end of the ship channel should be resolved by constructing fish passage facilities. Connections between the ship channel and the new island complexes at Liberty, Little Holland, and Prospect Islands would be considered.

The major sloughs to the east between the ship channel and the Sacramento River, including Miner, Steamboat, Oxford, and Elk, should be improved as salmon migration corridors. A riparian habitat would be improved along these sloughs. Setback levees along portions of these sloughs may expand the slough and adjacent marsh complexes. Increases in the hydraulic connections at the northern end of the slough complex on the Sacramento River and at the southern end at Prospect Island would increase tidal and net flows through the complex, which along with habitat improvements, could represent important rearing and migrating habitat improvements for salmon and other anadromous and resident fish.

Along the Sacramento River channel between Sacramento and Rio Vista, restoration is limited to improvements to riparian vegetation along the major federal levees and to protection and possible improvements to retain remaining shallow-water habitat and tule berms along the river sides of the levees. In addition, habitats would benefit from improving and maintain flows that contribute to riparian regeneration. These habitats may be important spawning habitat of delta smelt and other native Delta fishes and important rearing and migratory habitats of juvenile salmon and steelhead.

The vision for the Stone Lakes-Snodgrass Slough-Lower Cosumnes/Mokelumne complex at the northeast side of the North Delta Ecological Management Unit includes extensive habitat improvements. These improvements will be consistent with increasing the connection of wetlands and riparian woodlands in the Stone Lakes and Cosumnes preserves. Remnant marshes, riparian woodlands, and tidal sloughs along Snodgrass Slough would be protected and improved. Some small units of leveed agricultural lands would be converted to marsh-slough complexes. Flood control levees would be upgraded and riparian and shallow-water habitats improved on the waterside of the levees. Gated connections with appropriate fish passage facilities (and, potentially, screens) would be considered on the Sacramento River at the north end of Snodgrass Slough and Morrison Creek near Hood to provide this portion of the unit with water at a level consistent with pre-levee flows. Water hyacinth infestations would be controlled throughout the complex. All unscreened agricultural diversions located along salmon migratory corridors or spawning habitat of delta smelt would be screened.

Changes in the operation of the DCC gates would be considered depending on which program alternative is chosen.

East Delta Ecological Management Unit

The vision for the East Delta Ecological Management Unit focuses on restoration of native Delta habitats that will improve spawning, rearing, and migration habitats of native Delta fishes, as well as provide extensive new amounts of wetland, waterfowl, and wildlife habitat. Restoring a mosaic of habitat conditions at a landscape level should provide essential resources for all species, especially communities or assemblages of species that are rare within the Delta. Improvements along the south Mokelumne River and adjoining dead-end sloughs on the east edge of the Delta should be the focus of restoration efforts.

The vision for Georgiana Slough, Snodgrass Slough, the Cosumnes River and the South Ford of the Mokelumne River channel is to improve riparian and tidal marsh habitats and restore ecological processes, such as floodplain-river interactions, to the degree feasible to create a sustainable East Delta habitat corridor.

The vision for the east side of the unit along the South Mokelumne River and its adjoining dead-end sloughs (Beaver, Hog, and Sycamore) is extensive restoration of native Delta habitats. Levee setbacks and improvements along the river and sloughs would be accompanied by shallow-water and riparian habitat improvements.

Subsided leveed lands between the sloughs would be converted to floodplain overflow basins. These floodplains would support non-tidal, permanent tule-marsh wetlands, or seasonal agricultural production. After many decades of flooding, marsh growth, and sediment-laden flood overflow, these floodplains could be converted to tidal wetland.

Tidal headwaters of sloughs and adjacent lands would be opened to provide permanent tidal wetland marsh-slough complexes. Conversion of these agricultural lands would also reduce water diversions (i.e., loss of water and juvenile fish). Levee setbacks and a wider floodplain would improve habitat for fish including resident delta smelt and splittail and seasonal migrant salmon and steelhead from the Cosumnes and Mokelumne rivers.

South Delta Ecological Management Unit

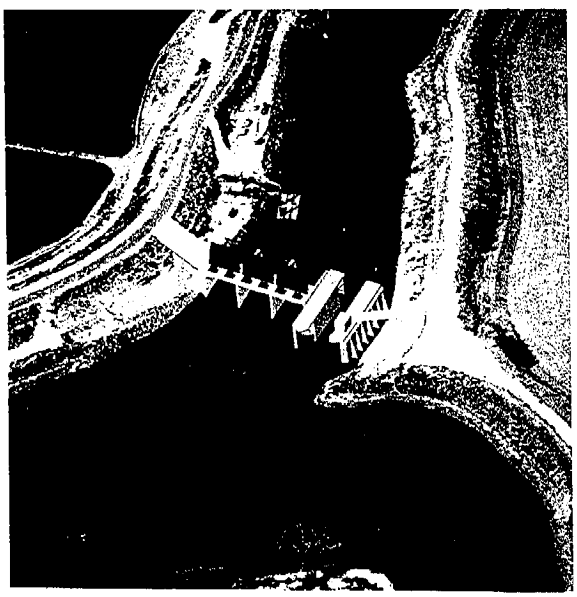
Large-scale habitat restoration, channel and floodplain improvements, hydraulics, and losses at unscreened diversions and water export facilities are the primary focus of the restoration program in the South Delta Ecological Management Unit. Restoring a mosaic of habitat conditions at a landscape level should provide essential resources for all species, particularly communities or assemblages of species that are rare within the Delta.

The vision for the South Delta Ecological Management Unit focuses on restoring floodplain habitat along the lower San Joaquin River between Mossdale and Stockton and improving riparian habitat along leveed sloughs throughout the unit. This is integral to the creation of the San Joaquin River habitat corridor. Improving interior slough complexes of the Old and Middle rivers would depend on which CALFED alternative is chosen for conveyance through the Delta. Minimal improvements would be made under alternatives that use existing Delta channels because these channels would remain major conduits for moving water to the export pumps. Other alternatives would provide more flexibility in the form of improvements in riparian and emergent wetland habitat and channel configurations. Depending on the preferred alternative, the South Delta Ecological Management Unit could be a location in which extensive restoration of tidal emergent wetlands and tidal perennial aquatic habitats occurs. This is influenced by the present land elevations and because land subsidence has been less dramatic that in other regions of the Delta.

A major focus of the vision in the south Delta will be expansion of the floodway in the lower San Joaquin River floodplain between Mossdale and Stockton. Setback levees and overflow basins offer opportunities to increase the flood-bearing capacity of the existing configuration of the river floodplain, as well as potential for creating significant amounts of native tidal emergent wetlands within the floodplain, regardless of which conveyance alternative is chosen.

Another important focus of the vision is to solve the problems associated with the export of water from the south Delta export facilities of the SWP and CVP near Byron and Tracy, respectively. Under all three CALFED alternatives, it is imperative that the loss of juvenile anadromous and resident fishes at the two export facilities be reduced as soon as possible. A new fish screen facility would be constructed that would screen all water for both facilities. The screen system would include a state-of-the-art fish collection, handling, and transport system that would reduce fish losses. Some alternatives would further reduce losses of fish from the south Delta by limiting diversions from the south Delta in seasons when fish are most abundant or vulnerable. Fish losses could also be reduced by providing alternative sources of water to south Delta islands, which would otherwise divert water from existing channels.

A barrier at the head of Old River would be installed to prevent San Joaquin River water and fish from moving into the southern Delta. The barrier would help ensure that San Joaquin River water and juvenile salmon would have some chance of reaching the western Delta and the San Francisco Bay. Precautions would be taken in the operation of the barrier to not cause increased delta smelt, winter-run chinook salmon, and other fishes movement south into the South Delta and greater losses at south Delta export facilities.



Conceptual view of a fish barrier at the Head of Old River (DWR).

Central and West Delta Ecological Management Unit

Restoring habitat is the primary focus of the restoration program in the Central and West Delta Ecological Management Unit. Restoring a mosaic of tidal emergent wetland and SRA habitat on a large scale should provide essential resources for all species dependent on the Delta. Protecting and enhancing levees around all the deeper islands should include major adjacent shoal and shallow-water habitats, as well as riparian and tule-berm (midchannel islands) improvements. Changes in channel hydraulics will protect and improve habitats in specific sloughs. Water conveyance through the Delta should be concentrated in specific channels that should be reinforced for that purpose, and little habitat restoration should be conducted along these channels so as not to encourage residence of juvenile fishes. Portions of deeper islands should be reclaimed where possible for tidal or nontidal marsh habitat. Unscreened diversions in important migration pathways of salmon and delta smelt should be screened or relocated to other channels.

The vision for the Central and West Delta Ecological Management Unit is to restore fresh emergent wetland habitat, shoal and shallow-water aquatic habitat, and adjacent riparian habitat. Along the main channel of the San Joaquin River where levees are being upgraded; wetland, shoal, shallow-water, and adjacent riparian habitat should be improved. Where feasible, new construction should set back levees on portions of islands where the ratio of levee length to protected agricultural acreage is high. This will potentially reduce levee construction and maintenance costs and provide new tidal shallow-water, slough, wetland, and riparian habitat.

These selected islands would be on higher elevation lands to minimize the need for fill; however, some fill would be needed on deeper corners. This might be closely linked with the LTMS strategy for the beneficial reuse of dredge materials as it would accelerate marsh rebuilding processes. On such setbacks, levees would initially be maintained while fill was applied and habitats developed. Eventually, the levees would be breached or gated to allow tidal flows into the newly developed habitats. In some cases, entire small islands may be reclaimed, similar to the way in which portions of western Sherman Island in the west Delta were reclaimed for aquatic and marsh habitat. Along the margins of the unit selected levees could be breached or removed to provide areas of tidal wetlands and adjacent grasslands. The amount of new habitats potentially derived from these actions represents as much as 10% of the total acreage in the Central and West Delta Ecological Management Unit.

Selected tidal channels and sloughs in the Central and West Delta Ecological Management Unit (e.g., Potato Slough and Disappointment Slough) retain good habitats in the form of midchannel islands, shoreline marshes and riparian woodlands, and shallow waters. These habitats would be protected and would also require active water hyacinth control.

On deeper Delta islands, levees should be upgraded to protect them from catastrophic failure. Portions of or all of some islands would be considered for establishing permanent nontidal wetlands. Approximately 30,000 acres of these islands would be appropriate for consideration of permanent or seasonal wetland development, or combination wildlife habitat and agricultural use. Selected islands may also be appropriate for flood overflow basins or seasonal water storage reservoirs.

Along the west side of the unit in the Highway 4 corridor, there are many opportunities to combine urban, agricultural, and native Delta habitat developments. There are many opportunities for tidal slough and marsh habitat development in this area.

Unscreened diversions along major pathways of salmon and delta smelt would be relocated or screened. Screening systems at Antioch electric power plants would be upgraded to reduce loss of fish to entrainment through or impingement on the fish screens. The extent of screening needs would depend on which program alternative is chosen

VISIONS FOR ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOWS: Much of the fresh water of the State drains the watersheds of the Central Valley through the Delta. A healthy pattern of freshwater inflow into and through the Delta would entail natural late winter and spring flow events especially in dry and normal water-year types. Such flow events would support many ecological processes and functions essential to the health of important Bay-Delta fish populations. Inflow to the Delta is impaired in dry and normal rainfall years from the storage and diversion of natural inflow to the basin watersheds. The need for inflow coincides with the need for natural flows in the mainstem rivers, their tributaries, and San Francisco Bay. Increasing low salinity habitat at Roe Island, Chipps Island, and at Collinsville will benefit rearing native fishes dependent on this type of habitat.

COARSE SEDIMENT SUPPLY: Maintain a sustainable supply of natural sediments to the Delta. Sediments are one of the basic ecological components contributing to the development of the Delta landscape over the past 6,000 years. Sediments are needed to maintain floodplains, shallow shoals, mudflats, mid-channel islands, and contribute to maintaining and restoring riparian, wetland, and aquatic habitats. In the longer term, sediments may play an important role in reversing land subsidence on many Delta islands.

NATURAL FLOODPLAINS AND FLOOD PROCESSES: Expand the Delta floodplain by setting back or removing portions of the levee. This would enhance floodwater and sediment retention in the Delta and provide direct and indirect benefits to floodplain dependent fish and wildlife. Such floodplain expansion should also help alleviate flooding potential in other areas of the Delta.

CENTRAL VALLEY STREAM TEMPERATURES: During spring and fall, Delta channels are used by anadromous fish for migrating between rivers and the Pacific Ocean and are used as rearing areas as well. Untimely high water temperatures stress migrating fish by delaying their movement or causing mortality. Improvements in riparian and SRA habitat along Delta channels would improve water temperatures in small but important increments in these areas during critical fall and spring migrating periods. Higher inflow in late winter and early spring will help delay warming of the Delta channels.

DELTA CHANNEL HYDRAULICS: Confinement of Delta channels and use of channels to convey water across the Delta has led to reduced productivity and habitat value of Delta channels. Restoration of natural hydraulic conditions in some Delta channels would improve productivity and habitat values.

BAY-DELTA AQUATIC FOODWEB: The aquatic foodweb of the Delta, which supports important resident and anadromous fish, has been severely impaired. The major foodweb stressors include drought, reductions in freshwater flow, water diversions, introductions of non-native species (e.g., Asiatic clams), and loss of shallow water and wetland habitats. Proposed improvements in spring flows, channel hydraulics, wetland habitats, and floodplain inundation should lead to a healthier and more productive aquatic foodweb. Improved water quality and greater sediment retention in wetland, riparian, and floodplain habitats will also increase foodweb productivity.

VISIONS FOR HABITATS

TIDAL PERENNIAL AQUATIC HABITAT: Land reclamation in the Delta has reduced the area of tidal aquatic habitats such as small sloughs, ponds, and embayments in tidal wetlands. Increased tidal wetland acreage and associated aquatic habitats will provide additional valuable fish and waterfowl habitats.

NONTIDAL PERENNIAL AQUATIC HABITAT: Increasing the area of ponds and lakes on leveed land in the Delta will provide needed habitats for shorebirds, waterfowl, and wildlife.

DELTA SLOUGHS: Increasing the number, length, and area of dead-end and open-end sloughs in the Delta will benefit native fishes, as well as waterfowl, wildlife, and neotropical songbirds.

MIDCHANNEL ISLANDS AND SHOALS: Channel islands in the Delta have associated remnant shallow-water, wetland, and riparian habitats that are valuable for fish and wildlife and sensitive plants. Maintaining and restoring these islands is important given the lack of such habitats and limited potential for creating new habitats within the Delta channels.

FRESH EMERGENT WETLAND HABITAT: Restoring tidal and nontidal marshes in the Delta will benefit foodweb productivity and water quality. It will also provide important habitat for fish, waterfowl, wildlife, and sensitive plant species and communities.

SEASONAL WETLAND HABITAT: Increased seasonal flooding of leveed lands and flood bypasses will provide important habitats for shorebirds, waterfowl, and raptors, particularly Swainson's hawk, native plants and wildlife and for the spawning, rearing, and migration of native fish species. Flooding and draining of seasonal wetlands also contributes to the aquatic and terrestrial foodwebs of the Delta and Bay.

RIPARIAN AND RIVERINE AQUATIC HABITAT: Restoring riparian ~~(waterside)~~ vegetation corridors along levees and associated SRA habitats will benefit many native fish and wildlife species dependent on this type of habitat.

INLAND DUNE SCRUB: Protecting remaining inland dune scrub habitat will protect special-status wildlife populations and special plant species.

PERENNIAL GRASSLANDS: Protecting and improving perennial grassland habitats will benefit special-status wildlife populations, special status plants, and help protect adjoining wetland habitats.

FRESHWATER FISH HABITAT: Freshwater fish habitats are an important component needed to ensure the sustainability of resident native and anadromous fish species. The Delta provides floodplain pool ephemeral water habitat, sloughs, oxbow lakes, and backwater habitats, valley floor rivers which include the main channels of the Sacramento and San Joaquin (Moyle and Ellison 1991). The quality of freshwater fish habitat in the Delta will be maintained through actions directed at streamflows, coarse sediment supply, stream meander, natural floodplain and flood processes, and maintaining and restoring riparian and riverine aquatic habitats and tidally influenced shallow water habitats.

ESSENTIAL FISH HABITAT: The Delta has been identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). Key features of EFH to maintain or restore in the Delta include substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

AGRICULTURAL LANDS: Improving habitats on and adjacent to agricultural lands in the Delta will benefit native waterfowl and wildlife species. Emphasizing certain agricultural practices (e.g., winter flooding and harvesting methods that leave some grain in the fields) will also benefit special-status wildlife such as sandhill cranes.

VISIONS FOR REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS: Screening, consolidating, reducing, and relocating water diversions will reduce loss of important fish and aquatic foodweb organisms. These actions will also improve Delta outflow and channel hydraulics. Relocating south Delta diversion and rehabilitating fish facilities should greatly reduce the annual losses to these diversions. Improved screening at large Delta power plants should reduce entrainment and impingement losses of many important Delta fish species.

LEVEES, BRIDGES, AND BANK PROTECTION: Levee construction and bank protection have led to the loss of riparian, wetland, and shallow-water habitat throughout the Delta. Habitat improvement on levees and shorelines should help restore biodiversity and ecological functions needed for aquatic and wildlife resources of the Delta.

DREDGING AND SEDIMENT DISPOSAL: Reducing the loss of and degradation to important aquatic habitat and vegetated berm islands caused by dredging activities would protect, restore, and maintain the health of aquatic resources in and dependent on the Delta.

INVASIVE SPECIES: Over the past several decades, the accidental introduction of many marine and estuarine organisms has greatly changed the plankton and benthic (bottom and shore dwelling) invertebrates of the Delta. These organisms come mainly from the ballast waters of ships from the Far East. The introduction of these invasive species has had further ramifications up the foodweb. Further changes can be expected if restrictions are not made on ballast water releases into the San Francisco Bay and Delta. Border inspections and enforcement of regulations regarding ballast water releases should reduce the number of invasions each year to the Delta. Where invasive species have become a serious problem, possible means will be developed to control their distribution and abundance.

PREDATION AND COMPETITION: The numbers of predatory fish at certain locations in the Delta (e.g., Clifton Court Forebay) are high and contribute to the loss of resident and anadromous fish. Reductions in these local predator concentrations may reduce predation on important fish, including juvenile chinook salmon, steelhead, striped bass, and delta smelt. Predator control would also improve fish salvage at the State Water Project facilities at Clifton Court Forebay. Programs and projects that exclude fish such as salmon and delta smelt from areas that harbor concentrations of predators will contribute to reducing the adverse effects of predation.

CONTAMINANTS: Reducing toxin inputs in discharges and from contaminated sediments is essential to maintain water quality. Reduced concentrations in waters entering the Delta should lead to lower concentrations in Delta water and in fish and invertebrate tissues. Fewer health warnings for human consumption of Delta fish and improved foodweb productivity would also be expected.

HARVEST OF FISH AND WILDLIFE: The legal and illegal harvest of fish may limit recovery of some populations in the Delta and its watersheds. Increasing enforcement will help reduce illegal harvest of striped bass and sturgeon in the Delta. Increased enforcement and public education should lead to reduced frequency of violations per check by enforcement personnel.

STRANDING: The loss of aquatic organisms, primarily fish species, will be better understood and remedial actions developed and implemented. The primary focus of this effort will be in the Yolo Bypass.

DISTURBANCE: Boat traffic in the Delta contributes to the erosion of remaining shallow water, riparian, and wetland habitats along Delta channels. Reducing boat speeds and traffic in channels where remnant or restored habitats are susceptible to wave erosion damage would help preserve existing remnant habitat and ensure the success of habitat restoration efforts. Reduced rates of erosion and loss of shoreline habitats would be expected in areas of reduced disturbance. Enforcement and /or stricter boating regulations on bilge pumping, refueling, and oil changes will result in decreased contaminant loading and improve water quality. Boating also adversely affect two critical biological events in the Delta: spawning seasons for fish, particularly shallow water spawners such as delta smelt, and wintering periods for waterfowl and shorebirds.

VISIONS FOR SPECIES

DELTA SMELT: The vision for delta smelt is to recover this State- and federally listed threatened species. Recovery of the delta smelt population in the Delta will occur through improved Delta inflow, greater foodweb productivity, increased areas and quality of aquatic habitats, including the South Delta, and reduced effects of water diversions. Higher production should be apparent in dry and normal water year types in response to improvement in flows, habitats, and foodweb and to reductions in stressors.

LONGFIN SMELT: The vision for longfin smelt is to recover this California species of special concern in the Bay-Delta estuary so that it resumes its historical levels of abundance and its role as an important prey species in the Bay-Delta aquatic foodweb. Achieving consistently high production of longfin smelt in normal and wetter years, which historically produced more abundant juvenile populations (year classes), will be critical to the recovery of longfin smelt.

SPLITTAIL: The vision for splittail is to recover this federally listed threatened species in order to contribute to the overall species richness and diversity and to reduce conflict between splittail protective measures and other beneficial uses of water in the Bay-Delta. Recovery of the Delta splittail population will occur through increased flooding of floodplains, higher late-winter Delta inflow, and improved tidal aquatic and wetland habitats. Greater production of young would be expected in dry and normal water year types.

GREEN STURGEON: The vision for green sturgeon is to recover this California species of special concern and to restore population distribution and abundance to historical levels. Restoration of this species contributes to overall species richness and diversity and reduces conflict between the need for protection for these species and other beneficial uses of water in the Bay-Delta. Green sturgeon would benefit from improved ecosystem processes, including adequate streamflow to attract adults to spawning habitat, transport larvae and early juveniles to productive rearing habitat, and maintain productivity and suitability of spawning and rearing habitat (including production of food).

CHINOOK SALMON: The vision for chinook salmon is to recover all stocks that are listed or proposed for listing under CESA or ESA. Central Valley chinook salmon populations will increase with improved late-winter and spring flows through the Delta, increases in wetland and floodplain habitats, lower spring water temperatures, an improved aquatic foodweb, and reduced effects of water diversions. Survival rates through the Delta should increase. Numbers of young salmon rearing in the Delta should increase with improved winter-spring flows and wetland habitats.

STEELHEAD TROUT: The vision for steelhead is to recover this federally listed threatened species. Steelhead will benefit from improved Delta inflow and outflow, channel hydraulics, and increased area of tidal marshlands. The vision is that restoration of ecological processes and habitats, along with a reduction of stressors, will contribute to stable and larger steelhead populations.

LAMPREY: The vision for anadromous lamprey is to maintain and restore population distribution and abundance to higher levels than at present. The vision is also to understand life history better and identify factors which influence abundance. Better knowledge of these species and restoration would ensure their long-term population sustainability.

SACRAMENTO PERCH: The vision for the Sacramento perch is to contribute to the recovery of this California species of special concern and to contribute to the overall species richness and diversity. Although extirpated from the Delta, restoration of Delta islands and heavily vegetated shallow water habitats may contribute to its restoration.

WHITE STURGEON: The vision for white sturgeon is to maintain and restore population distribution and abundance to historical levels. Restoration would support a sport fishery for white sturgeon and contribute to overall species richness and diversity and reduce conflict between the need for protection of this species and other beneficial uses of water in the Bay-Delta.

STRIPED BASS: The vision for striped bass is to maintain healthy populations, consistent with restoring natives species, to their 1960s levels of abundance to support a sport fishery in the Bay, Delta, and tributary rivers, and to reduce the conflict between protection of striped bass and other beneficial uses of water in the Bay-Delta. The striped bass population will benefit from increased inflows to the Delta in late winter and spring, an improved aquatic foodweb, and reduced effects of water diversions. Improvements in water quality and reducing summer losses to diversions may be important in the long-term recovery of striped bass. Given the high reproductive capacity of striped bass, improvements in production of young should quickly follow improvements in flow and foodweb and reductions in stressors.

AMERICAN SHAD: The vision for American shad is to maintain a naturally spawning population, consistent with restoring native species, to support a sport fishery similar to the fishery that existed in the 1960s and 1970s. Central Valley American shad populations will benefit from improved spring Delta inflow and an improved Delta aquatic foodweb. Populations would be expected to remain stable or increase. Increases would be expected in dry and normal rainfall years.

NON-NATIVE WARMWATER GAMEFISH: The vision for non-native warmwater gamefish is to maintain self-sustaining populations, consistent with restoring native species, in order to provide opportunities for consumptive uses such as angling.

NATIVE RESIDENT FISH SPECIES: The vision for native resident fish species is to maintain and restore the distribution and abundance of native species such as Sacramento blackfish, hardhead, and tule perch. Many native fish species will benefit from improved aquatic habitats and foodweb. Population abundance indices should remain stable or increase. The distribution of native resident fishes should increase with widespread habitat restoration. The extirpated Sacramento perch could be restored to new habitats in the Delta.

BAY-DELTA FOODWEB ORGANISMS: The vision for the Bay-Delta aquatic foodweb organisms is to restore the Bay-Delta estuary's once-productive food base of aquatic algae, organic matter, microbes, and zooplankton communities. Restoring the Bay-Delta foodweb organisms would require enhancing plankton growth and evaluating the need to reduce loss of plankton to water exports, particularly in drier years. Several options exist for enhancing plankton growth. Improving Delta inflow and outflow in spring of drier years will be an essential element of any plan. Another important element includes reducing the amount of toxic substances entering the system which may adversely affect foodweb organisms.

WESTERN SPADEFOOT: The vision for the western spadefoot is to maintain this California species of special concern in the Bay-Delta. Achieving this vision will contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta. Protecting and restoring existing and additional suitable aquatic, wetland, and floodplain habitats and reducing the effect of other factors that can suppress breeding success will be critical to the recovery of the western spadefoot. Restoration of aquatic, seasonal wetland, and floodplain habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will help recover this species by increasing habitat quality and area.

CALIFORNIA TIGER SALAMANDER: The vision for the California tiger salamander is to maintain existing populations of this Federal candidate species in the Bay-Delta. Achieving this vision will contribute to overall species richness and diversity and reduce conflict between the need for their protection and other beneficial uses of land and water in the Bay-Delta. Protecting and restoring existing and additional suitable aquatic, wetland, and floodplain habitats and reducing the effect of other factors that can suppress breeding success will be critical to the recovery of the California tiger salamander. Restoration of aquatic, seasonal wetland, and floodplain habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will help recover this species by increasing habitat quality and area.

CALIFORNIA RED-LEGGED FROG: The vision for the California red-legged frog is to maintain populations of this federally listed threatened species. Achieving this vision will contribute to the overall species richness and diversity and to reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. Protecting existing and restoring additional suitable aquatic, wetland, and riparian habitats and reducing mortality from non-native predators will be critical to achieving recovery of the California red-legged frog. Restoration of aquatic, wetland, and riparian habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will help in the recovery of this species by increasing habitat quality and area.

GIANT GARTER SNAKE: The vision for the giant garter snake is to contribute to its recovery in order to contribute to the overall species richness and diversity. Achieving this vision will reduce the conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. Protecting existing and restoring additional suitable wetland and upland habitats will be critical to achieving recovery of the giant garter snake. The proposed restoration of aquatic, wetland, riparian, and upland habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will help in the recovery of this species by increasing habitat quality and area.

WESTERN POND TURTLE: The vision for the western pond turtle is to maintain the abundance and distribution of this California species of special concern in order to contribute to the overall species richness and diversity. Achieving this vision will reduce the conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. Protecting existing and restoring additional suitable wetland and upland habitats will be critical to achieving recovery of the western pond turtle. The proposed restoration of aquatic, wetland, riparian, and upland habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will help in the recovery of these species by increasing habitat quality and area.

SWAINSON'S HAWK: The vision for the Swainson's hawk is to contribute to the recovery of this State-listed threatened species to contribute to the overall species richness and diversity. Improvements in riparian and agricultural wildlife habitats will aid in the recovery of the Swainson's hawk. Increased abundance and possibly some nesting would be expected in the Delta as a result of improved habitats.

CALIFORNIA BLACK RAIL: The vision for the California black rail is to contribute to the recovery of this State-listed threatened species to contribute to overall species richness and diversity. Restoring emergent wetlands in the Delta should aid in the recovery of the California black rail. Population abundance and distribution should increase in the Delta.

GREATER SANDHILL CRANE: The vision for the greater sandhill crane is to contribute to the recovery of this State-listed threatened species in the Bay-Delta. Improvements in pasture lands and seasonally flooded agricultural habitats, such as flooded corn fields, should help toward recovery of the greater sandhill crane population. The population should remain stable or increase with improvements in habitats.

SHOREBIRDS AND WADING BIRDS: The vision for shorebird and wading birds is to maintain and restore healthy populations through habitat protection and restoration and reduction is stressors. Shorebirds and wading birds will benefit from restoration of wetland, riparian, aquatic, and agricultural habitats. The extent of seasonal use of the Delta by these birds should increase.

RIPARIAN BRUSH RABBIT: The vision for the riparian brush rabbit is to contribute to the recovery of this State-listed endangered species in the Bay-Delta through improvements in riparian habitat and reintroduction to its former habitat. Restoring suitable mature riparian forest, protecting and expanding the existing population, and establishing five new populations will be critical to the recovery of the riparian brush rabbit. Restoration of riparian habitats in the South Delta Ecological Management Unit of the Sacramento-San Joaquin Delta Ecological Management Zone and the East San Joaquin Basin Ecological Management Zone and adjacent upland plant communities will help the recovery of this species by increasing habitat area and providing refuge from flooding.

WATERFOWL: The vision for waterfowl is to maintain and restore healthy populations at levels that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses consistent with the goals and objectives of the Central Valley Habitat Joint Venture as part of the North American Waterfowl Management Plan. Many species of resident and migratory waterfowl will benefit from improved aquatic, wetland, riparian, and agricultural habitats. Increase use of the Delta and possibly increases in some populations would be expected.

PLANT SPECIES AND COMMUNITIES: The vision for plant species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland, riparian, grassland, and upland habitats.

UPLAND GAME: The vision is to maintain healthy populations of upland game species at levels that can support both consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses, through protection and improvement of habitats and reduction in stressors. Protecting and restoring existing and additional suitable grassland, seasonal and emergent wetland, midchannel island and shoal, and riparian habitats, and improving management of agricultural lands and reducing the effect of stressors that can suppress breeding success will be critical to maintaining healthy upland game populations in the Bay-Delta.

NEOTROPICAL MIGRATORY BIRDS: The vision for the neotropical migratory bird guild is to restore and maintain healthy populations of neotropical migratory birds through restoring habitats on which they depend. Protecting existing and restoring additional suitable wetland, riparian, and grassland habitats will be critical to maintaining healthy neotropical migrant bird populations in the Bay-Delta. Large-scale restoration of nesting habitats will help reduce nest parasitism and predation by creating habitat conditions that render neotropical birds less susceptible to these stressors.

LANGE'S METALMARK BUTTERFLY: The vision for Lange's metalmark butterfly is to recover this federally listed endangered species by increasing its distributing and abundance through habitat protection and restoration.

DELTA GREEN GROUND BEETLE: The vision for the delta green ground beetle is to contribute to the recovery of this federally listed threatened species by increasing its populations and abundance through habitat restoration.

VALLEY ELDERBERRY LONGHORN BEETLE: The vision for the valley elderberry longhorn beetle is to recover this federally listed threatened species by increasing its populations and abundance through habitat restoration.

WESTERN YELLOW-BILLED CUCKOO: The vision for the western yellow-billed cuckoo is to contribute to recovery of this State-listed endangered species. There is no recent occurrence information for the yellow-billed cuckoo in the Delta. However, the cuckoo would become reestablished in the Delta and will benefit from improvements in riparian habitats. Improvements will result from efforts to protect, maintain, and restore riparian and riverine aquatic habitats throughout the Delta.

LISTED PLANT SPECIES: The vision for Mason's lilaeopsis, Suisun marsh aster, delta mudwort, delta tule pea, and delta coyote-thistle is to recover or contribute to the recovery of these species by integrating their habitat requirements into planning and implementation of projects to restore tidally influenced and other habitats.

WESTERN LEAST BITTERN: The vision is to maintain western least bittern and its habitat throughout the Delta by protecting and restoring forage, nesting, and roosting habitats in conjunction with other habitat restoration actions.

SIGNAL CRAYFISH: The vision for signal crayfish is to maintain populations at levels which will allow recreational and commercial harvest. Benefits for this introduced species will be indirect, resulting from streamflow modification, reduction in contaminant loadings, and restoration of tidally influenced shallow water habitats.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Attaining the vision for the Delta will involve a long-term commitment with short-term and long-term elements. Short-term elements include features that can and need to be implemented as quickly as possible either because of a long-standing need or a pressing opportunity. Plan elements where need, priority, technical and engineering feasibility, or cost effectiveness are questionable would be long-term. However, even long-term elements would in most cases benefit from short-term pilot studies that would address need, feasibility, science, and cost effectiveness.

Changes in freshwater inflow patterns to the Delta is a long-standing need; however, without developed supplies, the prescribed spring flows may not be possible in all year types. In the short-term, efforts would be made to provide the flows with available CVP water supplies in Shasta, Folsom, and New Melones Reservoirs using water prescribed by the Central Valley Project Improvement Act (§3406 b2 water) and additional water purchased from willing sellers (CVPIA §3406 b3 or CALFED purchased water). The effectiveness of water dedicated for such purposes would be maximized through use of tools such as water transfers. In the long term, additional environmental water supplies may be needed to meet all flow needs.

Related programs in this Ecological Management Zone include the CVPIA and Anadromous Fisheries Restoration Program, the SB 34 levee subvention program, Central Valley Habitat Joint Venture, the Riparian Habitat Joint Venture (a multiagency cooperative effort), Ducks Unlimited's Valley Care program, the Nature Conservancy's Cosumnes River and Jepson Prairie Preserves, the USFWS's Stone Lakes Refuge, the DFG's Yolo Basin Wildlife Area, East Bay Park's Big Break and Little Franks Tract recreation areas, and outreach programs that compensate private landowners who improve wildlife management of their lands. The U.S. Army Corps of Engineer's program to mitigate for habitat losses from levee protection in the Delta should coordinate closely with the restoration program.

Much of the infrastructure to implement the vision for the Delta now exists. Existing programs could implement many of the restoration actions outlined in this vision. In areas where cooperative agency and stakeholder efforts do not now exist, such organizations can be developed to help implement the program. Cooperative efforts where agencies have formed partnerships to restore valuable aquatic, wetland, and riparian habitats in the east Delta would be supported and used as a model for other similar efforts (e.g., the Cosumnes River Preserve, with the Nature Conservancy and Ducks Unlimited). Other examples include the establishment of wildlife refuges at Stone Lakes and the Yolo Bypass, each with multiple partners and commitments. The California Department of Water Resources, DFG, and the U.S. Fish and Wildlife Service (USFWS) own considerable properties in the Delta (e.g., West Sherman Island Wildlife Area), which with funding support can be restored or upgraded to fit the vision. The Interagency Ecological Program (IEP) is an established research and monitoring unit that, with support, can accomplish the expanded evaluation and monitoring needs.

Endangered Species Recovery Plan Implementation

The ERPP will be an important, if not major, component in the successful implementation of recovery measures for species listed under either the State or Federal ESAs. For example, many of the targets and programmatic actions listed later in this section are derived from existing recovery plans. Two plans of major importance include the Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes (U.S. Fish and Wildlife Service 1996) and the NMFS Proposed Recovery Plan for the Sacramento River Winter-run Chinook Salmon (National Marine Fisheries Service 1997).

Because the ERPP addresses endangered species from a broader ecosystem perspective, many restoration actions will benefit broad species communities and the habitats upon which they depend. These include actions to benefit aquatic and terrestrial fish and wildlife species as well as special plants and plant communities.

Central Valley Project Improvement Act

Restoring and maintaining ecological processes and functions in the Delta Ecological Management Zone will augment other important ongoing and future restoration efforts for the zone. The Anadromous Fish Restoration Program of the CVPIA (USFWS 1997) has a goal to double the natural production of anadromous fish in the system over the average production during 1967 through 1991. CVPIA authorized the dedication and management of 800,000 AF of CVP yield annually for the purpose of implementing the fish, wildlife, and habitat restoration purposes and measures that include water purchased for inflow to and outflow from the Delta.

Central Valley Habitat Joint Venture

The Central Valley Habitat Joint Venture is a component of the USFWS's North American Waterfowl Management Plan, with funding and cooperative project participation by federal, State, and private agencies. New funding sources, including CALFED restoration funds, are being sought to implement the Joint Venture. The Joint Venture has adopted an implementation plan that includes objectives to protect wetlands by acquiring fee-title or conservation easements and to enhance waterfowl habitat in wetlands and agricultural lands. Joint Venture objectives and targets have been adopted by the ERPP.

San Joaquin County Habitat Conservation Plan

The San Joaquin County Habitat Conservation Plan is nearing completion and describes mechanisms for offsetting past and future impacts associated with land use changes. The habitat conservation plan outlines an approach for acquiring lands using preservation criteria.

Delta Wildlife Habitat Protection and Restoration Plan

While not a formal plan, this plan is used to guide California Department of Fish and Game (DFG), USFWS, and other agencies' programs to wisely use and protect riparian and wetland habitats in the Bay and Delta. Its goals are to protect and improve habitat and inform the public of the magnitude of problems that threaten wildlife and their habitat. It also provides mechanisms for cooperation between local governments and State and federal agencies.

CALFED Bay-Delta Program

CALFED has funded over 20 ecosystem restoration projects in the Sacramento-San Joaquin Delta. Many of these projects deal with restoration of tidal aquatic habitat and screening of water diversions. Two of the more significant projects address the land subsidence problem, by studying methods to return the land to its pre-disturbance elevation. Department of Water Resources is allowing biomass to accumulate on Twitchell Island to reverse the subsidence. In another project, the United States Geological Survey is studying the movement and availability of sediment supplies in the Delta.

Linkage to Other Ecological Management Zones

Realizing the vision in this Ecological Management Zone depends in part on achieving the targets in the Sacramento River, Eastside Delta Tributaries, Yolo basin, and San Joaquin River Ecological Management Zones. Targets in the Suisun Marsh/North San Francisco Bay Ecological Management Zone should be pursued in combination with the Delta to restore important rearing habitats, reduce the introduction of contaminants, and control the introduction of non-native aquatic species. Meeting the flow needs for the Sacramento, Feather, Yuba, American, Mokelumne, Stanislaus, Tuolumne, and Merced rivers is essential to the Delta freshwater inflow needs. Aquatic, riparian, and wetland corridors in the Yolo and Eastside Delta Tributaries Ecological Management Zones are also directly linked and integral to habitat corridors in the Delta.

One important ecological process that needs further evaluation is sediment. The sediment budget of the Delta is of particular interest and there is a need to quantify sediment input, sediment depositional patterns in the Delta, and sediment output.

Restoration Targets and Programmatic Actions

Targets developed for the Sacramento-San Joaquin Delta Ecological Management Zone (and the 13 other ecological management zones) can be classified by their reliability in contributing to attainment of the Strategic Objectives. The target classification system used in the following section is as follows:

Class	Description
◆	Target for which additional research, demonstration, and evaluation is needed to determine feasibility or ecosystem response.
◆◆	Target which will be implemented in stages with the appropriate monitoring to judge benefit and success.
◆◆◆	Target that has sufficient certainty of success to justify full implementation in accordance with adaptive management, program priority setting, and phased implementation.

Ecological Processes

Central Valley Streamflows

General Target: The general target is to more closely approach the natural (unimpaired) seasonal Delta outflow patterns that:

- transport sediments,
- stimulate the estuary foodweb,
- provide for up and downstream fish passage,
- contribute to riparian vegetation succession,
- transport larval fish to the entrapment zone,
- maintain the entrapment zone and natural salinity gradient, and
- provide adequate attraction and migrating flows for salmon, steelhead, American shad, white

sturgeon, green sturgeon, lamprey striped bass, splittail, delta smelt, and longfin smelt.

Besides seasonal peak flows, low and varying flows are also essential elements of the natural Delta outflow pattern to which native plant and animal species have adapted. Specific targets for different flow pattern attributes may vary with the different storage and conveyance alternatives being considered in the CALFED Program.

TARGET 1: Provide a March outflow that occurs from the natural late-winter and early-spring peak inflow from the Sacramento River. This outflow should be at least 20,000 cfs for 10 days in dry years, at least 30,000 cfs for 10 days in below-normal water years, and 40,000 cfs for 10 days in above-normal water years. Wet-year outflow is generally adequate under the present level of development (◆◆).

PROGRAMMATIC ACTION 1A: Prescribed outflows in March should be met by the cumulative flows of prescribed flows for the Sacramento, Feather, Yuba, and American rivers. Assurances must be obtained (e.g., to limit Delta diversions) that these prescribed flows will be allowed to contribute to Delta outflow. A portion of the inflow would be from base (minimum) flows from the east Delta tributaries and the San Joaquin River and its tributaries.

TARGET 2: Provide a late-April to early May outflow that emulates the spring inflow from the San Joaquin River. The outflow should be at least 20,000 cfs for 10 days in dry years, 30,000 cfs in below normal years, and 40,000 cfs in above normal years. These flows would be achieved through base flows from the Sacramento River and flow events from the Mokelumne, Calaveras, Stanislaus, Tuolumne, and Merced rivers (◆).

PROGRAMMATIC ACTION 2A: Prescribed outflows in late April and early May should be met by the cumulative prescribed flows from the Stanislaus, Tuolumne, and Merced rivers (see East San Joaquin Basin Ecological Management Zone), and Mokelumne and Calaveras rivers (see Eastside Delta Tributaries Ecological Management Zone). It will be necessary to obtain assurances that these prescribed flows are allowed to contribute to Delta outflow. The flow event would be made up of:

- the Cosumnes River,
- Mokelumne, Calaveras, and San Joaquin tributary pulsed flows prescribed under the May 1995 Water Quality Control Plan, and
- supplemental flows.

TARGET 3: Provide a fall or early winter outflow that approximates the first "winter" rain through the Delta (◆).

PROGRAMMATIC ACTION 3A: Allow the first "significant" fall/winter natural flow into the Delta (most likely either from rainfall or from unimpaired flows from tributaries and lower watersheds below storage reservoirs or from flows recommended by DFG and the Anadromous Fish Restoration Program [AFRP]) to pass through the Delta to the San Francisco Bay by limiting water diversions for up to 10 days. (No supplementary release of stored water from reservoirs would be required above that required to meet flows prescribed by DFG and AFRP.)

TARGET 4: Provide a minimum flow of 13,000 cfs on the Sacramento River below Sacramento in May of all but critical years (U.S. Fish and Wildlife Service 1995) (◆).

PROGRAMMATIC ACTION 4A: Supplement flows in May of all but critical years as needed from Shasta, Oroville, and Folsom reservoirs to maintain an inflow of 13,000 cfs to the Delta.

RATIONALE: *The proposed March supplemental flows were selected as a representative value for impact analysis in the Programmatic EIS/EIR. Throughout the ERP, the need to determine optimal streamflow for ecological processes, habitats, and species is repeated. The issues of supplemental flows are complex in term of ecosystem improvements. The frequency, magnitude, duration, timing and rate of change of streamflows that form channels, create and maintain riparian habitat (including all species of vegetation), and promote all life stages of the various aquatic species dependent on a particular stream will never occur within a single year. An optimal flow regime will have to vary, perhaps significantly, from year to year. The supplemental flow recommendations will be an intensive exercise in adaptive management and must be based on credible scientific underpinnings.*

Changing the seasonal pattern of freshwater flows into and through the Delta will help restore the

Delta's ecosystem processes and functions. This ecosystem restoration is fundamental to the health of aquatic, wetland, and riparian resources.

Providing Delta outflow at the prescribed level in dry and normal years in March will provide the following benefits:

- improve survival of juvenile chinook salmon rearing in and passing downstream through the Delta,
- provide attraction flows to adult winter-run and spring-run chinook salmon, steelhead, striped bass, white and green sturgeon, splittail, and American shad migrating upstream through the Delta to spawning grounds in the Sacramento River and its tributaries,
- provide attraction flows for longfin and delta smelt moving upstream within the Delta to spawn in the Delta,
- provide downstream passage flows for steelhead, splittail, longfin smelt, and delta smelt to move through the Delta to the San Francisco Bay,
- help maintain lower water temperatures further into the spring to benefit adult and juvenile salmon, steelhead, longfin smelt, delta smelt, and splittail,
- stimulate the foodweb in the Delta and Bay,
- reduce potential effects of toxins released into Delta waters,
- promote growth of riparian vegetation along Delta waterways, and
- reduce loss of eggs, larvae, and juvenile fish into south Delta water diversions.

Supplementing an existing prescription for late April-early May pulse flow through the Delta from the San Joaquin River will assist juvenile San Joaquin chinook salmon and steelhead moving through the Delta to the Bay. The added flow will also help transport Delta and San Joaquin plankton and nutrients that have built up during the spring to the western Delta and Suisun Bay where they will stimulate the spring foodweb on which many of the important fish species living in the Delta depend. In addition, this flow will provide many of the same benefits described above for the March flow event. The flow event would be provided by supplementing the prescribed pulse flow in the 1995 Water Quality Control Plan with additional waters purchased from willing sellers on the Mokelumne, Stanislaus, Tuolumne, and Merced rivers.

Restoring the natural first "fall" flow through the Delta will provide the following benefits:

- support spring-run and other chinook salmon, steelhead, and American shad juveniles migrating from the mainstem rivers and tributaries in passing through the Delta to the Bay,
- provide attraction flows for adult fall-run and late-fall run chinook salmon, splittail, longfin smelt, delta smelt, and steelhead migrating upstream into or through the Delta, and
- reduce losses of migrating juvenile fish in south Delta pumping plants.

Maintaining a minimum inflow of 13,000 cfs from the Sacramento River in May will help maintain survival and transport of striped bass eggs and larvae, and white and green sturgeon from the Sacramento River above Sacramento into the Delta. This flow will also benefit remaining downstream migrating juvenile chinook salmon and steelhead from the Sacramento River and its tributaries, as well as upstream migrating winter- and spring-run chinook salmon and American shad. Supplemental average monthly storage releases of up to 2,500 cfs for 30 days (150,000 total acre-feet) may be necessary in dry years to meet this requirement. In normal and wet years, flows would generally exceed 13,000 cfs. Implementation of this action requires the development and application of an adaptive management program that includes development of testable hypothesis and implementation of a monitoring program to collect and analyze the data to evaluate the hypothesis.

Providing for larger flows during the seasons with when those flows occurred historically, particularly in normal or dry years, will help restore important ecological processes and functions that create and maintain habitat in the Delta. Delta channel maintenance, sediment and nutrient transport, and introductions of plant debris are some examples of processes improved by flow events. Spring flow *events in dry and normal years will help sustain riparian and wetland vegetation.*

COARSE SEDIMENT SUPPLY

TARGET 1: Maintain sediment supply to the Delta from upstream areas at levels needed to maintain existing habitats and to contribute to present and future efforts to reverse subsidence on Delta islands (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative investigation to determine the existing sediment budget in the Delta based on sediment input, use within the Delta, and sediment output.

RATIONALE: *Natural sediments of streams, rivers, and estuaries consist of mineral and organic silts, sands, gravel, cobble, and woody debris. These materials naturally enter, deposit, erode, and are transported through the Bay-Delta and its watershed. Sediment, like water, is one of the natural building blocks of the ecosystem. Many other ecological processes and functions, and habitats and species require specific types and amounts of sediment and the habitats sediments create.*

Finer sediments are important in the natural development of riparian and wetland habitats. Major factors that influence the sediment supply in the Bay-Delta and its watersheds include many human activities such as dams, levees, and other structures, dredging, and gravel and sand mining.

River-transported sediments are an essential component of the physical structure and nutrient base of the Bay-Delta ecosystem and its riverine and tidal arteries. The size, volume, and seasonal timing of sediments entering the riverine and estuarine systems should be compatible with both natural and altered flow regimes. Sediment transport should match channel and floodplain characteristics of individual rivers, streams, and tidal sloughs. A specific sediment management objective is to redistribute sediment in the watersheds and valley components of the ecosystem. An appropriate level, rate, and size of sediment should be redistributed to match specific habitat requirements and ecological functions.

NATURAL FLOODPLAIN AND FLOOD PROCESSES

TARGET 1: Expand the floodplain area in the North, East, South, and Central and West Delta Ecological Management Units by putting approximately 10% of leveed lands into the active floodplain of the Delta (◆◆).

PROGRAMMATIC ACTION 1A: Convert leveed lands to tidal wetland/slough complexes in the North Delta Ecological Management Unit. Permanently convert island tracts (Little Holland, Liberty, and Prospect) at the south end of the Yolo Bypass to tidal wetland/slough complexes. Convert small tracts along Snodgrass Slough to tidal wetland/slough complexes. Construct setback levees along Minor, Steamboat, Oxford, and Elk Sloughs.

PROGRAMMATIC ACTION 1B: In the East Delta Ecological Management Unit, construct setback levees along the South Mokelumne River and connecting dead-end sloughs (Beaver, Hog, and Sycamore).

PROGRAMMATIC ACTION 1C: Remove levees that hinder tidal and floodflows in the headwater basins of east Delta dead-end sloughs (Beaver, Hog, and Sycamore) and allow these lands to be subject to flood overflow and tidal action.

PROGRAMMATIC ACTION 1D: Convert deeper subsided (sunken) lands between dead-end sloughs in the East Delta Ecological Management Unit east of the South Mokelumne River channel either to overflow basins and nontidal wetlands or to land designated for agricultural use.

PROGRAMMATIC ACTION 1E: Construct setback levees in the South Delta Ecological Management Unit along the San Joaquin River between Mossdale and Stockton.

PROGRAMMATIC ACTION 1F: Convert adjacent lands along the San Joaquin River between Mossdale and Stockton either to overflow basins and nontidal wetlands or to land designated for agricultural use.

PROGRAMMATIC ACTION 1G: Construct setback levees on corners of Delta islands along the San Joaquin River channel in the Central and West Delta Ecological Management Unit. Open leveed lands to tidal action where possible along the margins of the West Delta Ecological Management Unit.

RATIONALE: *Subjecting approximately 10% of existing Delta leveed lands to tidal action and floodflows will greatly enhance the floodwater and sediment retention capacity of the Delta. The tracts at the south end of the Yolo Bypass, along the South Mokelumne River, and along the San Joaquin River channel are logical choices for this because they have limited levee systems and are already at high flood risk. These lands have had limited subsidence and offer good opportunities for restoring tidal wetland/slough complexes.*

The other significant area for setbacks is along the main channel of the San Joaquin River. "Cutting corners" on some islands where the levee length to land area maintained is now high would reduce levee construction and maintenance.

CENTRAL VALLEY STREAM TEMPERATURES

TARGET 1: More frequently maintain daily water temperatures in the Delta channels below 60°F in the spring and 65°F in the fall to meet the temperature needs of salmon and steelhead migrating through or rearing in the Delta (◆).

PROGRAMMATIC ACTION 1A: Improve riparian woodland habitats along migrating channels and sloughs of the Delta.

PROGRAMMATIC ACTION 1B: Improve SRA habitat along migration routes in Delta.

RATIONALE: *Maintaining water temperatures of less than 60°F in the spring and 65°F in the fall can improve survival of juvenile chinook salmon rearing in or migrating through the Delta. Maintaining maximum daily water temperatures in the channels and sloughs of the Sacramento-San Joaquin Delta Ecological Management Zone of less than 66°F in the fall will ensure healthy conditions for upstream migrating adult chinook salmon and early emigrating juveniles. Improved riparian habitat along Delta channels and the spring flow events should maintain cooler spring temperatures in dry and normal years. Improved riparian and SRA habitat will help to maintain lower Delta water temperatures from spring through fall.*

DELTA HYDRODYNAMICS

TARGET 1: Reestablish more natural internal Delta water flows in channels (◆◆◆).

PROGRAMMATIC ACTION 1A: Reduce velocities in selected Delta channels by increasing cross-sectional areas of channel by means of setback levees or by constricting flows into and out of the channels.

PROGRAMMATIC ACTION 1B: Increase tidal flow and cross-Delta transfer of water to south Delta pumping plants to selected channels to lessen flow through other channels.

PROGRAMMATIC ACTION 1C: Manage the operation of existing physical barriers so that resulting hydraulics upstream and downstream of the barrier are more like levels in the mid-1960s.

PROGRAMMATIC ACTION 1D: Close the DCC when opportunities allow, as specified in the 1995 Water Quality Control Plan and recommended by the U.S. Fish and Wildlife Service (1995), in the period from November through January when appropriate conditions trigger closure (i.e., internal Delta exports are occurring).

TARGET 2: Restore hydrodynamic conditions in the rivers and sloughs of the Delta sufficient to support targets for the restoration of aquatic resources (◆◆).

PROGRAMMATIC ACTION 2A: Restore 3,000 to 4,000 acres of tidal perennial aquatic habitat and 20,000 to 25,000 acres of tidally influenced freshwater marsh. *(Note: These recommendations are contained within programmatic actions presented in this section for tidal perennial aquatic habitat and fresh emergent wetland (tidal) and are not additions to acreages presented in the targets and programmatic actions for habitat.)*

TARGET 3: Maintain net downstream flows in the mainstem San Joaquin River from Vernalis to immediately west of Stockton from September through November to help sustain dissolved oxygen levels and water temperatures adequate for upstream migrating adult fall-run chinook salmon (◆◆).

PROGRAMMATIC ACTION 3A: Operate a barrier at the head of Old River from August through November.

TARGET 4: Restore 50 to 100 miles of tidal channels (303 to 606 acres) in the southern Yolo Bypass within the north Delta, while maintaining or improving the flood carrying capacity of the Yolo Bypass (◆). *(Note: This target is in addition to* *targets and programmatic actions presented in the Delta Slough habitat section.)*

PROGRAMMATIC ACTION 4A: Construct a network of channels within the Yolo Bypass to connect the Putah and Cache Creek sinks, and potentially the Colusa drain, to the Delta. These channels should effectively drain all flooded lands in the bypass after floodflows stop entering the bypass from the Fremont and Sacramento weirs. The channels would maintain a base flow through the spring to allow juvenile anadromous and resident fish to move from rearing and migratory areas.

PROGRAMMATIC ACTION 4B: Reduce flow constrictions in the Yolo Bypass such as those in the openings in the railway causeway that parallels Interstate 80.

RATIONALE: *Internal Delta hydraulics have been highly modified since the early 1950s. Adverse hydraulic action has created poor conditions for sustaining spawning, rearing, and foodweb production in the Delta and for the transport of larval fish such as delta smelt and striped bass; (U.S. Fish and Wildlife Service 1994 Delta Smelt Biological Opinion; U.S. Fish and Wildlife Service 1995 Delta Smelt Opinion on the 1995 Water Quality Control Plan; U.S. Fish and Wildlife Service 1995; Independent Scientific Group 1996).*

Restoring hydraulic conditions within the Delta by modifying physical barriers in the Delta will support natural transport functions, reduce entrainment (in diversions) into parts of the Delta where survival is low, and assist in transporting juvenile fish into and through the Delta to highly productive nursery areas in the western Delta and Suisun Bay. Modifying DCC operation will restore historical hydraulic conditions in lower Mokelumne channels of the north Delta (U.S. Fish and Wildlife Service 1994 Delta Smelt Biological Opinion; U.S. Fish and Wildlife Service 1995 Delta Smelt Opinion on the 1995 Water Quality Control Plan; U.S. Fish and Wildlife Service 1995). Internal Delta hydraulics can be improved through several operational or structural approaches. The removal of structural barriers that alter internal Delta hydraulic patterns may be possible, depending on which alternative is selected.

Maintaining adequate flows past Stockton will improve existing harmful conditions of low dissolved oxygen and high water temperatures that can hinder the upstream movement of adult San Joaquin fall-run chinook salmon. In addition, improved flows past Stockton will reduce straying of adult salmon into Central and South Delta channels (California Department of Fish and Game 1972).

Improving the channel network in the Yolo Bypass will improve the migration pathway for salmon produced in Putah and Cache creeks, as well as for upper Sacramento River salmon using the Yolo Bypass as a pathway to the Delta. A well-drained system with permanent sloughs will keep juvenile salmon from being stranded in the bypass when flows stop. Permanent sloughs will provide valuable juvenile salmon rearing habitat in late winter and early spring.

Improving habitats along riparian corridors in the Yolo Bypass will provide additional spawning and rearing habitat for splittail and rearing and migration habitat for juvenile chinook salmon and perhaps for delta smelt and other native resident fishes. Conditions will also improve for wildlife and waterfowl.

Restoring connections among Delta channels, freshwater marsh, and seasonal wetland habitats will enhance habitat conditions for special-status species such as the splittail. Restoring this habitat connectivity in a large-scale mosaic in the North Delta will help restore the ecosystem processes and functions fundamental to supporting the foodweb and will improve conditions for rearing chinook salmon, steelhead, sturgeon, juvenile delta smelt, striped bass, and splittail (Fahrig and Merriam 1985).

BAY-DELTA AQUATIC FOODWEB

TARGET 1: Increase primary and secondary nutrient productivity in the Delta to levels historically observed in the 1960s and early 1970s (◆).

PROGRAMMATIC ACTION 1A: Actions described above to restore streamflow, floodplain flooding, Delta hydraulics, tidal wetlands and sloughs, and riparian habitat would increase primary and secondary productivity in the Delta. Relocating the intake of the South Delta pumping plants to the North Delta would also increase Delta productivity.

RATIONALE: *Increasing the area of tidal wetland/slough habitat and the residence time of*

Delta waters will increase primary and secondary productivity. More flooding of floodplains will provide more nutrients and organic carbon inputs to Delta waters. Relocating the intakes of the South Delta pumping plants will increase the residence time of Central and South Delta waters and allow more of the highly productive San Joaquin waters to be retained in the Delta.

HABITATS

GENERAL RATIONALE

Restoring wetland and riparian habitats along with tidal perennial aquatic habitats is an essential element of the restoration strategy for the Sacramento-San Joaquin Delta Ecological Management Zone. The general approach for habitat restoration is to mimic to the extent feasible a well-connected mosaic of aquatic and riparian habitats. In some areas, these habitat should be a contiguous as possible avoiding small habitat patches in favor of larger. Habitat corridors in the Delta should be emphasized that interconnect with habitat corridors on the main stem Sacramento and San Joaquin rivers as well as the eastside tributaries such as the Mokelumne River.

The extent and distribution of the land-water interface (contact) between aquatic habitats and interconnected wetland and riparian habitats have been altered since the mid-1850s by Delta reclamation. Since 1906, the amount of land-water interface has been reduced 32% in the East Delta Ecological Management Unit, 25% in the South Delta Ecological Management Unit, and 45% in the Central and West Delta Ecological Management Unit.

Increasing the ratio of land-water interface and increasing the shoreline perimeter will help restore a complex habitat mosaic on a large scale in the Delta. This will support essential ecosystem processes and functions. These measures are also fundamental to supporting the foodweb and improving conditions for rearing chinook salmon, steelhead, sturgeon, delta smelt, striped bass, and splittail. Foodweb support functions for wildlife will also benefit (Cummins 1974; Clark 1992).

Restoring high-quality freshwater marsh and brackish water marsh, both seasonal and permanent, will increase the production and availability of natural forage for waterfowl and other wildlife. This restoration will also increase the overwinter survival rates of wildlife that winter in this Ecological Management Zone and will strengthen them for migration, thus improving their breeding success. Expanding these habitats will also reduce the amount and concentrations of contaminants that could, upon entering the Delta's sloughs, damage the health of the aquatic resources.

The restoration of all habitats will be within the structure of adaptive management. The program will move forward in a step-wise progression. Each element will be designed with a testable hypothesis and a monitoring program to collect the scientific data needed to evaluate the hypothesis will be in place. Implementation will begin on a small scale and depending on the monitoring results will either continue or be modified based on results of completed projects.

CONVERSION OF LINEAR MEASURES TO ACREAGES

Generally, the June 1999 version of the ERP reported a mix of acres and miles of riparian and riverine aquatic habitats. In this revision, miles of riparian habitat are converted to acres using the following assumption: unless otherwise noted in the ERP, riparian stream corridors are assumed to be 100 feet wide. This equates to 12.12 acres of riparian habitat per mile of corridor for one side of a stream or 24.24 acres per mile including a riparian corridor on each side of the stream. Miles of riparian corridor the Delta and Suisun Marsh have been converted to acres using 12.12 acres per mile of riparian corridor to be restored or enhanced. This is deemed sufficient for analysis purposes as some riparian habitat will be present only on one side of a stream channel and actual width of the corridor will vary greatly from a screen of riparian vegetation in some areas to dense riparian stands that may be 200 feet wide. Riparian acres for the Delta and Suisun Marsh were calculated from the prescriptions in the riparian and riverine aquatic habitat targets presented in Volume II of the ERPP.

The ERP reports tidal and Delta sloughs as miles of sloughs to be restored. To improve evaluation of restoration of slough habitats, slough miles have been converted to acres (6.06 surface acres per mile). The single assumption for the calculation was that average slough width was 50 feet. This width reasonably *describes the range of widths present in natural or restored sloughs, with upper branches being considerably less than 50 feet wide and lower sections exceeding 50 feet.*

TIDAL PERENNIAL AQUATIC HABITAT

TARGET 1: Restore 1,500 acres of shallow-water habitat in the North Delta Ecological Management Unit; 1,000 acres of shallow-water habitat in the East Delta Ecological Management Unit; 2,000 acres of shallow-water habitat in the South Delta Ecological Management Unit; and 2,500 acres of shallow-water habitat in the Central and West Delta Ecological Management Unit (◆◆).

PROGRAMMATIC ACTION 1A: Restore 500 acres of shallow-water habitat at Prospect Island in the North Delta Ecological Management Unit.

PROGRAMMATIC ACTION 1B: Restore 1,000 acres of shallow-water habitat in the downstream (south) end of the Yolo Bypass (Little Holland and Liberty islands) within the North Delta Ecological Management Unit.

PROGRAMMATIC ACTION 1C: Restore 1,000 acres of shallow-water habitat at the eastern edge of the East Delta Ecological Management Unit where existing land elevations range from 5 to 9 feet below mean sea level.

PROGRAMMATIC ACTION 1D: Restore 2,000 acres of shallow-water habitat at the south and eastern edge of the South Delta Ecological Management Unit where existing land elevations range from 5 to 9 feet below mean sea level.

PROGRAMMATIC ACTION 1E: Restore 2,500 acres of shallow-water habitat in the Central and West Delta Ecological Management Unit where existing land elevations range from 5 to 9 feet below mean sea level. A program of fill placement or longer-term subsidence reversal may be needed to accomplish this action.

PROGRAMMATIC ACTION 1F: Restore Frank's Tract to a mosaic of habitats using clean dredge materials and natural sediment accretion.

RATIONALE: *Restoring, improving, and protecting high-quality shallow-water habitat will provide greater foraging areas for rearing juvenile fish and waterfowl in this Ecological Management Zone. These areas typically provide high primary and secondary productivity and support nutrient cycling that sustains good forage. These areas also provide good forage for waterfowl that use underwater vegetation growing in the shoals and for diving ducks such as canvasback and scaup that eat clams (Fris and DeHaven 1993; Brittain et al. 1993; Stuber 1984; Shloss 1991; Sweetnam and Stevens 1993; San Francisco Estuary Project 1992a; U.S. Fish and Wildlife Service 1996; Lindberg and Marzuola 1993).*

Franks's Tract is a flooded Delta island that can be restored to a mosaic of habitat types with no impact to agriculture. Frank's Tract levees were breached and the island has been flooded since the early 1900s. The deep bed of the island does not provide good quality habitat for native fishes. Parts of the island could be elevated through a combination of dredge material placement, natural sediment accretion, and peat accumulation. Frank's Tract will be a functional component of the San Joaquin River corridor, a major fish rearing and migration area, as well as providing continuity with existing and other proposed habitats in the Central and West Delta Ecological Management Unit. Developing the tract must also occur in conjunction with the control or eradication of introduced, nuisance aquatic plants for restoration to be most beneficial to native species.

NONTIDAL PERENNIAL AQUATIC HABITAT

TARGET 1: Develop 500 acres of deep open-water areas (more than 4 to 6 feet deep) within restored fresh emergent wetlands in the Delta to provide resting habitat for water birds, foraging habitat for diving ducks and other water birds and semi-aquatic mammals that feed in deep water, and habitat for associated resident pond fish species (◆).

PROGRAMMATIC ACTION 1A: Develop 100 acres of open-water areas within restored fresh emergent wetland habitats in the West and Central Delta Ecological Management Unit such as on Twitchell or Sherman islands.

PROGRAMMATIC ACTION 1B: Develop 200 acres of open-water areas within restored fresh emergent wetland habitats in the East Delta Ecological Management Unit.

PROGRAMMATIC ACTION 1C: Develop 200 acres of open-water areas within restored fresh emergent wetland habitats in the South Delta Ecological Management Unit.

TARGET 2: Develop 2,100 acres of shallow, open-water areas (less than 4 to 6 feet deep) in restored fresh emergent wetland habitat areas in the Delta to provide resting, foraging, and brood habitat for water birds and habitat for fish and aquatic plants and semi-aquatic animals (◆◆).

PROGRAMMATIC ACTION 2A: Develop 500 acres of shallow, open-water areas within restored fresh emergent wetland habitats in the Central and West Delta Ecological Management Unit such as on Twitchell or Sherman Islands.

PROGRAMMATIC ACTION 2B: Develop 300 acres of shallow, open-water areas within restored fresh emergent wetland habitats in the East Delta Ecological Management Unit.

PROGRAMMATIC ACTION 2C: Develop 300 acres of shallow, open-water areas within restored fresh emergent wetland habitats in the South Delta Ecological Management Unit.

PROGRAMMATIC ACTION 2D: Develop 1,000 acres of shallow, open-water areas within restored fresh emergent wetland habitats in the North Delta Ecological Management Unit.

RATIONALE: *Restoring suitable resting areas for waterfowl and other wetland-dependent wildlife such as river otter will increase their over-winter survival rate. Other water-associated wildlife will also benefit (Madrone and Associates 1980).*

Restoring suitable resting areas for waterfowl and other wetland-dependent wildlife such as river otter will increase their over-winter survival rates. Other water-associated wildlife will also benefit (Madrone and Associates 1980).

Implementation of actions designed to increase or improve acreages of nontidal perennial aquatic habitats need to develop or integrate subsidence reversal and sediment accretion. These will assist in raising bottom elevations to levels that can support rooted submergent and emergent vegetation.

DELTA SLOUGHS

TARGET 1: Restore ecological structure and functions of the Delta waterways network by increasing the land-water interface ratio a minimum of 50% to 75% compared to 1906 conditions and by restoring 65 to 165 miles of small distributary sloughs (less than 50 to 75 feet wide) hydrologically connected to larger Delta channels (◆◆). *(Note: This target is in addition to the Delta slough target presented in the target section for Delta Channel Hydraulics.)*

PROGRAMMATIC ACTION 1A: To replace lost slough habitat and provide high-quality habitat areas for fish and associated wildlife, the short-term solution for the Central and West Delta Ecological Management Unit is to restore 20 miles of slough habitat. The long-term solution is to restore 50 miles of slough habitat (121-303 acres). In each the North Delta and East Delta Ecological Management Units, the short-term solution is to restore 10 miles of slough habitat. The long-term solution is to restore 30 miles of slough habitat (61-182 acres, each). In the South Delta Ecological Management Unit, the short-term solution is to restore 25 miles of slough habitat and the long-term solution is to restore 50 miles of slough habitat (152-303 acres).

PROGRAMMATIC ACTION 1B: Restore tidal action to portions of islands and tracts in the North and East Delta Ecological Management Units with appropriate elevation, topography, and water-landform conditions. This will sustain tidally influenced freshwater marshes with 20 to 30 linear miles (121-182 acres) of narrow, serpentine-shaped sloughs within the wetlands and floodplain. *(Note: The slough miles, or total acreages, are not additive to acreages presented for tidal fresh emergent wetland habitat. A key in restoring tidal habitats includes provision for tidal sloughs and upland transition habitats.)*

RATIONALE: *Restoring, improving, and protecting sloughs in the Ecological Management Units of the Sacramento-San Joaquin Delta Ecological Management Zone will help sustain high-quality shallow-water habitat for spawning of native fish and for foraging of juvenile fish. Restoring small dead-end sloughs and tidally influenced freshwater marshes and mudflats in the Sacramento-San Joaquin Delta Ecological Management Zone will provide habitat for spawning of native fish and for foraging of juvenile fish, increase production of primary and secondary food species, and support nutrient cycling that sustains quality forage. These sloughs can also provide loafing sites for waterfowl and habitat for the* *western pond turtle (Simenstad et al. 1992 and 1993; Lindberg and Marzuola 1993; Madrone and Associates 1980).*

Land-water interface targets represent a reasonable level necessary to restore Bay-Delta ecosystem functions and overall health by increasing water-to-perimeter shoreline ratios and patterns to those of the early 1900s. Delta slough habitat will be restored as a mosaic of habitats including slough, tidal perennial, and tidal emergent habitats.

MIDCHANNEL ISLANDS AND SHOALS

TARGET 1: Maintain existing channel islands and restore 50 to 200 acres of high-value islands in selected sloughs and channels in each of the Delta's Ecological Management Units (◆◆).

PROGRAMMATIC ACTION 1A: Actively protect and improve existing channel islands in the Delta.

PROGRAMMATIC ACTION 1B: Restore 50 to 200 acres of channel islands in the Delta where channel islands once existed.

TARGET 2: Restore 500 acres of shoals in the westernmost portion of the Central and West Delta (◆◆).

PROGRAMMATIC ACTION 2A: Implement a sediment management program that results in deposition and accretion within portions of Central and West Delta channels and bays, forming 500 acres of shallow shoal habitat restored to tidal influence.

RATIONALE: *Many of the remnant channel or "berm" islands in the Delta have been lost to continuing erosion and degradation. Restoring, improving, and protecting the riverine-edge habitat of these islands will provide habitat for juvenile salmon rearing in this Ecological Management Zone. Terrestrial vertebrates that will receive indirect benefits include the western pond turtle and shorebirds and wading birds (Fris and DeHaven 1993; Mahoney and Ermin 1984; Knight and Bottorf 1983; Knox 1984; Novick and Hein 1982; Moore and Gregory 1988; May and Levin 1991; Levin et al. 1995).*

Restoring, improving, and protecting high-quality shallow habitat will provide forage for rearing juvenile fish. These habitats typically provide high levels of primary (plant) and secondary (animal) productivity and support nutrient cycling functions that can sustain quality forage. These habitats also provide high-quality forage habitat for waterfowl who use submergent vegetation growing in the shoals and diving ducks such as canvasback and scaup that eat clams (Fris and DeHaven 1993; Brittain et al. 1993; Stuber 1984).

Restoring high-quality brackish tidal marshes on and adjacent to these islands will contribute to cycling nutrients, maintaining the foodweb, and increasing production of primary and secondary food species in a geographic location already noted for its value as a rearing habitat for estuarine fish. Several plant species of special concern such as the Suisun aster will benefit from increasing the area of brackish tidal marsh in the Delta (Landin and Newling 1988; Dionne et al. 1994; Lindberg and Marzuola 1993).

FRESH EMERGENT WETLAND HABITAT (TIDAL)

TARGET 1: Increase existing tidal freshwater marsh habitat in the Delta by restoring 30,000 to 45,000 acres of lands designated for floodplain restoration (◆◆).

PROGRAMMATIC ACTION 1A: Develop tidal freshwater marshes in the North Delta Ecological Management Unit.

PROGRAMMATIC ACTION 1B: Develop tidal freshwater marshes on small tracts of converted leveed lands along Snodgrass Slough.

PROGRAMMATIC ACTION 1C: Develop tidal freshwater marshes along the upper ends of dead-end sloughs in the east Delta.

PROGRAMMATIC ACTION 1D: Develop tidal freshwater marshes along all setback levees and levees with restored riparian habitat.

PROGRAMMATIC ACTION 1E: Develop tidal freshwater marshes on restored channel island habitat. *(Note: Any tidal freshwater marsh habitat developed is included in Target 1 for this habitat type.)*

RATIONALE: *Restoring tidally influenced freshwater marshes in the Sacramento-San Joaquin Delta Ecological Management Zone will increase* *production of primary and secondary food species and support nutrient cycling functions that can sustain quality forage conditions for fish, waterfowl, shorebirds, and wildlife (Lindberg and Marzuola 1993; Miller 1993; Simenstad et al. 1992 and 1993). Increasing the area of freshwater tidal marshes in each of the four Delta Ecological Management Units will help support the proper aquatic habitat for rearing and outmigrating juvenile chinook salmon, steelhead, and sturgeon and for rearing delta smelt, striped bass, and splittail. Restoring high-quality freshwater marshes, both tidal and nontidal, will contribute to nutrient cycling, maintaining the foodweb, and increased production of primary and secondary food species. In addition, increasing the area of freshwater marsh will contribute to an ecosystem that can accommodate sea level rise. This can only be effective, however, if upland migration corridors are available for the marshes to expand as sea level rises.*

The targets selected take into account the large losses of tidal freshwater marshes since the early 1900s. The Sacramento-San Joaquin Delta Ecological Management Zone lost nearly 90,000 acres, with the greatest losses in the North Delta and Central and West Delta Ecological Management Units. Acreage changes in the South Delta were insignificant during that period because most losses these occurred before 1900. Restoration targets are to restore between 30% and 50% of the losses since 1900. The level of restoration was increased in the South Delta because of the prior losses documented by Landin and Newling (1988). There was a substantial loss of fresh emergent wetlands in the South Delta Ecological Management Unit prior to the 1900s and a significant amount of wetlands could be restored.

FRESH EMERGENT WETLAND HABITAT (NONTIDAL)

TARGET 1: Restore a total of 2,000 acres of nontidal freshwater marshes in the North Delta Ecological Management Unit and 1,000 acres in the East Delta Ecological Management Unit; restore 4,000 acres of nontidal fresh emergent wetland in the South Delta Ecological Management Unit as part of a subsidence control program; and restore 10,000 acres of nontidal fresh emergent wetland in the Central and West Delta Ecological Management Unit as part of a subsidence control program (total of 17,000 acres) (◆◆).

PROGRAMMATIC ACTION 1A: Restore 1,000 acres of nontidal freshwater marshes on Twitchell Island.

PROGRAMMATIC ACTION 1B: Restore 1,000 acres of nontidal freshwater marshes in the Yolo Bypass.

PROGRAMMATIC ACTION 1C: Restore 1,000 acres of nontidal freshwater marshes in leveed lands designated for floodplain overflow adjacent to the dead-end sloughs in the East Delta Ecological Management Unit.

PROGRAMMATIC ACTION 1D: Restore 4,000 acres of nontidal freshwater marshes in the South Delta in lands designated for floodplain overflow.

PROGRAMMATIC ACTION 1E: Restore 10,000 acres of nontidal freshwater marshes on Delta Islands of the Central and West Delta Ecological Management Unit. *(Note: Up to 75% of this acreage may be restored to tidal actions after the appropriate land elevations are achieved through island accretion. Upon restoring tidal action, targets for the Central and West Delta Ecological Management Unit would be adjusted to avoid the need to restore additional non-tidal wetland above 2,500 acres.)*

RATIONALE: *The restoration of high-quality nontidal freshwater marshes will contribute to nutrient cycling, maintaining the foodweb, and supporting enhanced levels of primary and secondary food production. Increasing the areal extent of nontidal freshwater marsh in the Delta, particularly in the Central and West Delta Ecological Management Unit, will be an important component of subsidence control and island accretion. Permanent freshwater marsh can help arrest and in some cases reverse subsidence where peat oxidation has resulted in land elevations more than 15 feet below sea level. Increasing the area of freshwater marsh will contribute to an ecosystem that can accommodate sea level rise. Habitats for wetland wildlife will be improved. The targets selected take into account the large losses of nontidal freshwater marshes since the early 1900s. The Sacramento-San Joaquin Delta Ecological Management Zone lost nearly 90,000 acres with the greatest losses in the North Delta and Central and West Delta Ecological Management Units. Acreage changes in the South Delta were insignificant during that period because most losses there occurred before 1900.*

Seasonal Wetland Habitat

Target 1: Restore and manage at least 2,000 acres of additional seasonal wetland habitat and improve management of 1,000 acres of existing, degraded seasonal wetland habitat in the North Delta Ecological Management Unit (◆◆).

Programmatic Action 1A: Improve management of 1,000 acres of existing, degraded seasonal wetland habitat in the Yolo Bypass.

Programmatic Action 1B: Restore and manage 2,000 acres of additional seasonal wetland habitat in association with the Yolo Basin Wildlife Area.

Target 2: Restore and manage at least 6,000 acres of additional seasonal wetland habitat and improve management of 1,000 acres of existing, degraded seasonal wetland habitat in the East Delta Ecological Management Unit (◆◆).

Programmatic Action 2A: Develop a cooperative program to restore and manage 1,000 acres of additional seasonal wetland habitat on Canal Ranch.

Programmatic Action 2B: Develop a cooperative program to restore and manage 5,000 acres of additional seasonal wetland habitat.

Programmatic Action 2C: Improve management of 1,000 acres of existing degraded seasonal wetland habitat.

Target 3: Restore and manage at least 8,000 acres of additional seasonal wetland habitat and improve management of 1,500 acres of existing, degraded seasonal wetland habitat in the Central and West Delta Ecological Management Unit (◆◆).

Programmatic Action 3A: Restore and manage 4,000 acres of additional seasonal wetland habitat on Twitchell Island.

Programmatic Action 3B: Restore and manage 4,000 acres of additional seasonal wetland habitat on Sherman Island.

Programmatic Action 3C: Develop a cooperative program to improve management of 1,500 acres of existing degraded seasonal wetland habitat.

Target 4: Restore and manage at least 12,000 acres of additional seasonal wetland habitat and improve management of 500 acres of existing, degraded seasonal wetland habitat in the South Delta Ecological Management Unit (◆◆).

Programmatic Action 4A: Develop a cooperative program to restore and manage 12,000 acres of additional seasonal wetland habitat.

Programmatic Action 4B: Develop a cooperative program to improve management of 500 acres of existing degraded seasonal wetland habitat.

Rationale: *Restoring seasonal wetland habitats along with aquatic, permanent wetland, and riparian habitats is an essential element of the restoration strategy for the Sacramento-San Joaquin Delta Ecological Management Zone. Restoring the ratio of land-water interface will help restore a mosaic of complex habitats that will restore important ecosystem processes and functions. Restoring these habitats will also reduce the amount and concentrations of contaminants that could, once they enter the Delta's sloughs, interfere with restoring the ecological health of the aquatic ecosystem. Seasonal wetlands support a high production rate of primary and secondary food species and large blooms (dense populations) of aquatic invertebrates.*

Wetlands that are dry in summer are also efficient sinks for the transformation of nutrients and the breakdown of pesticides and other contaminants. The roughness of seasonal wetland vegetation filters and traps sediment and organic particulates. Water flowing out from seasonal wetlands is typically high in foodweb prey species concentrations and fine particulate organic matter that feed many Delta aquatic and semiaquatic fish and wildlife. To capitalize on these functions for the Delta aquatic zone, significant areas of restored seasonal wetlands in the Sacramento-San Joaquin Delta Ecological Management Zone should be subject to periodic flooding and overland flow from Delta and river floodplains.

Riparian and Riverine Aquatic Habitats

Target 1: Restore 10 to 20 linear miles of riparian and riverine aquatic habitat along the San Joaquin River in the South Delta Ecological Management Unit to create corridors of riparian vegetation of which 60% is to be over 75 feet wide and 40% is to be no less than 300 feet wide and 1 mile long (200 to 400 acres) (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to restore riparian habitat either by obtaining conservation easements or by purchase from willing sellers.

TARGET 2: Restore 15 to 25 linear miles of riparian and riverine aquatic habitat along other Delta island levees throughout the South Delta Ecological Management Unit. This will create riparian vegetation corridors of which 90% is to be more than 75 feet wide and 10%, no less than 300 feet wide and 1 mile long (177 to 295 acres) (◆◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to restore riparian habitat either by obtaining conservation easements or by purchase from willing sellers.

TARGET 3: Restore 10 to 15 linear miles of riparian and riverine aquatic habitat in the North Delta Ecological Management Unit along the Sacramento River below Sacramento of which 80% is to be more than 75 feet wide and 20% over 300 feet wide (145 to 218 acres)(◆).

PROGRAMMATIC ACTION 3A: Obtain conservation easements for, or purchase from willing sellers, land needed to restore 10 to 15 linear miles of riparian habitat along the Sacramento River in the North Delta Ecological Management Unit. Obtain conservation easements for, or purchase from willing sellers, land needed to create corridors of riparian vegetation.

TARGET 4: Restore 8 to 15 linear miles of riparian and riverine aquatic habitat in the East Delta Ecological Management Unit of which 80% is to be more than 75 feet wide and 20% over 300 feet wide (116 to 218 acres)(◆◆).

PROGRAMMATIC ACTION 4A: Obtain conservation easements for, or purchase from willing sellers, land needed to restore 5 to 10 linear miles along the Mokelumne River and 3 to 5 miles along the Cosumnes River in the East Delta Ecological Management Unit to create corridors of riparian vegetation.

TARGET 5: Restore 10 to 20 linear miles of riparian and riverine aquatic habitat in the North Delta Ecological Management Unit of which 80% is to be more than 75 feet wide and 20% over 300 feet wide (145 to 291 acres)(◆◆).

PROGRAMMATIC ACTION 5A: Obtain conservation easements for, or purchase from willing sellers, land needed to restore 5 to 10 linear miles along the Steamboat Slough as part of the development of a North Delta Habitat Corridor.

TARGET 6: Restore or plant riparian and riverine aquatic habitats and recreate slough habitat and set back levees (◆).

PROGRAMMATIC ACTION 6A: Obtain conservation easements for, or purchase from willing sellers, land needed to restore riparian habitat along newly created sloughs and sloughs with new levee setbacks.

PROGRAMMATIC ACTION 6B: Obtain conservation easements for, or purchase from willing sellers, land needed to restore riparian habitat along new or upgraded Delta levees.

TARGET 7: Protect existing riparian woodlands in North, East, and South Delta Ecological Management Units (◆◆).

PROGRAMMATIC ACTION 7A: Expand the Stone Lakes and Cosumnes River Preserves from their current size by an additional 500 acres of existing woodland habitat. Share costs with the Nature Conservancy to acquire in-fee title to the lands needed from willing landowners.

PROGRAMMATIC ACTION 7B: Purchase riparian woodland property or easements.

RATIONALE: *Many species of wildlife, including several species listed as threatened or endangered under the State and federal Endangered Species Acts and several special-status plant species in the Central Valley are dependent on or closely associated with riparian habitats. Riparian habitats support a greater diversity of wildlife species than any other habitat type in California. Degradation and loss of riparian habitat have substantially reduced the habitat area available for associated wildlife species. Loss of this habitat has reduced water storage, nutrient cycling, and foodweb support.*

Restoring, improving, and protecting high-quality riparian woodland habitat will enhance nutrient *cycling and foodweb support and provide habitat for terrestrial invertebrates that will sustain resident fish and rearing juvenile anadromous fish in the Delta. Terrestrial vertebrates that will benefit include the Swainson's hawk, western yellow-billed cuckoo, wading birds, neotropical birds, and the riparian brush rabbit. This habitat will also increase suitable habitat for wildlife such as the western pond turtle and wood duck (Bjornn et al. 1991; Shields et al. 1993; Jensen et al. 1987; Fris and DeHaven 1993; Mahoney and Erman 1984; Knight and Bottorff 1983).*

Large-scale riparian restoration projects are needed to restore the biodiversity (variety of species) and the sustainability and resilience of these habitats. This is consistent with the recommended strategy for restoration of rivers and aquatic ecosystems on a large landscape scale (National Research Council 1992; Noss and Harris 1986; Hutto et al. 1987; Scott et al. 1987; Noss et al. 1994). Large-scale restoration of broad, diverse riparian habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will support increased nesting populations of Swainson's hawks and other raptors, as well as the yellow-billed cuckoo. Wood ducks will also benefit from increases in riparian habitat. Heron and egret rookeries will increase as well (Baltz and Moyle 1984; Hudson 1991; Motroni 1981; National Resource Council 1992; Gaines 1974 and 1977).

Riparian woodland habitats are important habitat use areas for many species of wildlife in the Central Valley. The loss or degradation of historic stands of riparian woodland has substantially reduced the habitat area available for associated wildlife. Such woodlands will also contribute to the recovery of species such as Swainson's hawk. Actions to restore ecological processes and functions, increase and improve habitats, and reduce stressors are prescribed primarily to contribute to the recovery of aquatic species such as winter-run, spring-run, and late-fall-run chinook salmon; splittail; and delta smelt. These actions will also benefit the Swainson's hawk, greater sandhill crane, yellow-billed cuckoo, riparian brush rabbit, black rail, and giant garter snake.

INLAND DUNE SCRUB

TARGET 1: Enhance 50 to 100 acres of low- to moderate-quality Antioch inland dune scrub habitat in the Delta to provide high-quality habitat for special-status plant and animal species and associated wildlife (◆◆).

PROGRAMMATIC ACTION 1A: Support programs for protecting and restoring inland dune scrub habitat at existing ecological preserves in the Central and West Delta Ecological Management Unit.

PROGRAMMATIC ACTION 1B: Protect and restore inland dune scrub habitat areas adjacent to existing ecological preserves in the Central and West Delta Ecological Management Unit through either conservation easements or purchase from willing sellers.

RATIONALE: *An analysis of soils indicated that the historical extent of inland sand dunes in the Delta was probably less than 10,000 acres. The extent and habitat quality of inland dune scrub has declined as a result of recent land use changes. Inland dune scrub is a unique Delta community and supports several special-status plant and animal species, including the Lange's metalmark, which is federally listed as endangered. Protection and restoration of inland dune scrub habitat will help maintain existing special-status species and assist in recovery of their populations.*

FRESHWATER FISH HABITAT AND ESSENTIAL FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination (◆).

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for Delta ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitats. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of rivers and streams and their floodplains, and in maintaining and restoring riparian and riverine aquatic habitats.*

Perennial Grassland

Target 1: Restore 4,000 to 6,000 acres (total) of perennial grasses in the North, East, South, and Central and West Delta Ecological Management Units associated with existing or proposed wetlands and floodplain habitats (◆).

Programmatic Action 1A: Develop a cooperative program to restore 1,000 acres of perennial grassland in the North Delta Ecological Management Unit through either conservation easements or purchase from willing sellers.

Programmatic Action 1B: Develop a cooperative program to restore 1,000 acres of perennial grassland in the East Delta Ecological Management Unit through either conservation easements or purchase from willing sellers.

Programmatic Action 1C: Develop a cooperative program to restore 1,000 to 2,000 acres of perennial grassland in the South Delta Ecological Management Unit through either conservation easements or purchase from willing sellers.

Programmatic Action 1D: Develop a cooperative program to restore 1,000 to 2,000 acres of perennial grassland in the Central and West Delta Ecological Management Unit through either conservation easements or purchase from willing sellers.

Rationale: *Restoring wetland, riparian, and adjacent upland habitats in association with aquatic habitats is an essential element of the restoration strategy for this Ecological Management Zone. Eliminating fragmentation and restoring connection of habitats will enhance habitat conditions for special-status species such as the California black rail and foraging habitat for Swainson's hawk. For instance, the habitats for these species have been degraded by a loss of the adjacent escape cover needed during periods of high flows or high tides.*

Agricultural Lands

Target 1: Cooperatively manage 40,000 to 75,000 acres of agricultural lands (◆◆).

Programmatic Action 1A: Increase the area of Delta corn fields and pastures flooded in winter and spring to provide high-quality foraging habitat for wintering and migrating waterfowl and shorebirds and associated wildlife.

Programmatic Action 1B: Periodically flood pasture from October through March in portions of the Delta relatively free of human disturbance to create suitable roosting habitat for wintering greater sandhill crane, and for other wintering sandhill crane subspecies.

Programmatic Action 1C: Create permanent or semipermanent ponds in Delta farm areas that provide suitable waterfowl nesting habitat but lack suitable brooding habitat, to increase resident dabbling duck production.

Programmatic Action 1D: Increase the acreage farmed for wheat and other crops that provide suitable nesting habitat for waterfowl and other ground-nesting species in the Delta.

Programmatic Action 1E: Convert agricultural lands in the Delta from crop types of low forage value for wintering waterfowl, wintering sandhill cranes, and other wildlife to crop types of greater forage value.

Programmatic Action 1F: Defer fall tillage on corn fields in the Delta to increase the forage for wintering waterfowl, wintering sandhill cranes, and associated wildlife.

Programmatic Action 1G: Develop a cooperative program to improve management on 8,000 acres of Delta corn and wheat fields and to reimburse farmers for leaving a portion of the crop in each field unharvested as forage for waterfowl, sandhill cranes, and other wildlife.

Rationale: *Following the extensive loss of native wetland habitats in the Central Valley, some wetland wildlife species have adapted to the artificial wetlands of some agricultural practices and have become dependent on these wetlands to sustain their populations. Agriculturally created wetlands include rice lands; fields flooded for weed, salinity, and pest control; stubble management; and tailwater circulation ponds.*

Reducing the entrainment of lower trophic organisms (food species) such as phytoplankton and zooplankton, and of life stages of higher trophic organisms such as fish eggs, larvae, and juveniles into agricultural and export water diversions will increase production of primary and secondary food species. This will also support nutrient cycling functions that can sustain quality forage for aquatic resources in and dependent on the Delta (Chadwick 1974).

Managing agricultural lands to increase forage for waterfowl and other wildlife will increase the survival rates of overwintering wildlife and strengthen them for migration, thus improving breeding success (Madrone Associates 1980; Fredrickson and Reid 1988; Schultz 1990; and, Ringelman 1990).

Restoring roosting habitat in this Ecological Management Zone, especially when it is near forage habitat, will increase the overwinter survival of sandhill cranes and strengthen them for migration, thus improving breeding success. Decreasing in human disturbance in the roosting sites will also improve the health of the crane in the Delta. Actions to restore ecological processes and functions, increase and improve habitats, and reduce stressors are prescribed primarily to increase populations of lower level food species, aquatic and terrestrial invertebrates, and forage fish such as threadfin shad. Improving the foodweb of the Delta will help restore the health of the Bay-Delta's aquatic ecosystem.

Creating small ponds on farms with nearby waterfowl nesting habitat but little brood habitat will increase production of resident waterfowl species when brood ponds are developed and managed properly. Researchers and wetland managers with the DFG, U.S. Fish and Wildlife Service and the California Waterfowl Association have found that well managed brood ponds produce the high levels of invertebrates needed to support brooding waterfowl. Other wildlife such as the red-legged frog, tiger salamander, giant garter snake, and western pond turtle will also benefit. Restoring suitable nesting habitat near brood ponds will increase the production of resident waterfowl species. When the restored nesting habitat is properly managed, large, ground predators are less effective in preying on eggs and young of waterfowl and other ground-nesting birds.

Restoring nesting habitat, especially when it is near brood ponds, will increase the production of resident waterfowl species. When the restored nesting habitat is properly managed, large, ground predators are less effective in preying on eggs and young of waterfowl and other ground nesting birds. Managing agricultural lands to increase forage for waterfowl and other wildlife will increase the overwinter survival rates of wildlife and strengthen them for migration, thus improving breeding success (Madrone and Assoc. 1980; Fredrickson and Reid 1988; Schultz 1990; and Ringelman 1990). Following the extensive loss of native upland habitats, upland wildlife species have adapted to the artificial upland environment of some agricultural land uses and have become dependent on agricultural upland areas and field-border shelter belts to sustain their populations.

Habitat restoration will occur over a 30 year period. Initial efforts will be directed at lands presently in State or Federal ownership. Restoration will be strictly guided by adaptive management in which conceptual ecosystem models and hypotheses will be developed. Small projects will be implemented to test the hypotheses regarding habitat restoration. For example, one hypothesis might be that delta smelt will occupy tidal perennial aquatic habitat for foraging, spawning, and rearing. Monitoring will determine it the hypothesis is true or false (e.g., do delta smelt use restored habitat). Based on the results of monitoring under the adaptive management program, an evaluation will be made regarding the need and benefit of restoring additional acres of tidal perennial aquatic habitat.

The Delta Protection Commission suggested (letter to CALFED dated July 10, 1998) some alternatives for meeting habitat restoration targets in the Delta. Although it is premature to set priorities for the targets and programmatic actions in the Delta, the Commission suggested the following approaches:

- Restore and/or enhance lands currently in public or non-profit ownership (or currently in the acquisition process) and designated for restoration, including Twitchell Island, Sherman Island, and Prospect Island. Approximately 35,000 acres fall into this category.
- Acquire and/or enhance currently flooded lands to create and/or enhance emergent habitat, including Frank's Tract, Big Break, Mildred Island, Little Mandeville Island, etc. Approximately 7,000 acres fall into this category.
- Develop and implement management plans for upland areas already in public or non-profit ownership, including Calhoun Cut Ecological

Preserve (approximately 1,000 acres), Rhode Island, etc.

- *Develop and implement individual management plans for private agricultural properties and develop (or provide) funds to offset costs of voluntary implementation of such plans (plans could include flooding programs, enhanced levees and pumps to enhance flooding and drainage, recommend crop rotation cycles, size and location of permanent brood ponds, etc.).*
- *Develop and implement individual management plans for privately owned lands managed for wildlife habitat, such as duck clubs and upland hunting clubs, and develop (or provide) funds to offset costs of voluntary implementation of such plans.*
- *Control of stressors should be revised to avoid duplication with existing regulatory programs, such as existing dredging "windows," and the programs that are developed should respect the needs of existing land uses, such as water-oriented recreation. Where funds are needed to carry out specific programs, those funds should be made available to private land owners to implement CALFED programs.*

The Delta Protection Commission also suggested the approach for restoring a riparian corridor along the Delta portion of the Sacramento River should consider the ecological benefits of enlarging and enhancing a riparian corridor west of the Deep Water Ship Channel, within the Yolo Bypass. Such a waterway could connect to the main stem of the Sacramento River at either or both the Sutter Weir or the Sacramento Weir. There is an existing channel named the Tod Drain, which lies west of the Ship Channel. The Toe Drain is largely unvegetated by lies within the Yolo Bypass, where the lands are already subject to a flood easement purchased by the federal government to provide additional flood protection the city of Sacramento and the Delta area. While the Sacramento River can maintain flood flows of about 150,000 cfs, the Yolo Bypass can handle about three times as much flood flow (450,000 cfs). Locating an enhanced riparian corridor within the Yolo Bypass would also address the stranding of juvenile and adult fish when flood flows recede. Creating an enlarged channel would improve flood water conveyance capacity in the Yolo Bypass, which would then allow the introduction and maintenance of riparian vegetation into the flood bypass without reducing overall flow capacity during flood events.

The Delta Protection Commission also suggested that the South Fork of the Mokelumne River be considered for water conveyance and flood control, by dividing the flow of the Mokelumne River between its north and south forks. Both forks could be examined for additional habitat restoration opportunities as channel capacities are increased by dredging or construction of any necessary levee setbacks. There are significant flow constrictions in the upper reach of the South Fork Mokelumne, which if reduced, could provide important opportunities for flood control and habitat restoration. The Commission suggested that the Mokelumne River corridor must be multipurpose and provide water conveyance through the Delta, flood control for Sacramento and San Joaquin counties, and provide for a riparian corridor for aquatic and terrestrial species.

The Commission also provided information regarding wildlife friendly farming practices. In 1993-94, a Crop Shift Demonstration Project was conducted on Rindge Tract. More recently, short-season rice has been successfully grown in the Delta and could be a valuable crop that contributes to wildlife friendly agricultural practices. The California Department of Fish and Game recommended specific measures to mitigate impacts to wildlife from the demonstration project. Most of the mitigation measures were implemented as part of the demonstration project, and project monitoring provided positive results. Based on this demonstration project, a wildlife friendly agricultural practices program should consider the following:

- *Extend availability of post-harvest flooded grain fields to more fully cover period of usage by migratory birds.*
- *Enhance food value of post-harvest flooded grain fields by intentionally leaving more grain in the fields either by modifying harvest practices or intentionally not harvesting portions of the fields to be harvested.*
- *Create fringe areas during important periods to enhance forage opportunities for species such as greater sandhill cranes and Swainson's hawks.*

Table 6. Summary of ERPP Habitat Restoration Targets for the Sacramento-San Joaquin Delta Ecological Management Zone.

Habitat Type	North Delta Acreage	East Delta Acreage	South Delta Acreage	Central and West Delta Acreage	Total Acreage
Tidal Perennial Aquatic	1,500	1,000	2,000	2,500	7,000
Shoal	0	0	0	500	500
Nontidal Perennial Aquatic (deep open water)	0	200	200	100	500
Nontidal Perennial Aquatic (shallow open water)	1,000	300	300	500	2,100
Delta Sloughs	10-30 miles (61-182 acres)	10-30 miles (61-182 acres)	25-50 miles (152-303 acres)	20-50 miles (121-303 acres)	65-160 miles (395-970 acres)
Delta Sloughs (Yolo Bypass)	50-100 miles (303-606 acres)	--	--	--	50-100 miles (303-606 acres)
Midchannel Islands	50 to 200	50 to 200	50 to 200	50 to 200	200 to 800
Fresh Emergent Wetland (tidal)	TBD [to be determined]	TBD	TBD	TBD	30,000 to 45,000
Fresh Emergent Wetland (nontidal)	2,000	1,000	4,000	10,000	17,000
Seasonal Wetland	Improve: 1,000 Restore: 2,000	1,000 6,000	500 12,000	1,500 8,000	4,000 28,000
Riparian and Riverine Aquatic	20-35 miles plus 500 acres (691-1,009 acres)	8-15 miles (116-218 acres)	25-45 miles (377-695 acres)	--	53-96 miles plus 500 acres (1,684-2,422 acres)
Inland Dune Scrub	0	0	0	50 to 100	50 to 100
Perennial Grassland	1,000	1,000	1,000 to 2,000	1,000 to 2,000	4,000 to 6,000
Wildlife Friendly Agricultural Land	TBD	TBD	TBD	TBD	40,000 to 75,000
Total acres of all habitats to be restored excluding wildlife friendly agricultural practices					91,732 to 110,998

- *Disperse the program throughout the Delta to discourage over-concentration of species in a single area.*

Maintain the existing agricultural economy of the region by using a voluntary program in which participants receive compensation equal to their cost or loss of income.

Overall, the Delta Protection Commission has provided suggestions that will facilitate implementation of the long-term program. Although the recommended actions in this plan are still at the "Programmatic Level," near-term implementation plans and projects can incorporate these suggestions in order to develop actions that can be implemented with support of the Commission.

REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS

TARGET 1: Reduce loss of important fish species at diversions (◆◆◆).

PROGRAMMATIC ACTION 1A: Consolidate and screen agricultural diversions in the Delta.

PROGRAMMATIC ACTION 1B: Replace or upgrade the screens at the SWP and CVP intakes with positive-barrier, fish bypass screens and state-of-the-art fish holding and transportation systems. *(Note: The ecological benefits of this action could be substantially improved by selection of an alternative that has a provision to relocate the intakes, screening those intakes, and providing for fish bypasses as needed.)*

PROGRAMMATIC ACTION 1C: Upgrade screens at Pacific Gas & Electric Company's Contra Costa power plant with fine-mesh, positive barrier, fish bypass screens.

RATIONALE: *Loss of juvenile fish in diversions is detrimental to fish species of special concern (Larkin 1979; Erkkila et al. 1950).*

LEVEES, BRIDGES, AND BANK PROTECTION

TARGET 1: Increase shoreline and floodplain riparian habitat in the Delta by changing the vegetation maintenance practices on both the water and the land side of berms on 25 to 75 miles of the Sacramento, Mokelumne, and San Joaquin rivers, and on 25 to 100 miles of other Delta channels and sloughs confined by levees (◆◆).

PROGRAMMATIC ACTION 1A: Enter into agreements with willing levee reclamation districts to change levee and berm vegetation management practices that to establish and mature shoreline riparian vegetation. This will restore and maintain the health of Delta aquatic resources. Reimburse districts for any additional maintenance and inspection costs.

RATIONALE: *Restoring, improving, and protecting high-quality riparian woodland and willow scrub habitat will enhance nutrient cycling and the foodweb and provide habitat for terrestrial invertebrates that will sustain resident fish and juvenile anadromous fish. Terrestrial vertebrates that will benefit include the Swainson's hawk, western yellow-billed cuckoo, neotropical migrant songbirds, and the riparian brush rabbit. This action will also increase suitable habitat for wildlife such as the western pond turtle and wood duck (Bjornn et al. 1991; Shields et al. 1993; Jensen et al. 1987; Fris and DeHaven 1993; Mahoney and Erman 1984; and Knight and Bottorff 1983). Large-scale riparian restoration projects are needed to restore the variety of species and the sustainability and resilience of these habitats to support the ecological functions needed for aquatic resource restoration in the Bay-Delta. This is consistent with the recommended strategy for restoration of rivers and aquatic ecosystems on a large scale (National Research Council 1992; Noss and Harris 1986; Hutto et al. 1987; Scott et al. 1987; Noss et al. 1994).*

DREDGING AND SEDIMENT DISPOSAL

TARGET 1: Limit dredging in channel zones that are not essential for flood conveyance or maintenance of industrial shipping pathways, and avoid dredging in shallow water areas (depths of less than 3 meters at mean high water) except where it is needed to restore flood conveyance capacity (◆◆◆).

PROGRAMMATIC ACTION 1A: Use alternate sources (rather than Delta in-channel sources) of levee maintenance material, such as:

- excavation of abandoned nonessential levees,
- excavation material from the restoration of secondary tidal channels,

- dry-side island interior borrow pits,
- upland borrow sites,
- Cache Creek settling basin and Yolo Bypass sediment deposits, and
- deep water dredging sites in the San Francisco Bay.

PROGRAMMATIC ACTION 1B: Restrict or minimize effects of dredging near existing midchannel islands and shoals that are vulnerable to erosion and exhibit clear signs of area reduction from channel and bar incision (cutting).

TARGET 2: Avoid dredging during spawning and rearing periods for delta smelt and during rearing periods for winter-run chinook salmon (◆◆◆).

PROGRAMMATIC ACTION 2A: Follow DFG guidelines for dredging in the estuary.

PROGRAMMATIC ACTION 2B: Provide stockpiles of levee maintenance materials in three or more selected land-side areas to avoid the need to obtain material from Delta channels during restricted periods.

RATIONALE: *Soils for levee maintenance should not be taken from adjacent Delta waters because such dredging alters the physical and chemical characteristics of the aquatic habitat and disrupts aquatic organisms. Restoring, improving, and protecting high-quality shallow habitat will provide forage for rearing juvenile fish. These areas typically produce high levels of primary and secondary food species and support nutrient cycling that can sustain quality forage. These areas also provide high-quality forage for waterfowl that use submerge vegetation growing in the shoals and diving ducks such as canvasback and scaup that eat clams in these areas (Fris and DeHaven 1993; Britain et al. 1993; Stuber 1984). Losses or impacts to this habitat should be avoided to restore the health of the estuary (Schlosser 1991; Sweetnam and Stevens 1993; Herbold 1994).*

Impacts that could disrupt foraging and breeding activities of special-status estuarine fish should be avoided (Sweetnam and Stevens 1993; Moyle et al. 1992, Herbold 1994).

INVASIVE AQUATIC PLANTS

TARGET 1: Manage existing and restored dead-end and open-ended sloughs and channels within the Sacramento-San Joaquin Delta Ecological Management Zone so that the total surface area of these sloughs and channels covered by invasive non-native aquatic plants is reduced (◆).

PROGRAMMATIC ACTION 1A: Conduct large-scale, annual weed eradication programs throughout existing and restored dead-end and open-ended sloughs and channels within each of the Delta's Ecological Management Units. The goal is that less than 1% of the surface area of these sloughs and channels is to be covered by invasive non-native aquatic plants within 10 years.

PROGRAMMATIC ACTION 1B: Evaluate the feasibility of developing a program to commercially harvest and convert water hyacinth to methane (natural gas) and organic fertilizer.

TARGET 2: Reduce the potential for introducing non-native aquatic plant and animal species at border crossings (◆◆◆).

PROGRAMMATIC ACTION 2A: Provide funding to the California Department of Food and Agriculture to expand the current State border inspection process to include a comprehensive program of exclusion, detection, and management of invasive aquatic species such as purple loosestrife, and hydrilla.

RATIONALE: *Invasive aquatic plants have altered ecosystem processes, functions, and habitats through a combination of changes such as those to the foodweb and those from competition for nutrients, light, and space. The prescribed action is primarily to enhance foodweb functions and improve habitat for resident, estuarine, and anadromous fish and neotropical migratory birds, in part, by reducing the areas inhabited by invasive non-native plants and by large-scale restoration of optimal nesting habitat (Dudley and D'Antonio 1994; Anderson 1990; Zedler 1992; Bay-Delta Oversight Council 1994).*

INVASIVE RIPARIAN AND SALT MARSH PLANTS

TARGET 1: Reduce surface area covered by non-native plants to less than 1% (◆).

PROGRAMMATIC ACTION 1A: Control non-native riparian plants.

TARGET 2: Reduce the area of invasive non-native woody species, such as Giant Reed (i.e., Arundo or false bamboo) and eucalyptus, that compete with native riparian vegetation, by reducing the area of non-natives by 50% throughout the Delta and by eradicating invasive woody plants from restoration areas (◆◆).

PROGRAMMATIC ACTION 2A: Implement a program throughout the Delta to remove and suppress the spread of invasive non-native plants that compete with native riparian vegetation by reducing the aerial extent of species such as False Bamboo, eucalyptus, and non-native cordgrass (Spartina spp.) by 50%.

PROGRAMMATIC ACTION 2B: Implement a program throughout the Delta that, before restoration actions, eliminates invasive woody plants that could interfere with the restoration of native riparian vegetation.

RATIONALE: *Invasive non-native plants have altered ecosystem processes, functions, and habitats through a combination of changes such as those to the foodweb and those of competition for nutrients, light, and space. The prescribed actions are primarily to improve habitat for many fish and wildlife species and to support foodweb functions by establishing extensive riparian habitat throughout the Delta (Dudley and D'Antonio 1994; Madrone and Assoc. 1980; Bay-Delta Oversight Council 1994; Cross and Fleming 1989; Zedler 1992). There have been extensive Spartina eradication efforts in Willapa Bay, Washington, that could provide guidance in designing and implementing a similar control program in the western Delta and north San Francisco Bay. In most cases, the removal of invasive plants will require the replanting of native vegetation to maintain adequate levels of herbaceous cover, canopy closure, habitat structure, and to limit exotic recolonization.*

INVASIVE AQUATIC ORGANISMS

TARGET 1: Reduce or eliminate the influx of non-native aquatic species in ship ballast water (◆◆◆).

PROGRAMMATIC ACTION 1A: Fund additional inspection staff to enforce existing regulations.

PROGRAMMATIC ACTION 1B: Help fund research on ballast water treatment techniques that could eliminate non-native species before ballast water is released.

TARGET 2: Reduce the potential for introducing non-native aquatic organisms at border crossings (◆◆◆).

PROGRAMMATIC ACTION 2A: Provide funding to the California Department of Food and Agriculture to expand the current State border inspection process to include a comprehensive program of exclusion, detection, and management of invasive aquatic species such as the zebra mussel.

RATIONALE: *Every reasonable effort should be made to reduce the introduction of non-native organisms in the ballast water of ships that enter the Delta. Such organisms have greatly altered the zooplankton of the Delta over the past several decades. Further alteration could reduce the capacity of the Delta to support native fishes.*

Every reasonable effort should be made to reduce the introduction of non-native organisms at overland entrances to California. Inspections at borders have already found Zebra mussels that if allowed to enter Bay-Delta waters could have devastating economic and ecological effects.

PREDATION AND COMPETITION

TARGET 1: Reduce loss of juvenile fish in Clifton Court Forebay to predation by 75% to 90% (◆◆◆).

PROGRAMMATIC ACTION 1A: Evaluate alternate operational strategies to reduce entrainment of juvenile fish into Clifton Court Forebay.

TARGET 2: Reduce in-channel predation loss of juvenile fish near structures such as bridge pilings and diversions (◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to reevaluate opportunities to modify in-channel structures to eliminate predator habitat.

RATIONALE: *Diversions and other structures may provide habitat or opportunities for predatory fish and wildlife, which could be detrimental to fish species of special concern (Erkkila et al. 1950).*

Predation of juvenile fish in Clifton Court Forebay is a symptom of larger problems. These are probably insufficient rearing habitat in the Central Delta, high channel velocities, and insufficient flows in the San Joaquin River. Short-term efforts in Clifton Court Forebay should include, at a minimum, a predator *removal or control program near the fish facility and louver system. Additional focused research is needed on longer-term efforts to reduce predation and to improve the understanding of predator population growth. The longer-term solution to predation at this site lies in re-creating rearing and migration habitats throughout the Delta. Some of the water conveyance alternatives in the Delta could decrease the rates of predation by enlarging the forebay and closing the radial gates for longer periods.*

CONTAMINANTS

TARGET 1: Reduce loading, concentrations, and bioaccumulation of contaminants of concern to ecosystem health in the water, sediments, and tissues of fish and wildlife in the Sacramento-San Joaquin Delta Ecological Management Zone by 25 to 50% as measured against current average levels (◆◆).

PROGRAMMATIC ACTION 1A: Reduce the input of herbicides, pesticides, fumigants, and other agents toxic to fish and wildlife in the Delta by changing land management practices and chemical uses on 50,000 acres of urban and agricultural lands that drain untreated into Delta channels and sloughs. Actions will focus on modifying agricultural practices and urban land uses on a large scale. To reduce the concentration of pesticide residues, the amount applied will be reduced and the amount of pesticide load reaching the Delta's aquatic habitats will be further reduced by taking advantage of biological and chemical processes within wetland systems to help break down harmful pesticide residues.

PROGRAMMATIC ACTION 1B: Reduce levels of hydrocarbons and other contaminants entering the Delta foodweb from high releases into the estuary at oil refineries.

RATIONALE: *Reducing the concentrations and loads of contaminants including hydrocarbons, heavy metals, and other pollutants in the water and sediments of the Sacramento-San Joaquin Delta Ecological Management Zone will help ensure reduction of sublethal and chronic impacts of contaminants, whose impacts on population levels are hard to document. (Bay Delta Oversight Council 1994; Hall 1991; U.S. Fish and Wildlife Service 1996; San Francisco Estuary Project 1992b; Sparks 1992; Diamond et al. 1993; Rost et al. 1989).*

Improved inchannel flows within the Delta from seasonal reductions in water use and improved flows attributed to enhanced supplies of environmental water will also contribute to reducing concentrations (Charbunneau and Resh 1992; U.S. Environmental Protection Agency 1993). Human health warnings associated with consuming fish and wildlife have been issued because of high levels of substances such as mercury and selenium. Large-scale restoration of aquatic and wetland habitats may contribute to reducing levels of hydrocarbons, heavy metals, and other pollutants. However, addressing point sources of concern such as the oil refineries on Suisun and San Francisco Bays and elevated releases of selenium as a result of refining oil from sources high in selenium can also help reduce these contaminants (Charbunneau and Resh 1992).

HARVEST OF FISH AND WILDLIFE

TARGET 1: Reduce illegal harvest of anadromous fish and wildlife in the Delta by increasing enforcement (◆◆◆).

PROGRAMMATIC ACTION 1A: Provide additional funding to the DFG for additional enforcement.

PROGRAMMATIC ACTION 1B: Provide additional funding to local county sheriff's departments and local park agencies for additional enforcement.

PROGRAMMATIC ACTION 1C: Provide rewards for the arrest and conviction of poachers.

RATIONALE: *Actions to reduce illegal harvest of fish and wildlife are prescribed primarily to contribute to the recovery of aquatic species such as winter-run, spring-run, and late fall-run chinook salmon; green sturgeon; splittail; and steelhead. They will also contribute to the recovery of species such as Swainson's hawk, greater sandhill crane, yellow-billed cuckoo, riparian brush rabbit, black rail, and giant garter snake (U.S. Fish and Wildlife Service 1996; San Francisco Estuary Project 1992b; Bay-Delta Oversight Council 1993; California Department of Fish and Game 1991).*

STRANDING

TARGET 1: Reduce or eliminate the stranding of juvenile chinook salmon on floodplains, shallow ponds, and levee borrow areas (◆◆).

PROGRAMMATIC ACTION 1A: Conduct surveys of stranding in the Yolo Bypass under a range of flow conditions and develop recommendations to resolve the problem.

RATIONALE: *Under many flow conditions, stranding is likely in the Yolo Bypass and is a minimal problem. However, under conditions in which the Sacramento River reach high flows and flow is diverted into the flood bypasses, and then flow quickly recede, stranding is likely a serious problem. Timing also plays a important role in determining the severity of the problem. The California Department of Water Resources has been investigating stranding of juvenile fish in the Yolo Bypass and identified areas where remedial actions are probably appropriate to reduce the loss of juvenile fish. Further analysis is needed of the potential magnitude of the problem and additional options to reduce the potential severity of the problem need to be identified.*

DISTURBANCE

TARGET 1: Reduce boat traffic and boat speeds in areas where levees or channel islands and their associated shallow-water and riparian habitat may be damaged by wakes. This will protect important Delta habitats such as berm islands from erosion caused by boat wake (◆◆).

PROGRAMMATIC ACTION 1A: In the Central and West Delta Ecological Management Unit, establish and enforce no wake zones of 1 to 3 miles in Disappointment Slough, of 1 to 2 miles in White Slough, and of 3 to 4 miles in Middle and Old rivers in areas with remnant berms and midchannel islands.

PROGRAMMATIC ACTION 1B: In the East Delta Ecological Management Unit, establish and enforce no wake zones of 1 to 3 miles of the Mokelumne River, of 2 to 4 miles in Snodgrass Slough, and of 3 to 4 miles in Beaver, Hog, and Sycamore Sloughs in areas with remnant berms and midchannel islands.

TARGET 2: Reduce boat wakes near designated important California black rail nesting areas in the Delta from March to June to levels necessary to prevent destruction of nests. This will help in recovery of this listed species (◆◆).

PROGRAMMATIC ACTION 2A: Establish and enforce no wake zones within 50 yards of important California black rail nesting areas in the Delta from March to June.

PROGRAMMATIC ACTION 2B: Establish and enforce no motorized boating zones in 5 to 25 miles of existing dead-end channels in the Delta from March to June.

PROGRAMMATIC ACTION 2C: Establish and enforce no motorized boating zones in the small tidal channels created in restored tidal freshwater marshes and Delta floodplains of levee setbacks.

TARGET 3: Reduce boat wakes near important shallow water spawning areas in the Delta from March to June to levels necessary to protect successful spawning behavior and success. This will help in recovery of listed species (◆).

PROGRAMMATIC ACTION 3A: Identify important shallow water spawning areas and establish and enforce no wake zones within 50 yards of these important Delta habitats from March to June.

RATIONALE: *Protecting the highest quality and largest berm island complexes will advance the ERPP's strategy of protecting and restoring large areas of habitat rather than small fragmented areas (National Research Council 1992; Resource Agency 1976; San Francisco Estuary Project 1992a; San Joaquin County 1979; U.S. Fish and Wildlife Service 1992).*

Actions taken to restore ecological processes and functions, increase and improve habitats, and reduce stressors in this Ecological Management Zone are prescribed primarily to contribute to the recovery of aquatic species such as winter-run, spring-run, and late-fall-run chinook salmon; green sturgeon; splittail; and steelhead. They will also contribute to the recovery of species such as the black rail. (Madrone 1980; Schlosser 1991; San Francisco Estuary Project 1992a; U.S. Fish and Wildlife Service 1978; Schlorff 1991).

Additional research is needed to identify important shallow water spawning areas and the potential adverse effects of boat traffic on the spawning success of native Delta fishes.

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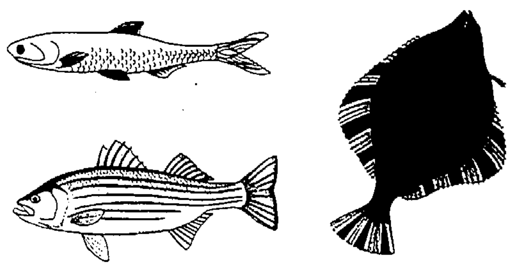
◆ SUISUN MARSH/NORTH SAN FRANCISCO BAY ECOLOGICAL MANAGEMENT ZONE



INTRODUCTION

Suisun Marsh and North San Francisco Bay are the portions of San Francisco Bay downstream of the Delta and upstream of Central San Francisco Bay. These areas include San Pablo and Suisun Bays, the adjacent Suisun Marsh, and the Contra Costa shoreline. North Bay was once bordered on the north by extensive marshes. Baylands alteration has now reduced the marshes to northern San Pablo Bay and Suisun Bay, including Petaluma, Napa, and Suisun marshes. Healthy marshes provide many ecological benefits including very high productivity, flood moderation and shoreline protection. Many of the tidal emergent marshes have been reclaimed for agriculture, salt production, duck clubs, and managed freshwater marshes. These lands are protected from flooding by hundreds of miles of levees. Remnants of the tidal salt marshes remain along the margins of San Pablo and Suisun Bay. The largest intact undiked wetlands remaining in Suisun Marsh are associated with Cutoff Slough and Hill Slough in north central Suisun Marsh.

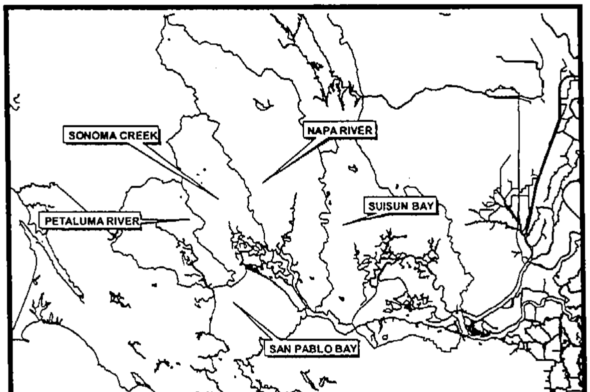
Suisun Marsh and North San Francisco Bay support many species of native and non-native fish, waterfowl, shorebirds, and other wildlife. This ecological management zone also supports many native plant communities including several significant rare and endangered plants which are dependent of wetland processes. All Central Valley anadromous fish migrate through the North Bay and depend on the North Bay and marshes for some critical part of their life cycle. Many Pacific Flyway waterfowl and shorebirds pass through or winter in the North Bay and marshes. The North Bay and adjacent marshes are important nursery grounds for many marine, estuarine and anadromous fish species. Four runs of chinook salmon, steelhead, green sturgeon, white sturgeon, striped bass, lamprey, and American shad migrate through the Delta on their journey between the Pacific Ocean and Central Valley spawning rivers. Young salmon may spend important weeks and months feeding in the North Bay and marshes before migrating to the ocean. Many sturgeon and striped bass spend much of their lives in the North Bay. Many marine (ocean) species depend on the North Bay as nursery area for young, including Pacific herring, northern anchovy, and Dungeness crab. Native resident fish, including longfin smelt, delta smelt, and splittail, spend much of their lives within the North Bay and marshes. Considerable areas of waterfowl and wildlife habitat occur on and along the margins of the North Bay and in the marshes.

Ecological factors having the greatest influence on North Bay and marsh fish and wildlife include freshwater inflow from rivers, wetlands, riparian vegetation, and aquatic habitat diversity. Stressors include water diversions, poor water quality, legal and illegal harvest, wave and wake erosion, and introduced non-native plant and animal species. Stressors to Suisun and North Bay saline emergent plant communities supporting sensitive plant and wildlife resources include freshwater discharges which are outside of the natural variability of seasonal runoff. For example, fresh wastewater treatment outfalls sustained outside of the normal runoff season have been proven detrimental to saline emergent wetlands. Stressors may also include water management activities which result in increased depth and duration of flooding in high marsh zone beyond the range of natural variability and seasonality.

DESCRIPTION OF THE MANAGEMENT ZONE

The Suisun Marsh/North San Francisco Bay Ecological Management Zone is the westernmost zone of the Ecosystem Restoration Program. Its eastern boundary is the Collinsville area, and to the west it is bounded by the northwestern end of San Pablo Bay. The northern boundary follows the ridge tops of the Coast Ranges and includes the Petaluma River, Sonoma Creek, the Napa River, Suisun Bay and marsh and San Pablo Bay. This Ecological Management Zone is composed of five Ecological Management Units:

- Suisun Bay and Marsh,
- Napa River,
- Sonoma Creek,
- Petaluma River, and
- San Pablo Bay.



Map of the Suisun Marsh/North San Francisco Bay Ecological Management Zone and Units.

The general structure of San Francisco Bay is that of a series of embayments, each containing a central expanse of open water overlying subtidal sediments, and ringed by intertidal wetlands, mudflats, and /or rocky shores. These different kinds of areas constitute the major distinctive habitat-types of the ecosystem. Hydrologically, the Bay may be divided into two broad subdivisions with differing ecological characteristics: a *southern reach* consisting of South Bay, and a *northern reach* composed of Central, San Pablo, and Suisun Bays. The southern reach receives little freshwater discharge, leading to high salinity and poor circulation. It also has more extreme tides. The northern reach (which this vision addresses) directly receives Delta outflow, is characterized by less extreme tides and a pronounced horizontal salinity gradient, ranging from near full marine conditions in Central Bay to near fresh water conditions in Suisun Bay. Central and Suisun Bays contain sizeable islands. Features not present in San Pablo and South Bays.

Historically (ca 1800), San Francisco Bay included more than 242,000 acres of tidally influenced bayland habitats and about 90,000 acres of adjacent habitats (Goals Project 1999). Tidal marsh (190,000 acres) and tidal flats (50,000 acres) accounted for 98% of the bayland habitats. Today, only 70,000 acres remain. In the Suisun Bay and marsh, tidal marsh and tidal flat habitats have declined from 68,000 acres to about 15,000 acres. Similar declines have occurred in the North Bay region with tidal marsh and tidal flats declining from about 68,000 acres to about 25,000 acres (Goals Project 1999).

Today, the important habitat types in the Suisun Marsh/North San Francisco Bay Ecological Management Zone are tidal perennial aquatic habitat, tidal saline emergent wetland, seasonal wetland, perennial grassland, agricultural land, and riparian habitat. The separation of wetlands from tidal flows and the reclamation of emergent wetlands have altered ecological processes and functions in Suisun Marsh and the North Bay. Removing tidal action from the marsh and baylands soils has resulted in oxidation of the soil and, subsequently, subsidence (settling) of interior islands and adverse changes in wetland soils chemistry. Losing these processes and functions has reduced available habitat for native species of fish, plants, and wildlife; reduced water quality; and decreased the area available for dispersing flood waters and depositing suspended silt.

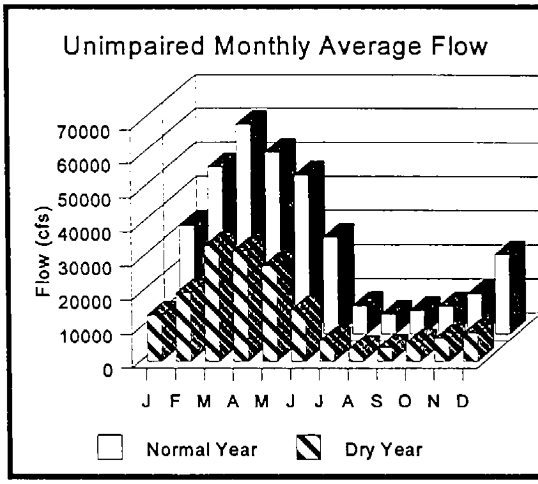
Species that have been affected include the salt marsh harvest mouse, California clapper rail, California black rail, waterfowl, shorebirds, Suisun shrew, and many other wildlife species. Many special-status plant species, including the soft-haired bird's beak, Suisun thistle, and Suisun aster, have also been adversely affected. Many species of native marine, estuarine, freshwater, and anadromous fish also depend on this habitat type for important parts of their life cycles. Fish species that continue to depend on tidal marshes and adjoining sloughs, mudflats and embayments include delta smelt, longfin smelt, chinook salmon, green sturgeon, white sturgeon, Pacific herring, starry flounder, splittail, and striped bass.

Submerged aquatic vegetation (SAV), especially seagrass, communities and habitats provide valuable habitat for fish and invertebrates in the San Pablo Bay and north San Francisco Bay and is an important foraging habitat for waterfowl. San Pablo Bay contains the greatest acreages of seagrass of any water body in the Bay-Delta system. The relative present-day rarity of seagrass beds suggests it could be considered a habitat of special concern in the system.

Ecological processes essential to a healthy Suisun Marsh and San Francisco Bay include freshwater inflow, flood and floodplain processes, and aquatic foodweb processes. The disruption of ecological processes in this zone, such as separating wetlands from tidal flows, has prevented the marshes from the accretion of bottom sediments necessary to keep up with sea level rise, reduced nutrient input to the zone, and reduced the output of other organics and fixed nutrients. Ecological processes essential to a healthy Suisun Marsh and San Francisco Bay include both freshwater inflow within natural (unimpaired) variability and also tidal inflow to deliver important ocean salts and maintain this brackish-saline system. In addition, rare events such as extreme pulse flow hydrographs associated with high outflow years and rare events such as extreme winter drought conditions which this system experienced historically may be equally important in maintaining the biological diversity of this mixed salinity zone.

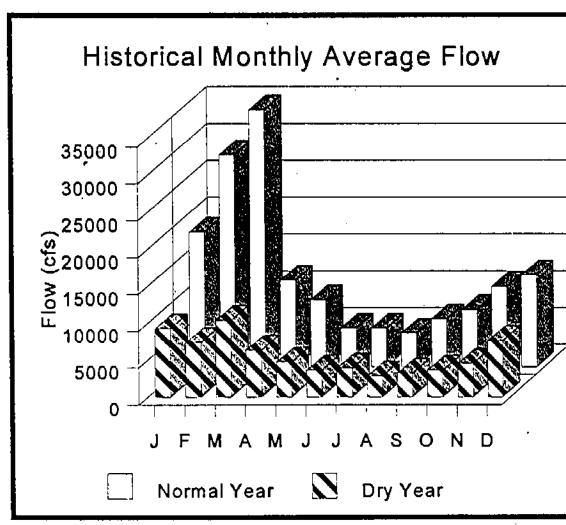
Hydrology is the physical process with the greatest influence on aquatic and wetland habitats, the many species of plants and animals that use the Bay, and the concentrations of pollutants in the marshes and North Bay. In areas downstream of the X2 isohaline (low salinity zone) which are well-mixed, ocean tides clearly dominate over and above freshwater inflow. The historical dominance of halophytic vegetation in Suisun Marsh also suggests that tidal hydrology may be more important to Suisun than freshwater inflows. The historical tidal prism prior to diking of the Suisun and North Bay marshes was also higher than present condition.

Freshwater inflow to the North Bay varies greatly from year to year. In 70 years of historical record, Bay inflow has ranged from a high of 50 million acre-feet (af) to a low of 8 million af, with an average of approximately 24 million af. During this period, freshwater inflow to the Bay has changed markedly because of upstream water storage in reservoirs and water-supply diversions developed in 1940s, 1950s, and 1960s. Spring freshwater inflows, which once averaged 20,000 to 40,000 cubic feet per second (cfs) in dry years and 40,000 to 60,000 cfs in normal years, now average only 6,000 to 10,000 cfs in dry years and 15,000 to 30,000 cfs in normal years. In the driest years, spring freshwater inflows from the



Unimpaired Delta Outflow, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Delta were formerly 8,000 to 14,000 cfs; presently these flows average only 2,500 to 3,000 cfs. In dry and normal years, summer flows have remained in the range of 4,000 to 8,000 cfs, because channels carry irrigation water and Delta outflow needed to meet water quality criteria in the Delta. Winter freshwater inflows from the Delta in dry and normal years have been reduced from former levels of 15,000 to 60,000 cfs to current levels of 7,000 to 35,000 cfs because much of the runoff from winter rains and snowmelt is now stored in foothill reservoirs. Flows in highest rainfall years are relatively unchanged, although short-term peaks are reduced by flood-control storage in large foothill reservoirs.



Historical Delta Outflow, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Freshwater inflows from the local watershed in the Vaca Mountains and Coast Range have also been modified from historic conditions. This influence, however, needs further review to clarify potential adverse downstream impacts.

Natural flood and floodplain processes are the periodic inundation of the floodplain during tidal cycles and peak flow events that would typically occur in late winter and spring during all but the driest years. Land reclamation and levee construction have eliminated much of the natural North Bay floodplain. This floodplain reduction forces water to rapidly exit the marshes and bays through confined channels and sloughs. While flows in most high rainfall years may be relatively unchanged, very large floods can devastate shoreline areas of the North Bay due to loss of floodplain and flood basin storage and other dampening effects of floods.

Aquatic foodweb productivity in the North Bay has declined over the past several decades due to several factors, including loss of tidal exchange, changes in freshwater inflow, Delta conditions, water diversions, water quality, and the introduction of exotic species. Foodweb productivity, beginning at the primary production level (i.e., plant cell production), is essential to maintaining important fish population. Primary productivity in the North Bay and adjacent marshes depends on spring freshwater flow events to bring in essential nutrients and recycle nutrients in the marshes. Primary productivity has been limited by heavy infestations of Asian clams that efficiently filter algae from the water column thus reducing the standing crop of phytoplankton.

With the reclamation of tidal marshes in the North Bay, there was an accompanying loss of shallow-water aquatic habitats on which many marine, estuarine resident and anadromous fish and estuarine invertebrates depend. Shallow-water habitats around the North Bay provide spawning and rearing habitat for many native resident Bay-Delta fishes and important rearing and migratory habitat for many Central Valley salmon and steelhead populations. Tidal perennial aquatic habitat benefits native waterfowl, wading and shorebirds, and other wildlife, as well as native plants that depend on such habitat.

Lakes and ponds (nontidal perennial aquatic habitats) found behind levees on reclaimed islands support simple invertebrate communities, riparian habitat, and wintering waterfowl. Such habitat within the North Bay also benefits waterfowl, as well as many plant and wildlife species.

After more than 100 years of land reclamation activities in the North Bay and marshes, many linear miles of natural sloughs have been lost. Sloughs are important spawning and rearing areas for many Bay-Delta fish species, as well as waterfowl and other wildlife. Of the natural sloughs that remain, most have severely degraded natural habitat values from loss of the tidal prism, dredging, levee confinement, riparian vegetation loss, high water flow, and poor water quality (i.e., from municipal, industrial, and agricultural drains).

Tidal marshes (including tidal perennial aquatic habitat, saline emergent wetlands, tidally influenced fresh emergent wetlands, and sloughs), once the most widespread habitat in the Bay-Delta, are now restricted to remnant patches. There have been extensive losses of saline emergent wetland habitat in the North Bay and adjacent marshes. Most of the remaining saline emergent wetlands lack adjacent upland transition habitat and other attributes of fully functioning saline emergent wetlands because of agricultural practices and urban and industrial development. Saline emergent wetlands provide important habitat for many plants, waterfowl, and other wildlife species. In addition, saline emergent wetlands contribute important plant detritus and nutrient recycling to the aquatic foodweb of the Bay-Delta estuary, as well as important habitat to some fish and aquatic invertebrate species.

Seasonal wetlands include vernal pools, wet meadows or pastures, and other seasonally wetted habitats, such as managed duck clubs. Most of this habitat is located on levee-protected lands. Such habitats were once very abundant during the winter rainy season or after seasonal flooding. With reclamation, flooding occurs primarily from accumulation of rainwater behind levees, from directed overflow of flood waters to bypasses, or from flooding leveed lands (e.g., managed wetlands). Seasonal wetlands are important habitat to many waterfowl, shorebird, and other wildlife species.

Upland habitats are found mainly on the outer edges of the North Bay and adjacent marshes. They consist primarily of grasslands and remnant oak woodland and oak savanna (intermittent woodland and grassland). Perennial grasslands are an important transition habitat for many wildlife species and are buffers to protect wetland and riparian habitats. Much of the grassland habitat associated with wetlands has been lost to agriculture (i.e., pasture, grain, vineyards, and orchards) and development (i.e., home construction, golf courses). Grasslands are important buffers for wetland habitat and provide habitat for many plant and animal species.

Riparian habitat, both forest and shrub, is found on the water and land side of levees, berms, berm islands, and in the interior of some islands. This habitat ranges in value from disturbed (i.e., sparse, low value) to relatively undisturbed (i.e., dense, diverse, high value). The highest value riparian habitat has a dense and diverse canopy structure with abundant leaf and invertebrate biomass. The canopy and large woody debris in adjacent aquatic habitat provide the shaded riverine aquatic habitat that many important fish and wildlife species depend on during some portion of their life cycles. The lower value riparian habitat is frequently mowed, disced, or sprayed with herbicides, resulting in a sparse habitat structure with low species diversity.

Riparian habitat is used by more wildlife than any other habitat type. From about 1850 to the turn of the century, most of the riparian forests in the Bay-Delta were cut down for fuelwood as a result of the Gold Rush, river navigation, and agricultural clearing. Remnant patches are found on levees, channel islands, and along the margins of the North Bay and adjacent marshes. Riparian habitats and their adjacent shaded riverine aquatic habitat benefit many fish and wildlife species.

Agricultural habitats also support populations of small animals, such as rodents, reptiles, and amphibians, and provide opportunities for foraging raptors (soaring birds of prey, such as hawks and eagles). Nonflooded fields and pastures are also habitat for pheasants, quail, and doves. The North Bay and adjacent marshes support a variety of wintering and breeding raptors. Preferred habitat consists of tall trees for nesting and perching near open agricultural fields, which support small rodents and insects for prey. Both pasture land and alfalfa fields support abundant rodent populations. The Swainson's hawk, a raptor species listed by the State as threatened, breeds and occasionally winters in the Bay-Delta.

Water diversions in the North Bay and adjacent marshes divert freshwater inflow and brackish waters. Though diversions vary seasonally, relatively high rates can occur in any month of the year. Most water diverted from the North Bay and marshes is used locally. With many diversions unscreened or poorly screened, great numbers of fish and aquatic invertebrates are lost. In addition to organisms, diversions remove a disproportionately large portion of the nutrients and detrital (organic debris) load that drive the Bay-Delta foodweb. Losses of fish, invertebrates, and nutrients and organic debris limit the potential for the recovery of many fish species and improving Bay-Delta aquatic foodweb productivity. Lack of adequate screening and location of water diversions in sensitive areas contribute to the loss of important fish and aquatic foodweb organisms.

Levee construction and bank protection have led to the loss of wetland and shallow-water habitat throughout the North Bay and adjacent marshes. Habitat on levees and shorelines needs improvement to restore biodiversity and ecological functions needed for Bay-Delta aquatic and wildlife resources. Riparian habitats in this zone are found along the tributary streams in the upper reaches. Riparian habitat is not generally found in areas subject to reclamation by levee construction due to high salinity.

Dredging and disposal of dredge materials have contributed to the loss and degradation of important aquatic habitats such as tidal wetlands, mudflats, and sloughs in the North Bay and adjacent marshes.

Over the past several decades, the accidental introduction of many marine and estuarine organisms from the ballast waters of ships from the Far East has greatly changed the planktonic and benthic invertebrate fauna of the Bay-Delta, with further ramifications higher in the foodweb. Further changes can be expected if restrictions are not made on ballast water releases into the San Francisco Bay and Delta.

Toxins continue to enter the North Bay and adjacent marshes in large amounts from municipal, industrial, and agricultural discharges. The toxins have had a demonstrated effect on the health, survival, and reproduction of many important Bay-Delta fish and their foodweb organisms. Toxins in fish tissues are also a health risk to people who eat Bay-Delta fish. Continued reductions of toxins from discharges and releases from the sediment (e.g., disturbed by natural forces and dredging) are essential to the restoration program.

The legal and illegal fish harvest may limit recovery of some populations in the Bay-Delta and its watersheds. Sturgeon harvest in the North Bay and elsewhere may affect recovery of these populations.

Boat traffic in sloughs and channels contributes to the erosion of remaining shallow water, riparian, and wetland habitat. High boat speeds and traffic in channels where remnant or restored habitats are exposed to wave erosion jeopardize remnant habitat and limit the potential success of habitat restoration efforts. For example, an increase in jet ski use in Suisun Marsh following the improvement of local public launch facilities is also causing erosion and noise disturbance problems directly impacting sensitive channel side plant communities and nesting clapper rails in relict tidal marsh habitats.

The delta smelt population of the Bay-Delta estuary is a federally and state-listed threatened species. It depends on the North Bay and adjacent marshes for spawning and rearing habitat. It lives in fresh and brackish bays and sloughs of the Bay-Delta. Its decline is related to poor habitat conditions during drought periods. It benefits from high freshwater inflow, particularly during the late winter and spring of dry years, adequate slough and shallow water habitat, reduced effects of water diversions, and increased the aquatic foodweb productivity.

The longfin smelt populations of the Bay-Delta lives within the brackish water and saltwater of northern San Francisco Bay and migrate upstream into the Delta to spawn. The decline in the longfin smelt population has coincided with a number of changes in the estuary including: low flows in late winter and spring, reduced freshwater flows through the Delta and into Suisun Bay, water diversion (particularly in drier years), and contaminants.

Like delta smelt, splittail is a native resident species of the Bay that depends on the North Bay and adjacent marshes for much of its life cycle for spawning, rearing, and feeding. The splittail is a recently listed federal threatened species. The Bay-Delta population has declined, especially during recent droughts. Splittail depend primarily on shallow water habitats, including shorelines, sloughs, and aquatic habitats associated with wetlands and floodplain lands subject to seasonal inundation (e.g., the adjacent marshes of the North Bay). The splittail population benefits from wetland and slough habitat, a more productive aquatic foodweb, and higher late winter and spring freshwater flows during dry years. Losses to water diversions may also be a limiting factor.

White sturgeon and green sturgeon populations in the Central Valley use the North Bay for migrating, feeding, and as a nursery area for young and juveniles. Populations appear to be stable, but the green sturgeon is a California species of special concern due to low population size. Sturgeon benefit from high late winter and spring freshwater inflow, a productive aquatic foodweb, and bay habitat. Legal and illegal harvest and losses to water diversions may be limiting population abundance.

All four runs of chinook salmon in the Central Valley depend on the North Bay and adjacent marshes during at least a portion of their life cycle. The North Bay and adjacent marshes provide migratory and rearing habitat for salmon in all months. Many chinook salmon populations have declined in recent decades from a combination of ocean, river, and Bay-Delta factors. Freshwater flow reductions through the Bay-Delta and increases in water diversions have led to declines in salmon populations. Improving late winter and spring freshwater flows through the Bay-Delta and reducing losses to diversions are essential needs in salmon recovery.

Chinook salmon also benefit from lower water temperatures in spring and fall, as well as adequate aquatic habitats and high foodweb productivity. Tidal perennial marsh habitat and adjoining sloughs and aquatic habitats in the North Bay and adjacent marshes are important juvenile rearing habitat. Juvenile chinook salmon are lost to water diversions in North Bay and adjacent marshes.

Steelhead were historically present in the Napa River, Sonoma Creek, and Petaluma River Ecological Management Units, and are still present in most of these streams. The major factor limiting steelhead populations in these streams is agricultural development including water diversion, barriers due to diversion dams, high water temperatures and other water quality impacts from urban and agricultural runoff.

The striped bass population of San Francisco Bay and the Sacramento and San Joaquin rivers depends on the North Bay and adjacent marshes for much of its life cycle. The North Bay and adjacent marshes provide important feeding and juvenile rearing habitat for striped bass. Reduced freshwater flow and increased water diversions have resulted in a declining striped bass population over the past several decades. Poor Bay-Delta water quality may also be limiting survival of young and adults. Striped bass also benefit from high aquatic foodweb productivity. Loss of tidal perennial aquatic, wetland, and slough habitats may also limit striped bass production. Many striped bass young are lost in water diversions. Artificially rearing young striped bass salvaged at south Delta pumping plant fish facilities or supplementing production with hatchery reared fish may be necessary to sustain the population under present limiting factors.

American shad is an anadromous fish that spawns in the Sacramento River and its major tributaries. They pass through the Bay-Delta on their upstream spawning migration in spring, and in the fall, young fish pass through on their way to the ocean. A small portion of the population rears in North Bay waters. Though the population appears stable and healthy, low productivity in drought periods is a concern. American shad production is higher with higher late winter and spring freshwater flow through the Bay-Delta in dry and normal rainfall years, improved aquatic foodweb production, and lower relative rates of water diversions.

There are many native and non-native fish species resident to the Delta, like delta smelt and splittail, that will benefit from improved aquatic habitats and foodweb production in the Delta. Many native fish species have declined gradually over the past century from habitat loss and non-native fish introductions. More recently native resident (nonmigratory) species have further declined from changes in freshwater flow, water diversions, poor water quality, and further non-native species introductions and habitat degradation. For many of these species, improvements to their native habitats, including sloughs and tidal marshes, are essential in restoring these populations. Native residents will also benefit from more natural freshwater flow patterns, improved water quality, and reduced losses to water diversions.

Marine fishes include many species that are abundant and important ecologically in the Bay and coastal waters. Two ecologically valuable species are the Pacific herring and northern anchovy, whose young are important in the foodweb as prey of salmon, sturgeon, and striped bass, as well as other fish and waterfowl such as cormorants and terns. Pacific herring, Dungeness crab, and Bay shrimp also support commercial fisheries. Starry flounder contribute to the local Bay-Delta sport fishery. The Bay and Delta are essential spawning and nursery areas for many marine fish and invertebrates found in the Bay and coastal waters.

Factors that affect the survival and production of marine fish and invertebrates in the Bay-Delta include Delta outflow, water diversions, foodweb productivity, availability and quality of shallow water and wetland habitats, and water quality. In addition, the aquatic foodweb is linked to the transitional wetland foodweb which extends up into the high marshes and adjacent uplands. These are important ecological links which contribute to the detrital based portion of the aquatic foodweb.

Improvements in production and survival of marine and estuarine fishes in the Bay and Delta will provide ancillary benefits to important estuarine, anadromous, and resident fishes of the Bay-Delta.

Many marine species depend on the North Bay and adjacent marshes for spawning or as nursery areas. Pacific herring spawn in the Bay each winter, and their young are abundant in the North Bay into summer. Young northern anchovy spawned in the ocean enter the North Bay each summer to feed. Starry flounder, shiner perch, and many other marine-estuarine fish also use the Bay for spawning, rearing, and feeding. Dungeness crab use the North Bay as a nursery area. Several shrimp species are abundant in the North Bay.

Bay-Delta aquatic foodweb organisms include bacteria, algae, zooplankton (e.g., copepods and cladocerans), epibenthic invertebrates (e.g., crayfish, Neomysis and Crangon shrimp), and benthic invertebrates (e.g., clams). Foodweb organisms are essential for the survival and productivity of fish, shorebird and other higher order animal populations in the Bay-Delta estuary. Some organisms are non-native species (e.g., certain zooplankton and Asian clams) that may be detrimental to native species and the foodweb in general. Recent declines in aquatic foodweb organisms of the Bay-Delta, particularly in drier years, has caused a reduction in overall Bay-

Delta productivity. Important aquatic foodweb organisms include algae, bacteria, rotifers, copepods, cladocera, and mysid shrimp.

Once possibly abundant, the giant garter snake and western pond turtle are now rare in the Bay-Delta. Improvements in wetland, riparian, and grassland habitats around the Delta margins could greatly benefit these species.

Once abundant in the Bay-Delta, Swainson's hawks are now rare. Improvements in agricultural, grasslands, and riparian habitats will aid in Swainson's hawk recovery.

The California clapper rail is State and federally listed as an endangered species. A long-term decline in tidal emergent wetlands has reduced the population in the Bay-Delta.

A long-term decline in emergent wetlands has reduced the California black rail population in the Delta. Restoring emergent wetlands in the Delta should aid in California black rail recovery.

The Suisun song sparrow lives only in the Suisun Bay marshes. It depends on brackish marsh and riparian habitats. Its population has declined with the loss of brackish marshes.

The salt marsh harvest mouse is a State and federally listed endangered species. It depends on tidal salt marshes and its population has declined with the loss of tidal salt marsh habitat.

Herons, egrets, and other shorebirds and wading birds breed and winter throughout the Central Valley, the North Bay, and adjacent marshes. Their populations depend on aquatic and wetland habitats. Shorebirds and wading birds will benefit from restoring wetland, riparian, aquatic, and agricultural habitats.

Many waterfowl species overwinter in the Bay-Delta and depend on high-quality foraging habitat to replenish their energy reserves. They depend on wetland, riparian, aquatic, and agricultural habitats. Many resident and migratory waterfowl species will benefit from improved aquatic, wetland, riparian, and agricultural habitats.

LIST OF SPECIES TO BENEFIT FROM RESTORATION ACTIONS IN THE SUISUN MARSH/NORTH SAN FRANCISCO BAY ECOLOGICAL MANAGEMENT ZONE

- delta smelt
- longfin smelt
- splittail
- chinook salmon
- steelhead trout
- striped bass
- green sturgeon
- white sturgeon
- American shad
- native resident fishes
- Pacific herring
- marine fishes and shellfishes
- Bay-Delta foodweb organisms
- grass shrimp
- special status plants
- California freshwater shrimp
- giant garter snake
- western pond turtle
- Swainson's hawk
- California clapper rail
- California black rail
- Suisun song sparrow
- salt marsh harvest mouse
- San Pablo California vole
- Suisun ornate shrew
- shorebirds
- wading birds
- waterfowl
- Delta green ground beetle
- Lamprey.

DESCRIPTIONS OF ECOLOGICAL MANAGEMENT UNITS

SUISUN BAY AND MARSH ECOLOGICAL MANAGEMENT UNIT

The boundaries of the Suisun Bay and Marsh Ecological Management Unit are Collinsville on the east, the Contra Costa County shoreline to the south, the Benicia Bridge to the west, and the ridge tops of the Coast Ranges to the north. The marshland and bay are in a valley, bordered on the north and south by the Coast Ranges. The predominant habitat types in this zone are tidal perennial aquatic habitat, tidal brackish emergent wetland, seasonal nontidal wetland, and grassland. The marsh is primarily a managed wetland, with levees to control water level and seasonal flooding with fresh water.

Historically, the eastern portion of Suisun Marsh was predominantly tidal fresh and brackish water marsh. The western portion of the marsh was predominately fresh and brackish marshland with more saline marsh existing on the western edge. Within these broad marshes were sloughs, channels, ponds, and small bays. Except for parts of Suisun Bay, the segment had relatively few tidal flats. Large areas of moist grasslands connected the baylands with upland areas (Goals Project 1999).

An extensive network of sloughs conveys tidal flows and some freshwater flow into the marsh. Montezuma Slough, the largest of these, is connected to Suisun Bay at its eastern and western ends. The slough is an important nursery area for many fish, including chinook salmon, striped bass, splittail, and delta smelt. The Suisun Marsh Salinity Control Structure was constructed near the eastern slough entrance and began operation in the fall of 1988 to limit the tidal influx of saltwater from the Bay into Suisun Marsh. The salinity control structure operates from September through May by closing during flood tides and opening during ebb tides to keep salinity in the slough low throughout the managed wetland flooding season.

Efforts in the 1970s resulted in protecting the Suisun Marsh, the largest remaining brackish marsh in California. The marsh is an extremely important resource for migratory waterfowl, associated wildlife (including several threatened and endangered species), and many fish species. The marsh also harbors sensitive plant species and communities including several rare species. The Suisun thistle is a Suisun endemic and is found nowhere else in the world. The Suisun Marsh Protection Plan played a key role in reducing development pressure and other adverse impacts associated with human disturbance, such as accidental fires, careless application of pesticides and herbicides, and urban runoff.

NAPA RIVER ECOLOGICAL MANAGEMENT UNIT

The Napa River Ecological Management Unit is within the Napa River watershed and includes the river, an extensive marsh/slough complex, and the lower river estuary connecting to San Pablo Bay. Historically, this area was nearly all tidal salt marsh and tidal brackish marsh dominated by the flow patterns of the lower Napa River (Goals Project 1999). Currently, most of the baylands have been reclaimed for salt or agricultural production. A network of sloughs fringed by saline emergent marsh is also present. The sloughs have become silted as a result of lost tidal prism. The baylands are surrounded by uplands composed primarily of grasslands which are rapidly being converted to urban and agricultural (vineyard) uses. In the north, natural upper river watershed habitats have been reduced by agricultural and urban development and flood control measures. Vernal pools and other seasonal wetland habitats characteristic of the upper watershed have been almost entirely eliminated in the Napa River Ecological Management Unit.

The Napa River historically consisted of a fairly broad riparian corridor and programs to restore riparian and shaded riverine aquatic habitat will be an important component of the program, particularly in the upper Napa River area to provide habitat for wildlife and aquatic habitat for fish species. The tidal marshes of this area are of limited size and habitat quality due to past reclamation. Remaining tidal marshes are linear with little channel development. The larger sloughs have silted up due to a reduced tidal prism.

SONOMA CREEK ECOLOGICAL MANAGEMENT UNIT

The Sonoma Creek Ecological Management Unit is located southwest of the Napa River Ecological Management Unit. The main habitat types in the area are tidal and seasonal marsh, tidal sloughs, and upland areas, such as vernal pools, grassland, and savanna. Historically, this area was nearly all tidal salt marsh and tidal brackish marsh. Some areas of moist grasslands existed to the north and west along upper Sonoma Creek and in the drainages surrounding Lake Tolay (Goals Project 1999).

The lower portions of the unit are baylands, composed of tidal sloughs with fringing marshes, some diked managed wetlands, diked farm lands, mostly oat and hay, and surrounding uplands characterized by grasslands, vernal pools, and oak woodlands quickly being converted to vineyards. Tidal marshes and channels are reduced as a result of reclamation. Seasonal wetlands develop during the rainy season on reclaimed agricultural lands. Urban development along the upper river is associated with the city of Sonoma. Vineyards are the predominant land use in the upper watershed, particularly on the valley floor. The mountains of the watershed are characterized by oak woodlands, chaparral, and mixed conifer habitats. As in the Napa River Ecological Management Unit, much of the vernal pool, seasonal wetland and oak savanna habitat previously present on the valley floor has been eliminated as a result of agricultural and urban development.

Petaluma River Ecological Management Unit

The Petaluma River Ecological Management Unit is located west of the Sonoma Creek unit on the northwest margin of San Pablo Bay. The habitat types in this watershed are marsh wetlands and uplands, such as grassland. The lower portion of the watershed is composed of tidal marshes and sloughs, and diked seasonal wetlands and historic bayland which have been reclaimed for agriculture. Historically, tidal marsh was the dominant habitat type in this ecological management unit. Salt marsh existed near the mouth of the Petaluma River, and small tidal flats existed at the river mouth (Goals Project 1999).

The diked agricultural lands intermittently pond water during the rainy season which provided habitat for shorebirds and waterfowl. The surrounding uplands are characterized by open grasslands and oak savannas. This unit contains the largest extant natural tidal marsh on the west coast. The upper watershed is rapidly developing with Petaluma, the largest city. Agricultural uses include grazing, oat hay production, and vineyards.

San Pablo Bay Ecological Management Unit

The San Pablo Bay Ecological Management Unit includes San Pablo Bay and the adjacent mudflat and marsh baylands, both diked and non-diked. Habitat varies from deep bay marine habitat to edge mudflats and marsh/slough complexes. Bay habitat varies from nearly fresh water at its eastern end, during periods of high freshwater outflow, to nearly seawater salinity levels (32 parts per thousand) during the periods of lowest outflow at the western end of San Pablo Bay. Salinity in the bay is stratified (layered) during high outflow conditions, but is not stratified in dry periods/years. The mixing zone is upstream is San Pablo Bay in dry years.

Historically, this unit supported large tidal marshes that were bordered by extensive mudflats (Goals Project 1999). Although it is generally less productive than the less saline Suisun Bay to the east, San Pablo Bay is a productive estuary that has important spawning and rearing habitat for many marine, estuarine, and anadromous fish and marine-estuarine invertebrates (e.g., shrimp, crabs, and clams).

Vision for the Ecological Management Zone

The vision for the Suisun Marsh/North San Francisco Bay Ecological Management Zone includes the concept of "whole marsh management." This vision embodies key parameters needed to successfully restore ecological processes, habitats, and to restore, maintain, or recover a wide diversity of fish, wildlife, and plant species.

The Goals Project (1999) proposed a series of key considerations in restoration of the Suisun Marsh/North San Francisco Bay Ecological Management Zone. The considerations include:

- large, connected patches of tidal marsh habitat centered on existing populations of species concern (e.g., salt marsh harvest mouse, California clapper rail),
- placement of tidal marshes along the edge of the Bay an at the mouths of tributary streams to maximize benefits for aquatic organisms,
- incorporating natural features such as large tidal channels, marsh ponds, transitional pannes, and beaches to optimize habitats for many species of fishes, shorebirds, and waterfowl,

- utilize managed saline and seasonal ponds near mudflats to provide high-tide habitat for shorebirds,
- provide natural habitat transitions between bayland habitats and adjacent upland habitats to provide habitat required by many special status plant species,
- provide continuous corridors of riparian habitat along streams tributary to the Bay, and
- maintain upland buffers to protect all existing and restored wetland habitats from disturbance.

The vision for the Suisun Marsh/North San Francisco Bay Ecological Management Zone includes providing a more natural freshwater outflow pattern from the Delta in dry and normal rainfall years, restoring tidal and nontidal wetlands, restoring tidal perennial aquatic habitat, and screening unscreened and poorly screened diversions. These changes will assist in the recovery of special-status species and increase important fish, wildlife, and plant communities. Local and regional agency and stakeholder initiatives will help attain this vision.

The vision focuses on improving the natural freshwater inflow pattern to San Francisco Bay and restoring important, tidally influenced aquatic and wetland habitats and adjacent uplands. Other focal points are reducing stressors, such as non-native marine invertebrates in ship ballast water and contaminants in municipal, industrial, and agricultural discharges into the Bay, and reducing losses of juvenile fish and their food organisms at unscreened diversions. Habitat improvements will benefit the salt marsh harvest mouse, Suisun song sparrow, California clapper rail, and California black rail, as well as many native waterfowl and wildlife species living in and around the North Bay. Improving freshwater inflow and habitat will benefit delta smelt, splittail, chinook salmon, striped bass, longfin smelt, and other anadromous and resident marine and estuarine fishes and larger marine invertebrates (e.g., shrimp, crabs, and clams) of the Bay, as well as the estuarine foodweb (e.g., algae and planktonic and bottom-dwelling animals) on which the fish depend. Separate visions have been prepared for many of these processes, stressors, habitats, and species. Volume I contains additional detail on the status and restoration needs of these resource elements and the specific restoration approach.

The vision for the Suisun Marsh/North San Francisco Bay Ecological Management Zone is closely tied to the vision for the Sacramento-San Joaquin Delta Ecological Management Zone. It is indirectly related to visions for the mainstem rivers and tributary watersheds. Flows and habitats in these areas are integrally linked. Many important anadromous fish and waterfowl species that use the Central Valley are affected by conditions in multiple Ecological Management Zones.

Restoring Suisun Marsh and North San Francisco Bay will improve the natural production of marine, estuarine, and anadromous fish; resident wildlife; migratory waterfowl; other winter migrants and neotropical birds; and special-status plants, plant communities, and associated terrestrial invertebrates. Several waterfowl species whose populations have declined in recent times, such as the canvasback and redhead, should also benefit.

Improving Suisun Marsh and North San Francisco Bay health will help to achieve the restoration goals set for the Sacramento-San Joaquin Delta Ecological Management Zone. Likewise, improving conditions in the Sacramento-San Joaquin River Delta (Delta) will benefit the Bay.

Goals for the Suisun Marsh/North San Francisco Bay Ecological Management Zone include protecting and enlarging remaining areas of native habitat and establishing connectivity among these areas. Enlarging the San Francisco Bay and San Pablo Bay National Wildlife Refuges and other State and local wildlife areas; expanding restoration efforts in the Napa Marsh area, Petaluma Marsh, and Sonoma baylands; and restoring connectivity among these features will help achieve the vision for this Ecological Management Zone. Expanding restoration efforts in the northeastern portion of Suisun Marsh and restoring connectivity with areas such as the Jepson Prairie Preserve in the Yolo Basin Ecological Management Zone and the Sacramento-San Joaquin Delta Ecological Management Zone will also contribute to this effort.

Potentially high-quality spawning, rearing, and migrating habitat will be restored to benefit important fish species that use Suisun Marsh and the Bay during at least a portion of their lives. This effort includes improving freshwater inflow patterns, particularly in dry and normal water years, and restoring extensive areas of tidal aquatic and wetland habitats in Suisun Marsh and the Bay.

VISIONS FOR ECOLOGICAL MANAGEMENT UNITS

SUISUN BAY AND MARSH ECOLOGICAL MANAGEMENT UNIT

The vision for the Suisun Bay and Marsh Ecological Management Unit is to restore tidal marsh and to restore and enhance managed marsh, riparian forest, grassland, and other habitats.

Efforts and opportunities to restore tidal action to selected managed wetlands and promote natural riparian and wetland succession in Suisun Marsh will be expanded. Shallow-water, wetland, and riparian habitats within the marsh and along the shorelines of the Bay will be protected and improved, where possible. Upland habitats adjacent to riparian and wetland habitats will also be protected and improved. Efforts will focus on increasing the acreage open to tidal flows (e.g., by removing or opening levees) and providing connectivity among habitat areas to aid in the recovery of species, such as the salt marsh harvest mouse, clapper rail, and black rail. Those habitat areas will provide essential shelter and nesting cover during high tides. Improving marsh and slough habitats will benefit chinook salmon, striped bass, delta smelt, splittail, and other estuarine resident fish in the marsh and Suisun Bay.

Diverting water from Suisun Marsh channels for managed nontidal wetlands and controlling the salinity of water entering the marsh through Montezuma Slough will continue, but with consideration for maintaining the natural hydrologic regime and salinity levels of the slough and marsh. Efforts to screen diversions in the marsh will also continue to minimize the entrainment of juvenile fish. Water quality standards specified in the 1995 Water Quality Control Plan will be met in the eastern marsh and at several locations in the central marsh. Flows into the northwestern marsh will be improved.

Water diversions from Suisun Bay for cooling at the Pittsburg power plant will be conducted with minimal adverse effects on eggs, larvae, and juvenile fish. New fish screening technology or alternative sources of cooling water (such as cooling towers) will be considered.

Oil refinery operations in the Bay will be modified to reduce discharges of high levels of contaminants, such as selenium.

Suisun Marsh and Suisun Bay will function as high-quality spawning and rearing habitat and an effective fish migration corridor. A healthy Suisun Marsh-Bay ecosystem will be an important link in the estuary foodweb by improving primary and secondary productivity. Marsh and Bay productivity will improve as freshwater inflow events increase in dry and normal years and acreage of tidal wetlands and associated tidal perennial aquatic habitat increases.

NAPA RIVER ECOLOGICAL MANAGEMENT UNIT

The vision for the Napa River Ecological Management Unit is to restore large areas of tidal marsh to benefit salt marsh harvest mouse and California clapper rail; manage inactive salt ponds to benefit waterfowl; restore a continuous band of tidal marsh along the bayshore to benefit fish species; improve tidal circulation; manage diked wetlands and seasonal wetlands to improve seasonal ponding for shorebirds, wading birds and waterfowl; enhance riparian vegetation and marsh/upland transitional habitats; and provide upland buffers.

Restoration efforts will be focused in the Napa Marsh Wildlife Area, Cullinan Ranch, and Scagg Island. Habitats should be protected and natural expansion and succession should be supported to restore large, contiguous (connected) areas of tidal saline emergent wetland, riparian, and upland habitats. The existing habitat areas are sparse and low quality, because dikes and levees have disrupted the natural tidal flows and sediment supply that are essential to maintain marsh habitat. Restoring tidal action to additional portions of the marsh and improving water quality will enhance the health of the marsh. This, in turn, will aid in the recovery of species, such as the salt marsh harvest mouse and clapper rail in the southern part of the Ecological Management Unit. Fish species, such as chinook salmon, striped bass, splittail, and delta smelt, will benefit from the improved health of the marsh and associated improvements in the tidal slough complex and lower river estuary.

Sonoma Creek Ecological Management Unit

The vision for the Sonoma Creek Ecological Management Unit is to restore large patches of tidal marsh along the entire shoreline of San Pablo Bay; restore tidal marsh along Sonoma Creek; establish managed marsh or enhanced seasonal pond habitat for shorebirds; enhance riparian habitat along Sonoma Creek; and enhance marsh/upland transitional habitats.

Existing habitat will be maintained, and current and future restoration efforts in Napa/Sonoma Marsh will be expanded. The marsh is sparse and low quality, because dikes and levees have disrupted the natural sediment supply essential for maintaining marsh habitat. Leveed, historic marshland will be opened to tidal action, creating larger, more contiguous marsh areas. An expanded marsh/slough complex will support greater salt marsh harvest mouse and clapper rail populations, as well as splittail, delta smelt, juvenile chinook salmon, and striped bass. Restoration of existing managed marshlands may not be desirable as these lands support significant numbers of shorebirds and waterfowl. To achieve the restoration objective, acquisition and restoration of other diked baylands may be required.

Petaluma River Ecological Management Unit

The vision for the Petaluma River Ecological Management Unit is to restore a continuous band of tidal marsh along the bayshore from Tolay Creek to the Petaluma River; restore tidal marsh along the Petaluma River; establish managed marsh or enhanced seasonal pond habitat on agricultural baylands not restored to tidal habitat; protect moist grasslands; enhance riparian vegetation and marsh/upland transitional habitats; and to provide upland buffers and provide natural transitional habitat between marshes and upland areas.

Petaluma Marsh and its associated tidal slough network will be expanded. Outside of Petaluma Marsh, marsh habitat areas are sparse and low quality, because dikes and levees have disrupted the natural tidal flow and sediment supply essential for maintaining tidal emergent wetland habitat.

San Pablo Bay Ecological Management Unit

The vision for the San Pablo Bay Ecological Management Unit is to restore tidal marsh along the bayshore and to establish managed marshes or enhance seasonal pond habitat on agricultural baylands not restored to tidal action.

The ecological health of San Pablo Bay and its function as an important nursery area for marine, estuarine, and anadromous fish can be improved by increasing freshwater inflow in spring during years with low and normal freshwater outflow, protecting and expanding tidal marsh/slough habitat complexes along the margins of the bay, and reducing the input of pollutants into the bay. Removing dikes and levees along the bay's shoreline, where appropriate, will aid in the recovery and expansion of tidal emergent wetland habitat.

Visions for Ecological Processes

Central Valley Streamflows: A healthy pattern of freshwater inflow to Suisun Marsh and the North Bay would involve natural late-winter and spring flow events that support ecological processes and functions essential to the health of important Bay-Delta fish populations. Inflow to the Bay is impaired in dry and normal water years by storage and diversion of natural inflow to basin watersheds. The need for inflow to the Bay coincides with the need for natural flows in the mainstem rivers, their tributaries, and the Delta.

Natural Floodplain and Flood Processes: Expansion of the North Bay floodplain by setting back or removing levees would enhance floodwater and sediment retention and provide direct and indirect benefits to fish and wildlife that depend on natural floodplain inundation. Such floodplain expansion should also help to alleviate the flooding potential in other areas of the Bay-Delta.

Bay-Delta Aquatic Foodweb: The aquatic foodweb of the Delta, which supports important resident and anadromous fish, has been severely impaired by drought, reductions in freshwater flow, water diversions, introductions of non-native species (e.g., Asiatic clams), and loss of shallow water and wetland habitats. Proposed improvements in spring flows, channel hydraulics, wetland habitats, and floodplain inundation should lead to a healthier and more productive aquatic foodweb. Improved water quality and greater sediment retention in wetland, riparian, and floodplain habitats will also increase foodweb productivity.

VISIONS FOR HABITATS

TIDAL PERENNIAL AQUATIC HABITAT: Aquatic habitat within and associated with tidal wetland habitat is important to fish populations that use the Bay. The area of such habitat has been substantially reduced over the past century by land reclamation. Large areas of tidal habitat have been diked and reclaimed for agriculture, salt production, industry, nontidal wetlands (e.g., duck clubs), and other uses. Restoring large areas of presently leveed land to tidal influence may increase important fish species production by providing more spawning, feeding, and migrating habitat and increasing foodweb production throughout the Bay.

NONTIDAL PERENNIAL AQUATIC HABITAT: Open water habitats in managed wetlands, such as ponds, provide valuable waterfowl and wildlife habitats. Such habitat should be included in restoration efforts involving nontidal saline emergent wetlands.

TIDAL SLOUGHS: Sloughs are an important native habitat for fish and wildlife. Many slough complexes in the wetlands along the North Bay have disappeared as a result of land reclamation and levee construction. Restoring tidal wetland-slough complexes will provide valuable habitat for fish, including chinook salmon, striped bass, delta smelt, and longfin smelt.

SALINE EMERGENT WETLANDS (TIDAL): Tidal saline emergent wetland habitat in the Bay has been drastically reduced as a result of land reclamation. Such habitat is essential to estuary functions and the health of many fish, waterfowl, and wildlife species. Wetlands also enhance water quality in the Bay by filtering out sediments and contaminants.

SEASONAL WETLANDS: Seasonal wetlands in Suisun Marsh provide valuable wetland habitat for waterfowl and shorebirds, as well as other wildlife.

VERNAL POOLS: Vernal pools provide habitat for many listed plant and invertebrate species. Vernal pool protection and restoration will be closely linked to other actions related to restoring wetland, riparian, and adjacent upland habitats.

RIPARIAN AND SHADED RIVERINE AQUATIC HABITAT: Riparian and shaded riverine aquatic (SRA) habitats have been greatly reduced as a result of development along streams in areas above the lower marshes, sloughs, and Bay shorelines. Such habitat has value to many special-status plant and animal species. In addition, SRA habitat is important for juvenile chinook salmon and many other resident and anadromous fish using the Bay.

ESSENTIAL FISH HABITAT: The Suisun Marsh/North San Francisco Bay Ecological Management Zone has been identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). Key features of EFH to maintain or restore in this ecological management zone include substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

PERENNIAL GRASSLANDS: Grasslands associated with wetland margins are important habitats for some special-status plant and wildlife species. Wetlands should be restored along with the associated aquatic and upland habitats.

VISIONS FOR REDUCING OR ELIMINATING STRESSORS

WATER DIVERSION: Water diversions in North Bay watersheds, in Suisun Marsh, and upstream in the Delta and rivers affect freshwater flow in the Bay and remove fish and their foodweb organisms from the Bay. Unscreened diversions will be screened and poorly functioning screens will be improved to reduce fish loss. Where possible, diversions will be consolidated to reduce the number of diversions requiring screening. Most diversions in the Bay are confined to Suisun Marsh and Suisun Bay.

INVASIVE SPECIES: Over the past several decades, the inadvertent introduction of many marine and estuarine organisms from the Far East in the ballast water of ships has greatly changed the plankton and benthic invertebrate fauna of the Bay, with further consequences throughout the foodweb. Further changes can be expected if ballast water releases into the Bay are not restricted. Therefore, more stringent ballast water release restrictions are needed to reduce the influx of exotic species. Other invasive species such as exotic cordgrass (Spartina spp) are becoming established and control measures are needed to reduce future potential adverse affects. This vision incorporates the need to reduce the adverse impacts of already introduced species while seeking measures and opportunities to reduce or eliminate the impact from potential future introductions.

NON-NATIVE WILDLIFE: Reducing the numbers of non-native species and therefore the effects these species have on native wildlife will require a coordinated approach that includes restoring ecosystem processes and functions where applicable and possible, restoring native habitats, reducing or eliminating other stressors that suppress native species, and efforts to control non-native species.

PREDATION AND COMPETITION: Millions of chinook salmon and striped bass have been stocked in North Bay waters to improve the survival of these species and their contributions to spawning populations. Although the presence of these fish in the Bay could be considered natural, the stocking of millions of hatchery smolts into small areas of the North Bay within a short period may affect the survival and production of important Bay species, such as longfin smelt.

CONTAMINANTS: Toxic contaminants continue to enter the Bay in large amounts as a result of municipal, industrial, and agricultural discharges. These toxins have had a demonstrated adverse effect on the health, survival, and reproduction of many important Bay fish species and their foodweb organisms. Toxins in fish tissues also pose a health risk to people who eat fish from the Bay. Continuing to reduce levels of toxic contaminants from discharges and releases of toxins from sediment (i.e., disturbed by natural forces and dredging) is an essential step in the restoration program. The level of toxins in the Bay is also closely tied to inputs upstream in the Delta and rivers; therefore, efforts to improve water quality should be coordinated throughout the basin.

HARVEST OF FISH AND WILDLIFE: Legal and illegal fish harvest may limit recovery of some populations in the Bay-Delta system and its watersheds. Striped bass, salmon, steelhead, and sturgeon harvest in the Bay may affect the recovery of these populations.

DISTURBANCE: Human activity, particularly boat wakes in sloughs and channels in tidal wetland areas, disturbs nesting waterfowl and erodes habitat. Disturbance to the endangered California clapper rail which also may occur includes boating and hunting. Restricting boat speeds and access by motorized boats in special areas will reduce these stresses.

VISIONS FOR SPECIES

DELTA SMELT: The vision for delta smelt is to recover this State-and federally listed threatened species in order to contribute to the overall species richness and diversity of the Bay-Delta. Recovery of the delta smelt population in the Bay-Delta will occur through improved freshwater inflow and Delta outflow patterns, greater foodweb productivity, increased areas and quality of aquatic habitats, and reduced effects of water diversions. Higher delta smelt production should be apparent in dry and normal water year types in response to improved flows, habitats, and foodweb, and reductions in stressors.

LONGFIN SMELT: The vision for longfin smelt is to recover this California species of special concern in the Bay-Delta estuary so that it resumes its historical levels of abundance and its role as an important prey species in the Bay-Delta aquatic foodweb. Achieving consistently high production of longfin smelt in normal and wetter years, which historically produced more abundant juvenile populations (year classes), will be critical to the recovery of longfin smelt.

SPLITTAIL: The vision for splittail is to recover of this federally listed threatened species. Recovery of the Bay-Delta splittail population will occur through improved floodplain inundation, higher late-winter Delta inflow, and improved tidal aquatic and wetland habitats. Greater production of young would be expected in dry and normal water year types.

CHINOOK SALMON: The vision for Central Valley chinook salmon is to recover all stocks presently listed or proposed for listing under the State or federal ESAs, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that use fully existing and restored habitats. Central Valley salmon populations will remain stable or increase with improved late-winter and spring flows into and through the Delta, increases in wetland and floodplain habitats, lower spring water temperatures, an improved aquatic foodweb, and reduced effects of water diversions. Survival rates through the Bay-Delta should increase. Numbers of young salmon rearing in the Bay-Delta should increase with improved winter-spring flows and wetland habitats.

STEELHEAD TROUT: The vision for Central Valley steelhead trout is to recover this species listed as threatened under the ESA and achieve naturally spawning populations of sufficient size to support inland recreational fishing and the use fully existing and restored habitats. Steelhead will benefit from improved streamflows and riparian and shaded riverine aquatic habitat in the upper stream reaches. The vision is that restoration of ecological processes and habitats, along with a reduction of stressors, will contribute to stable and larger steelhead populations.

STRIPED BASS: The vision for striped bass is to maintain healthy populations, consistent with restoring native species, to their 1960s level of abundance to support a sport fisher in the Bay, Delta, and tributary rivers. The striped bass population will benefit from increased freshwater inflow to the Bay-Delta in late winter and spring, an improved aquatic foodweb, and reduced effects of water diversions. Improvements in water quality and reducing summer losses to diversions may be important in the long-term recovery of striped bass. Given the high reproductive capacity of striped bass, improvements in young production rates should be readily apparent when improvements are made to flow and foodweb, and when stressors are reduced.

GREEN STURGEON: The vision for green sturgeon is to recover this California species of special concern and restore population distribution and abundance to historical levels. Sturgeon populations should remain stable or increase with improved streamflows and aquatic foodwebs.

WHITE STURGEON: The vision for white sturgeon is to maintain and restore population distribution and abundance to historical levels. Sturgeon populations should remain stable or increase with improved streamflows and aquatic foodwebs.

AMERICAN SHAD: The vision for American shad is to maintain a naturally spawning population, consistent with restoring native species, that supports a sport fishery similar to the fishery that existed in the 1960s and 1970s. Central Valley American shad populations will benefit from improved spring freshwater inflow to the Bay-Delta and an improved Bay-Delta aquatic foodweb. Populations would be expected to remain stable or increase. Increases would be expected in dry and normal rainfall years.

NATIVE RESIDENT FISH SPECIES: The vision for native resident fish species is to maintain and restore the distribution and abundance of native species to contribute to overall species richness and diversity. Many native and non-native fish species will benefit from improved aquatic habitats and foodweb. Population abundance rates remain stable or increase. The distribution of native resident fishes should increase with widespread habitat restoration. The locally extinct Sacramento perch could be restored to new habitats in Suisun Marsh and the unique population of hardhead in the Napa River will be maintained.

LAMPREY: The vision for river lamprey is to maintain population abundance and distribution to contribute to the overall species diversity in the Napa River.

PACIFIC HERRING: The vision for Pacific herring is to maintain self-sustaining populations in order to support commercial fishing. With improved freshwater inflow to the North Bay and Suisun Marsh and more tidal emergent wetland and associated tidal perennial aquatic habitat, marine and estuarine fish and invertebrate population abundance and distribution would increase. Pacific herring survival and production in the North Bay should increase with an improved aquatic foodweb.

BAY-DELTA FOODWEB ORGANISMS: The vision for the Bay-Delta aquatic foodweb organisms is to restore the Bay-Delta estuary's once-productive food base of aquatic algae, organic matter, microbes, and zooplankton communities. Restoring the Bay-Delta foodweb organisms would require enhancing plankton growth and reducing loss of plankton to water exports, particularly in drier years. Several options exist for enhancing plankton growth. Improving Delta inflow and outflow in spring of drier years will be an essential element of any plan. Other elements include reducing losses to exports from the system and reducing the amount of toxic substances entering the system. Probably the best way to improve the aquatic foodweb is to restore tidal marshes and the connectivity to tidal flows in addition to the restoration of freshwater flows since and important part of the food web was probably driven by detritus originating from nearby marshes. A key to achieving this vision is expanded support of basic research to define and better understand the important links between the aquatic foodweb and adjacent terrestrial or transitional wetland foodweb.

GRASS SHRIMP: The vision for grass shrimp is to maintain self-sustaining populations in order to support recreational and commercial fisheries.

SPECIAL STATUS PLANT SPECIES: The vision for special status plant species (Mason's lilaeopsis, Suisun Marsh aster, Suisun thistle, soft bird's-beak, Antioch Dunes evening-primrose, Contra Costa wallflower, bristly sedge, Point Reyes bird's-beak, delta mudwort, delta tule pea, and delta coyote-thistle) is to contribute to their recovery by protecting and preserving important habitats sites within the Bay-Delta.

CALIFORNIA FRESHWATER SHRIMP: The vision for California freshwater shrimp is to maintain existing population distribution and abundance of the this federally listed endangered species.

GIANT GARTER SNAKE: The vision for giant garter snake is to contribute to the recovery of this State and federally listed threatened species. Restoring aquatic, riparian, and wetland habitats in the Bay-Delta will aid giant garter snake and western pond turtle recovery.

WESTERN POND TURTLE: The vision for western pond turtle is to maintain and restore their abundance and distribution in order to contribute to overall species richness and diversity. Restoring aquatic, riparian, and wetland habitats in the Bay-Delta will aid giant garter snake and western pond turtle recovery.

SWAINSON'S HAWK: The vision for Swainson's hawk it to contribute to the recovery of this State and federally listed threatened species. Improvements in riparian and agricultural wildlife habitats will aid in the Swainson's hawk recovery. Increased sightings and possibly increased nesting would be expected in the Bay-Delta.

CALIFORNIA CLAPPER RAIL: The vision for California clapper rail is to contribute to the recovery of this State and federally listed threatened species. Restoring emergent wetlands in the North Bay and adjoining marshes should aid California clapper rail recovery. Population abundance and distribution should increase in the North Bay and adjoining marshes.

CALIFORNIA BLACK RAIL: The vision for California black rail is to contribute to the recovery of this State-listed threatened species. Restoring emergent wetlands in the North Bay and adjoining marshes should aid in California black rail recovery. Population abundance and distribution should increase in the North Bay and adjoining marshes.

SUISUN SONG SPARROW: The vision for the Suisun song sparrow is to recover this species of special concern in Suisun Marsh and the western Delta. The Suisun song sparrow abundance and distribution in the Suisun Marsh should increase with new tidal wetlands and improved riparian habitat in the marshes.

SAN PABLO SONG SPARROW: The vision for the San Pablo song sparrow is to maintain and restore the habitat of this species of special concern. The San Pablo song sparrow abundance and distribution should increase with new tidal wetlands and improved riparian habitat in the marshes.

SALTMARSH COMMON YELLOWTHROAT: The vision for the saltmarsh common yellowthroat is to contribute to the recovery of this species by maintaining and restoring habitat

SALT MARSH HARVEST MOUSE: The vision for the salt marsh harvest mouse is to contribute to the recovery of this State and federally listed endangered species through restoring salt marsh habitat in San Pablo and Suisun bays and adjacent marshes. New and improved salt marsh habitat in the North Bay and adjoining marshes will help in salt marsh harvest mouse recovery.

SAN PABLO CALIFORNIA VOLE: The vision for the San Pablo California vole is to contribute to the recovery of the species of special concern to contribute to overall species richness and diversity.

SUISUN ORNATE SHREW: The vision for the Suisun ornate shrew is to recover this California species of special concern to contribute to overall species richness and diversity.

SHOREBIRDS AND WADING BIRDS: The vision for the shorebird and wading bird guilds is to maintain and restore healthy populations through habitat protection and restoration, and reduction is stressors. Shorebirds and wading birds will benefit from wetland, riparian, aquatic, and agricultural habitats restoration. Seasonal use of the North Bay and adjoining marshes by these birds should increase.

WATERFOWL: The vision for waterfowl is to maintain and restore healthy populations at levels that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses consistent with the goals and objectives of the Central Valley Habitat Joint Venture and North American Waterfowl Management Plan. Many resident and migratory waterfowl species will benefit from improved aquatic, wetland, riparian, and agricultural habitats. Increase use of the North Bay and adjoining marshes and, possibly, increases in some populations would be expected.

DELTA GREEN GROUND BEETLE: The vision for the Delta green ground beetle is to contribute to the recovery of this federally listed threatened species by increasing their populations and abundance through habitat restoration.

NEOTROPICAL MIGRATORY BIRDS: The vision for the neotropical migratory bird guild is to restore and maintain healthy populations of neotropical migratory birds through restoring habitats on which they depend. Protecting existing and restoring additional suitable wetland, riparian, and grassland habitats will be critical to maintaining healthy neotropical migrant bird populations in the Bay-Delta. Large-scale restoration of nesting habitats will help reduce nest parasitism and predation by creating habitat conditions that render neotropical birds less susceptible to these stressors.

CALIFORNIA RED-LEGGED FROG: The vision for the California red-legged frog is to maintain populations of this federally listed threatened species. this vision will contribute to the overall species richness and diversity and to reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. Protecting existing and restoring additional suitable aquatic, wetland, and riparian habitats and reducing mortality from non-native predators will be critical to achieving recovery of the California red-legged frog.

WESTERN LEAST BITTERN: The vision is to maintain western least bittern and its habitat throughout the Delta by protecting and restoring forage, nesting, and roosting habitats in conjunction with other habitat restoration actions.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Changing freshwater inflow patterns to the Bay, the major ecosystem process in the plan for the Delta, is a longstanding need; however, without developed supplies, the prescribed spring flow events and minimum freshwater inflows may not be available in all water-year types. In the short term, efforts will focus on providing the needed flows with available water supplies from the Central Valley Project (CVP) facilities at Shasta, Folsom, and New Melones Reservoirs using water prescribed by the Central Valley Project Improvement Act (CVPIA) and water purchased from willing sellers. The effectiveness of the water releases would be maximized through the use of tools such as water transfers. Property acquisitions with water rights from willing sellers are also a tool for acquiring water. In the long term, additional water supplies may be needed to meet remaining environmental needs.

Much of the infrastructure to implement the vision for the marsh and bay already exists. Restoration will be implemented through these existing programs. In areas where no cooperative agency and stakeholder efforts are underway, such organizations can be developed to help implement the program. To be successful, the restoration program must help to coordinate existing restoration programs being undertaken by State and federal resource agencies.

The recommendations in this plan will coincide with numerous programs and projects to protect and restore the Bay-Delta estuary. These programs are described below.

San Francisco Bay Area Wetlands Ecosystem Goals Project

The San Francisco Bay Area Wetlands Ecosystem Goals Project is a comprehensive, science-based program which had developed recommendations regarding where and how much of the various types of wetland should be restored in the Suisun Bay and San Francisco Bay areas. Many of the goals that have been presented are consistent or enhance the ERPP prescriptions to improve the ecological health of processes, habitats, and species in this ecological management zone.

San Francisco Estuary Project

The San Francisco Estuary Project has four goals to restore the physical, chemical, and biological integrity of the San Francisco Bay-Delta Estuary:

- protect existing wetlands,
- restore and enhance the ecological productivity and habitat values of wetlands,
- expedite a significant increase in the quantity and quality of wetlands, and
- educate the public about the values of wetland resources.

Central Valley Project Improvement Act

Restoring and maintaining ecological processes and functions in the Suisun Marsh and North Bay Ecological Management Zone will augment other important ongoing and future restoration efforts for the zone. With the CVPIA program, the Anadromous Fish Restoration Program (AFRP) of the U.S. Fish and Wildlife Service (USFWS 1997) has a goal to double the natural anadromous fish production in the system over the average production during 1967 through 1991. CVPIA authorized dedicating and managing 800,000 af of CVP yield annually to implement the fish, wildlife, and habitat restoration purposes and measures that include water purchased for inflow to and outflow from the Delta. The CVPIA AFRP includes provisions for restoring habitat and reducing stressors, such as unscreened water diversions.

Recovery Plan for Sacramento-San Joaquin Delta Native Fishes

The scope of the plan includes San Francisco Bay and the Delta. The intent is to promote conservation of the ecosystems on which the native fishes, such as chinook salmon, delta smelt, longfin smelt, splittail, and Sacramento perch, depend. The plan outlines a strategy for restoration, including actions, The goals, strategies for recovery, and programmatic actions presented in the plan have been adopted by the ERPP. The plan includes targets for populations, habitat restoration, structural changes, and Delta outflow to the Bay that have been included in the ERPP. Important recovery actions in this plan include placing the 2 parts per thousand isohaline (X2 SWRCB standard) at Roe Island, Chipps Island, or at the confluence of the Sacramento-San Joaquin rivers at Collinsville. Suitable placement of the 2 parts per thousand isohaline is key to providing adequate shallow water habitat for delta smelt, longfin smelt, and splittail.

Recovery Plan for Salt Marsh Harvest Mouse and California Clapper Rail

The recovery plan for the salt marsh harvest mouse and clapper rail focuses on protecting existing marshes, creating new marsh habitat with unrestricted tidal sloughs, pickleweed habitat for mice, and suitable nesting habitat for the rail. This recovery plan, prepared and approved in 1984, is being revised by the USFWS. The goals and objectives that are being developed in the revised recovery plan may lead to corresponding adjustments in ERPP targets and programmatic actions.

Suisun Marsh Management and Protection Plans

The Suisun Marsh Management Plan was mandated by the Suisun Marsh Preservation Act of 1977. Its goal is to maximize waterfowl food production while maintaining a diverse marsh flora capable of supporting the present wide variety of wildlife in the marsh. The plans were developed to mitigate (avoid, reduce, or compensate for) the effects on the marsh of the federal Central Valley Project and State Water Project. Though the plan's focus is to manage diked wetlands, plan elements are consistent with ERP objectives and targets. A primary management area, consisting of 58,000 acres of tidal and managed wetlands, and secondary management areas of 28,000 acres of grasslands, have been identified for management and protection. Restoring tidal wetlands and sloughs in Suisun Marsh will be consistent with Suisun Marsh Management Plan goals.

Interagency Ecological Program Suisun Ecological Workgroup

The Suisun Ecological Workgroup (SEW) was convened at the request of the State Water Resources Control Board as a component of the "Program of Implementation" in the 1995 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. SEW is and ad hoc multi-agency/organization work group whose goal is to review the scientific basis for the current salinity standards in Suisun Marsh and make recommendations for comprehensive brackish marsh standards. The primary goals of the SEW are: (1) characterize the brackish water ecosystem for Suisun Marsh, (2) evaluate the effects of existing Western Suisun Marsh water quality standards on beneficial uses, (3) determine and recommend appropriate resource-specific standards, (4) recommend narrative standards for tidal wetlands, (5) assess impacts of implementing appropriate resources-specific standards on other resources, (6) develop appropriate multi-resource (ecosystem) water quality standards, (7) consider alternative models, and (8) recommend future studies and compliance monitoring programs.

Central Valley Habitat Joint Venture

The Central Valley Habitat Joint Venture is a component of the USFWS's North American Waterfowl Management Plan, with funding and cooperative project participation by federal, State, and private agencies. New funding sources including CALFED restoration funds, are being sought to implement the Joint Venture. The Joint Venture has adopted an implementation plan that includes Suisun Marsh. Objectives include protecting wetlands by acquiring fee-title or conservation easements and enhancing waterfowl habitat in wetlands and agricultural lands. Joint Venture objectives and targets have been adopted by the ERP.

Recovery Plan for the Sacramento River Winter-Run Chinook Salmon

The winter-run recovery plan is being prepared and will be implemented by the Nation Marine Fisheries Service (NMFS). The draft plan includes recommendations for improving riparian and tidal marsh habitats in the Bay and Delta. ERPP objectives and targets are consistent with those of the recovery plan.

San Francisco Estuary Project Comprehensive Conservation and Management Plan

The San Francisco Estuary project's (SFEP's) purpose is to promote effective management of the Bay-Delta estuary and restore and maintain the estuary's water quality and natural resources. There are eleven programs within the management plan, including wetland management and habitat restoration in the North Bay stream watersheds. Programs include protecting remnant stream habitats and restoring shaded riverine aquatic habitats. Objectives include restoring and creating habitats, including tidal saltmarsh and adjacent upland habitats. A plan is being developed for managing the San Francisco Bay National Wildlife Refuge. Many SFEP and CCMP objectives and targets are included in the ERPP.

Agreement on San Joaquin River Protection

In an effort to resolve issues brought forth in the State Water Resources Control Board's 1995 Water Quality Control Plan for the Bay/Delta, the San Joaquin River Tributaries Association, San Joaquin River Exchange Contractors Water Authority, Friant Water Users Authority, and the San Francisco Public Utilities Commission collaborated to identify feasible, voluntary actions to protect the San Joaquin River's fish resources. In spring 1996, these parties agreed on a "Letter of Intent to Resolve San Joaquin River Issues." This agreement, when finalized, has the potential of providing the following:

- higher minimum base flows,
- significantly increased pulse flows,

- installation and operation of a new fish barrier on the mainstem San Joaquin River,
- set up a new biological monitoring program, and
- set aside federal restoration funds to cover costs associated with these measures.

One of the important components of the Agreement is the development of the Vernalis Adaptive Management Program (VAMP) to improve environmental conditions on the San Joaquin River. Elements of this potential adaptive management program include a range of flow and non-flow habitat improvement actions throughout the watershed, and an experimental program designed to collect data needed to develop scientifically sound fishery management options for the future.

CALFED Bay-Delta Program

CALFED has funded seven ecosystem restoration projects in the Suisun Marsh/North San Francisco Bay Ecological Management Zone. Two projects screen diversions for managed wetlands on the Suisun Marsh and three restore habitat. A project by the Central Costa County Sanitary District discourages pesticide use by encouraging homeowners to use integrated pest management techniques.

Linkage to Other Ecological Management Zones

Restoration efforts in all Ecological Management Zones upstream of the Suisun Marsh and North San Francisco Bay will contribute to the health and recovery of this zone. Likewise, efforts in this zone will contribute to the health of the Delta and salmon and steelhead population recovery in the Sacramento and San Joaquin River basins.

Successfully realizing the vision for this Ecological Management Zone depends, in part, on achieving targets in the Sacramento-San Joaquin Delta, Sacramento River, Eastside Delta Tributaries, and San Joaquin River Ecological Management Zones. These include targets associated with restoring streamflow processes, reducing contaminants, and improving and increasing riparian and wetland habitats. Efforts toward achieving targets in these zones should interact to restore important rearing habitat, reduce the introduction of contaminants, and control the introduction of non-native aquatic species. For example, essential for meeting the Bay freshwater inflow prescriptions are efforts to meet the individual flow prescriptions for the Sacramento, Feather, Yuba, American, Mokelumne, Stanislaus, Tuolumne, and Merced rivers. Aquatic, riparian, and wetland corridors in the Delta are also directly linked and integral to habitat corridors in Suisun and San Pablo Bays.

Restoration Targets and Programmatic Actions

Ecological Processes

Central Valley Streamflow (Freshwater Inflow)

Target 1: More closely emulate the natural seasonal freshwater inflow pattern to North San Francisco Bay to:

- transport sediments,
- allow upstream and downstream fish passage,
- contribute to riparian vegetation succession,
- permit transport of larval fish to the entrapment zone,
- maintain the low salinity zone in Suisun Bay, and
- provide adequate attraction flows for upstream, through-Bay migrating salmon.

Delta outflow in dry and normal years will be improved by coordinating releases and natural flows in the Sacramento River Basin to provide a March flow event of at least 20,000 cfs for 10 days in dry years, at least 30,000 cfs for 10 days in below-normal years, and at least 40,000 cfs for 10 days in above-normal years. The existing smaller, late-April and early-May flow event will be improved with additional water releases from San Joaquin River and Delta tributaries to provide flows of magnitudes and durations similar to those prescribed for March (◆◆).

Programmatic Action 1A: Develop a cooperative program to provide target flows in dry and normal years by allowing inflows to major storage reservoirs, prescribed in the visions of upstream Ecological Management Zones, to pass downstream into and through the Delta. (This action would result from an accumulation of recommendations for spring flow events and minimum flows from upstream Ecological Management Zones.)

RATIONALE: *The proposed March supplemental flows were selected as a representative value for impact analysis in the Programmatic EIS/EIR. Throughout the ERP, the need to determine optimal streamflow for ecological processes, habitats, and species is repeated. The issues of supplemental flows are complex in term of ecosystem improvements. The frequency, magnitude, duration, timing and rate of change of streamflows that form channels, create and maintain riparian habitat (including all species of vegetation), and promote all life stages of the various aquatic species dependent on a particular stream will never occur within a single year. An optimal flow regime will have to vary, perhaps significantly, from year to year. The supplemental flow recommendations will be an intensive exercise in adaptive management and must be based on credible scientific underpinnings.*

Restoring freshwater flows into Suisun Marsh/North San Francisco Bay Ecological Management Zone consistent with natural hydrologic conditions in the Bay-Delta watershed will help restore fundamental ecosystem processes and functions for the North Bay's aquatic and wetland resources. Increasing spring freshwater inflows will benefit the Bay and help move outmigrating juvenile chinook salmon and steelhead through the Bay toward the ocean. Spring plankton blooms in the North Bay, stimulated by freshwater outflow, support the North Bay's functions as a primary nursery ground for many important fish and crustacean species. These include chinook salmon, striped bass, delta smelt, splittail, Pacific herring, starry flounder, northern anchovy, Dungeness crab, several species of Bay shrimp, and many species of planktonic and benthic invertebrates that make up the Bay's foodweb. Spring freshwater flows also stimulate tidal emergent marsh productivity by providing necessary nutrients and sediments. Freshwater inflows of 20,000 to 40,000 cfs in dry and normal years, compared to the existing 10,000 to 30,000 cfs, would ensure that the low salinity zone of the estuary and X2 would be located well downstream in Suisun Bay, especially in dry years, and allow some fresh water to reach San Pablo Bay through tidal circulation and mixing. (Note: the location of X2 is the distance from the Golden Gate Bridge to the point at which the daily average salinity is 2 parts per thousand (ppt) at the bottom.)

NATURAL FLOODPLAIN AND FLOOD PROCESSES

TARGET 1: Expand the floodplain area in the Napa River, Sonoma Creek, and Petaluma River Ecological Management Units by putting approximately 10% of leveed lands into the active floodplain (◆◆◆).

PROGRAMMATIC ACTION 1A: Convert leveed lands to tidal wetland/slough complexes.

RATIONALE: *Restoring approximately 10% of existing leveed lands to tidal action and floodflows will greatly enhance the floodwater and sediment retention capacity of the area and contribute nutrients for the aquatic foodweb.*

BAY-DELTA AQUATIC FOODWEB

TARGET 1: Increase primary and secondary nutrient productivity in the Suisun Marsh/North San Francisco Bay to levels historically observed in the 1960s and early 1970s (◆◆).

PROGRAMMATIC ACTION 1A: Actions described to restore streamflow, floodplains, tidal wetlands and sloughs, and riparian habitat would increase primary and secondary productivity in the Suisun and North San Francisco Bay areas.

PROGRAMMATIC ACTION 1B: Implement an expanded aquatic foodweb research program to understand the linkage of adjacent and transitional wetland habitats better and the aquatic foodweb.

RATIONALE: *Increasing the area of tidal wetland/slough habitat will increase primary and secondary productivity. More flooding of floodplains will provide more nutrients and organic carbon inputs.*

HABITATS

GENERAL RATIONALE

Restoring tidally influenced wetlands are an essential focus of restoration efforts in the Suisun Marsh/North San Francisco Bay Ecological Management Zone. Habitats of particular interest include tidal perennial aquatic habitat, saline emergent wetlands, and tidal slough habitat. Restoration of these habitats will require a mosaic of habitats including adjacent *habitats that need to be comprised of seasonal wetlands, non-tidal perennial aquatic habitats, perennial grasslands, and riparian habitats. Restoration targets were set with the realization of the difficulty in locating lands for restoration. In the Suisun Marsh, for example, the restoration of tidally influenced habitats will likely require the conversion of existing managed wetlands. The conversion of these existing freshwater wetlands will be offset to the extent possible by restoring existing degraded wetland habitats and by improvement to existing unmanaged wetlands. Likewise, in the San Pablo Bay Ecological Management Unit, restoration of habitat will be constrained by the fact that the area is characterized by open bay and intertidal flats with very limited opportunities for restoration of other shallow water habitat types.*

TIDAL PERENNIAL AQUATIC HABITAT

TARGET 1: Restore 1,500 acres of shallow-water habitat in the Suisun Marsh/North San Francisco Bay Ecological Management Zone (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to acquire and restore 1,500 acres of shallow-water habitat in the Suisun Bay and Marsh Ecological Management Unit.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to evaluate the feasibility of restoring shallow-water habitat in the San Pablo Bay Ecological Management Unit.

RATIONALE: *Restoring, improving, and protecting high-quality, shallow-water habitat will provide foraging habitat for juvenile fish in this Ecological Management Zone. These areas typically provide high primary and secondary productivity and support nutrient-cycling functions that can sustain high-quality foraging conditions. Opening new areas to tidal flows will also help restore a more natural tidal action to the Bay-Delta. These tide-influenced areas also provide high-quality foraging habitat for waterfowl that use mudflat or submergent vegetation growing in shallow water and diving ducks, such as canvasback and scaup, that consume clams in these areas (Fris and DeHaven 1993, Brittain et al. 1993, Stuber 1984, Schlosser 1991, Sweetnam and Stevens 1993, San Francisco Estuary Project 1992a, U.S. Fish and Wildlife Service 1996, and Lindberg and Marzuola 1993).*

Restoration of shallow water habitat in the San Pablo Bay Ecological Management Unit may not be possible as the unit is characterized by open bay and intertidal flats. No lands may be available for restoration.

Development of shallow water habitats in the North Bay will require large-scale tidal restoration to expand and maintain third through fifth order slough channels. Larger sloughs provided the shallow water habitat which existed under historic conditions in the North Bay. Acquiring and restoring diked subsided lands will create shallow water habitats in the short-term. Sedimentation will occur over the long-term and the area will develop into a saline emergent marsh. This objective is probably only achievable in the Napa River, Sonoma Creek, and Petaluma River Ecological Management Units.

NONTIDAL PERENNIAL AQUATIC HABITAT

TARGET 1: Develop 1,600 acres of deeper (3-6 feet deep) open-water areas to provide resting habitat for water birds, foraging habitat for diving ducks and other water birds that feed in deep water (◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to acquire and develop 400 acres of deeper open-water areas adjacent to restored saline emergent wetland habitats in the Suisun Bay and Ecological Management Unit.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to acquire and develop 400 acres of deeper open-water areas adjacent to restored saline emergent wetland habitats in each the Napa River, Sonoma Creek and Petaluma River Ecological Management Units (1,200 acres total).

RATIONALE: *Restoring suitable resting areas for waterfowl and other wetland-dependent wildlife species will increase the overwinter survival rate of these populations. Other water-associated wildlife species will also benefit (Madrone Associates 1980).*

TIDAL SLOUGHS

TARGET 1: Restore slough habitat for fish and associated wildlife species. Restore 5 miles of slough habitat in the near-term, and 10 miles in the long-term, in the Suisun Bay and Marsh Ecological Management Unit (30-61 acres). Restore 10 miles of slough habitat in the near-term, and 20 miles in the long-term, in the Napa River Ecological Management Unit (61-121 acres). Restore 10 miles of slough habitat in the near-term, and 20 miles in the long-term, in the Sonoma Creek Ecological Management Unit (61-121 acres). Restore 10 miles of slough habitat in the near-term, and 20 miles in the long-term, in the Petaluma River Ecological Management Unit (61-121 acres) (◆◆).

PROGRAMMATIC ACTION 1A: In association with wetland/marsh restoration efforts, construct sloughs in marsh/slough complexes by acquiring land and purchasing easements.

RATIONALE: *Restoring, improving, and protecting slough habitat in the units of the Suisun Marsh/North San Francisco Bay Ecological Management Zone will help sustain high-quality shallow-water habitat that provides spawning habitat for native fish and foraging habitat for rearing juvenile fish. Restoring sloughs, along with tidally influenced freshwater areas and saline emergent marsh, will provide spawning habitat for native fish and foraging habitat for rearing juvenile fish; contribute to high levels of primary and secondary productivity; and support nutrient-cycling functions that can sustain high-quality foraging conditions. These sloughs can also provide resting sites for waterfowl and habitat for the western pond turtle (Simenstad et al. 1992, Lindberg and Marzuola 1993, and Madrone Associates 1980). Tidal sloughs can also provide important loafing sites for waterfowl, particularly diving ducks in the North Bay. The miles of targeted sloughs represent a reasonable restoration level as indicated by maps available from the early 1900s and existing configurations in the Ecological Management Units.*

In general, tidal slough restoration should be associated by tidal marsh restoration. Sloughs are a function of the marshes they traverse. The acreage of marsh and soils, sediments, hydrodynamics will limit the amount of tidal marsh that can be restored. These sloughs can also provide loafing sites for waterfowl, particularly diving ducks in the North Bay.

SALINE EMERGENT WETLANDS

TARGET 1: Restore tidal action to 5,000 to 7,000 acres in the Suisun Bay and Marsh Ecological Management Unit; 1,000 to 2,000 acres in the Napa River Ecological Management Unit; 500 to 1,000 acres each in the Sonoma Creek, Petaluma River, and San Pablo Bay Ecological Management Units (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to acquire, in fee-title or through a conservation easement, the land needed for tidal restoration, and complete the needed steps to restore the wetlands to tidal action.

TARGET 2: Protect 6,200 acres of existing saline emergent wetlands in the Suisun Bay and Marsh Ecological Management Zone (◆◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to acquire, in fee-title or through a conservation easement, existing wetlands subject to tidal action.

TARGET 3: Restore full tidal action to muted marsh areas along the north shore of the Contra Costa shoreline (◆◆).

PROGRAMMATIC ACTION 3A: Develop a cooperative program to evaluate, acquire, in fee-title or through a conservation easement, and restore existing muted wetlands to full tidal action.

RATIONALE: *Restoring tidally influenced saline marsh in this Ecological Management Zone will contribute to increasing levels of primary and secondary productivity and support nutrient-cycling functions that can sustain high-quality foraging conditions (Lindberg and Marzuola 1993, Miller 1993, Simenstad et al. 1992). Increasing the area occupied by saline tidal marsh in each Ecological Management Unit will help support the proper aquatic habitat conditions for rearing and outmigrating juvenile chinook salmon, steelhead, and sturgeon and rearing delta smelt, striped bass, and splittail. Restoring high-quality saline marshes, both tidal and nontidal, will contribute to nutrient cycling, maintaining the foodweb, and supporting enhanced levels of primary and secondary production. Increasing the area occupied by nontidal saline marsh will contribute to subsidence control and island accretion (growth) efforts. Permanent saline marsh can help arrest and, in some cases, reverse subsidence where peat oxidation has lowered land elevations to more than 15 feet below sea level. Increasing the area occupied by saline marsh will contribute to an ecosystem that can accommodate sea-level rise and provide a more natural tidal pattern and associated benefits to the foodweb and water quality of the Bay* *and Delta. Habitat conditions for wetland-associated wildlife will be improved.*

The targets for saline emergent wetlands will probably be achieved or even exceeded by several ongoing programs. These include activities to restore saline emergent wetlands which are contained within land acquisition programs by the U.S. Fish and Wildlife Service and Department of Fish and Game.

SEASONAL WETLANDS

TARGET 1: Assist in protecting and enhancing 40,000 to 50,000 acres of existing degraded seasonal wetland habitat in the Suisun Bay and Marsh Ecological Management Unit per the objectives of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan. (◆◆◆).

PROGRAMMATIC ACTION 1A: Support the cooperative program to improve management of up to 26,000 acres of degraded seasonal wetland habitat in the of the Suisun Bay and Marsh Ecological Management Unit.

PROGRAMMATIC ACTION 1B: Support the development of a cooperative program to improve management of up to 32,000 acres of existing seasonal wetland habitat in the Suisun Bay and Marsh Ecological Management Unit.

TARGET 2: Acquire and convert 1,000 to 1,500 acres of existing farmed baylands in the Suisun Marsh to seasonal wetlands (◆◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to acquire, in fee-title or through a conservation easement, existing farmed baylands and restore tidal action.

RATIONALE: *Restoring wetland and riparian habitats in association with aquatic habitats is an essential restoration strategy element for this Ecological Management Zone. This restoration is fundamental to supporting the foodweb and enhancing conditions for rearing chinook salmon, steelhead, sturgeon, juvenile delta smelt, striped bass, and splittail. Foodweb support functions for wildlife will also benefit (Cummins 1974, Brostoff and Clark 1992).*

Seasonal wetlands can help reduce concentrations and loads of pesticide residues in water and sediments, which help to reduce sublethal and long-term impacts of specific contaminants for which it is difficult to document population-level impacts conclusively. Modifying agricultural practices and land uses on a large scale will reduce the concentrations of pesticide residues through a combined approach. This approach involves reducing the amount of pesticide applied and the amount reaching aquatic Suisun Marsh and San Francisco Bay habitats. This will be done by biological and chemical processes in wetland systems that break down harmful pesticide residues. Improved inchannel flows in this Ecological Management Unit resulting from seasonal reductions in water use and enhanced environmental water supplies will also help to reduce contaminant concentrations (San Francisco Estuary Project 1992a).

Restoring high-quality freshwater marsh and brackish marsh, both seasonal and permanent, will increase the production and availability of natural forage for waterfowl and other wildlife. It will increase the overwinter survival rates of wildlife populations in this Ecological Management Zone and improve their body condition before they migrate. As a result, breeding success will be improved. Managing these habitats will also reduce the amount and concentrations of contaminants that could, upon entering the sloughs, interfere with efforts to restore aquatic ecosystem health.

Target 1 "enhance 40,000 to 50,000 acres of degraded seasonal wetland habitat" is consistent with the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan. Programmatic Action 1A "enhance 26,000 acres of degraded seasonal wetland habitat" is already being implemented by Ducks Unlimited as part of a grant through the North American Wetlands Conservation fund. The intent of the ERPP is to remove the levees of some managed wetlands to allow the restoration of tidally influenced habitats and expand the acreages of wet meadows or pastures. The greatest need to restore where possible, tidal wetland areas. This may result in a need to replace any losses of managed wetlands by creating additional wetland areas. However, there may not be area for any additional acres of managed wetlands as the majority of agricultural lands have already been converted to managed wetlands. For example, the following figures provided by the Suisun Resource Conservation

District display the possible difficulty in creating additional managed wetlands.

Existing Land Use	*Existing Acreage*
managed wetlands	*52,000 acres*
unmanaged tidal wetlands	*6,300 acres*
bays and sloughs	*30,000 acres*
uplands and grasslands	*27,700 acres*

VERNAL POOL

TARGET 1: Protect and manage vernal pools in the Suisun Bay and Marsh Ecological Management Unit that provide suitable habitat for listed fairy shrimp species, the Delta green ground beetle, and special-status plant species to assist in these species' recovery (◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to acquire and manage 100 acres of vernal pools and 500 to 1,000 acres of adjacent buffer areas

TARGET 2: Restore vernal pools that have been degraded by agricultural activities to provide suitable habitat for special-status invertebrates and plants and amphibian, such as the spadefoot toad, to assist in the recovery of these populations (◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to restore the quality of vernal pools and their adjacent habitats.

RATIONALE: *Restoring wetland, riparian, and adjacent upland habitats in association with aquatic habitats is an essential restoration strategy element for the Suisun Marsh/North San Francisco Bay Ecological Management Zone. Restoring this habitat mosaic on a large scale will help restore ecosystem processes and functions and provide additional protection to listed species associated with this habitat type.*

RIPARIAN AND SHADED RIVERINE AQUATIC HABITATS

TARGET 1: Restore 10 to 15 linear miles of riparian habitat along riparian scrub and shrub vegetation corridors in each Ecological Management Unit. In this restored habitat, 60% should be more than 15 yards wide, and 40% should be no less than 5 yards wide and 1 mile long(◆◆◆).

PROGRAMMATIC ACTION 1A: Coordinate with landowners and managers to restore and maintain 10 to 15 linear miles of riparian habitat along corridors of riparian scrub and shrub vegetation in each Ecological Management Unit. Of this, 60% should be more than 15 yards wide, and 40% should be no less than 5 yards wide and 1 mile long (40-60 acres in each of 5 units).

RATIONALE: *Many wildlife species, including several species listed as threatened or endangered under the State and federal Endangered Species Acts (ESAs) and several special-status plant species in the Central Valley, depend on or are closely associated with riparian habitats. Riparian scrub and shrub will help provide needed escape cover for these species during high-flow periods. Riparian vegetation in the western portion of the Suisun Marsh/North San Francisco Bay Ecological Management Zone is limited by water salinity. Riparian restoration will most likely occur in the upper reaches of the Ecological Management Units in areas that may be tidally influenced but which have low salinity.*

ESSENTIAL FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination (◆◆).

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for Delta ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitats. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of rivers and streams and their floodplains, and in maintaining and restoring riparian and riverine aquatic habitats.*

PERENNIAL GRASSLANDS

TARGET 1: Restore 1,000 acres of perennial grasses in each Ecological Management Unit associated with existing or proposed wetlands (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to restore perennial grasslands by acquiring conservation easements or purchasing land from willing sellers.

RATIONALE: *Restoring wetland, riparian, and adjacent upland habitats in association with aquatic habitats is an essential restoration strategy element for this Ecological Management Zone. Eliminating fragmentation and restoring connectivity will enhance habitat conditions for special-status species, such as the Suisun song sparrow, California black rail, and salt marsh harvest mouse. For instance, the habitats for these species have been degraded by the loss of adjacent, suitable escape cover that is needed by the salt marsh harvest mouse during periods of high flows or high tides. Fragmentation has also interfered with daily and seasonal migratory movements and genetic interchange within the population (Novick and Hein 1982).*

Table 7: Summary of ERPP Habitat Restoration Targets for the Suisun Marsh/ North San Francisco Bay Ecological Management Zone.

Habitat Type	Suisun Bay and Marsh	Napa River	Sonoma Creek	Petaluma River	San Pablo Bay	Total
Tidal Perennial Aquatic	1,500	0	0	0	Feasibility study	1,500 acres
Nontidal Perennial Aquatic (deep, open water)	400	400	400	400	0	1,600 acres
Tidal Sloughs	5-10 miles (30-61 acres)	10-20 miles (61-121 acres)	10-20 miles (61-121 acres)	10-20 miles (61-121 acres)	0	35-70 miles (213-424 acres)
Saline Emergent Wetland (restore)	5,000-7,000	1,000-2,000	500-1,000	500-1,000	500-1,000	7,500 -12,000 acres
Saline Emergent Wetland (protect)	to be determined (TBD)	TBD	TBD	TBD	TBD	6,200 acres
Seasonal Wetland (Protect existing)	40,000-50,000	0	0	0	0	40,000-50,000 acres
Seasonal Wetland (Restore)	1,000-1,500	0	0	0	0	1,000-1,500 acres
Vernal Pools	100	0	0	0	0	100 acres
Vernal Pool Buffer Area	500-1,000	0	0	0	0	500-1,000 acres
Riparian and Riverine Aquatic	10-15 miles (40-60 acres)	10-15 miles (40-60 acres)	10-15 miles (40-60 acres)	10-15 miles (40-60 acres)	10-15 miles (40-60 acres)	50-75 miles (200-300 acres)
Perennial Grassland	1,000	1,000	1,000	1,000	1,000	5,000 acres
Total acres of all habitats to be restored include tidal perennial, nontidal perennial saline emergent wetland, seasonal wetland, vernal pool and vernal pool buffer, and perennial grassland.					17,200-22,700 acres	
Total acres of existing habitats to be protected and enhanced					46,200-56,200 acres	
Total miles of tidal sloughs to be restored					35-70 miles (213-424 acres)	
Total miles of riparian and riverine aquatic habitat to be restored					50-75 miles (200-300 acres)	

Reducing or Eliminating Stressors

Water Diversions

Target 1: Reduce entrainment losses of juvenile fish at diversions by 25 to 50% by installing positive-barrier fish screens on large diversion structures (◆◆◆).

Programmatic Action 1A: Develop a cooperative program to consolidate, screen, or eliminate diversions in the Suisun Marsh/North San Francisco Bay Ecological Management Zone.

Programmatic Action 1B: Evaluate opportunities to use alternative means to provide cooling water at the Pittsburg power plant.

Rationale: *Large diversions on the main channels of Suisun and San Pablo Bays and adjoining marsh/slough complexes entrain juvenile and small adult fish at rates that could be detrimental to the survival of species of special concern (Chadwick and Von Geldern 1964, 1974; Larkin 1979; and Erkkila et al. 1950). The reduction target reflects preliminary data indicating that entrainment through the smallest diversions on small channels might not pose a significant threat to the successful restoration of Bay-Delta health. The success of screening in the estuarine zone is difficult and dependent on critical protective operations and facilities. For example, bypass flows or bypass systems are needed to move target species away from the zone of influence and into areas safe from entrainment.*

For many years the entrainment and loss of juvenile fish at the Pittsburg power plant has been overlooked as a source of juvenile mortality. This potential stressor should be reevaluated and actions should be recommended to reduce fish losses if appropriate.

Invasive Aquatic Plants

Target 1: Manage existing and restored dead-end and open-end sloughs and channels within the Ecological Management Zone so that less than 1% of the surface area of these sloughs and channels is covered by invasive non-native aquatic plants (◆◆).

Programmatic Action 1A: Conduct large-scale, annual weed eradication programs throughout existing and restored dead-end and open-end sloughs and channels in each Ecological Management Unit so that less than 1% of the surface area of these sloughs and channels is covered by invasive non-native aquatic plants within 10 years.

Rationale: *Invasive aquatic plants have altered ecosystem processes, functions, and habitats by modifying the foodweb and competing for nutrients, light, and space. Nesting birds are particularly vulnerable to increased predation from non-native ground-dwelling predators and competition from non-native nest parasites. Actions taken in the Suisun Marsh/North San Francisco Bay Ecological Management Zone to address this objective are prescribed primarily to enhance foodweb functions and improve habitat conditions for resident, estuarine, and anadromous fish and neotropical migratory birds. This can be accomplished, in part, by reducing the area inhabited by invasive non-native plants and by restoring large areas of optimal nesting habitat (Dudley and D'Antonio 1994, Anderson 1990, Zedler 1992, and Bay-Delta Oversight Council 1994).*

Invasive Aquatic Organisms

Target 1: Reduce or eliminate the influx of non-native aquatic species in ship ballast water (◆◆◆).

Programmatic Action 1A: Fund additional inspection staff to enforce existing regulations.

Programmatic Action 1B: Help fund research on ballast water treatment techniques that could eliminate non-native species before ballast water is released.

Target 2: Reduce the potential for influx of non-native aquatic plant and animal species at border crossings (◆◆◆).

Programmatic Action 2A: Provide funding to the California Department of Food and Agriculture to expand or establish, as appropriate, a comprehensive program to exclude, detect, and manage invasive aquatic species, such as zebra mussel.

Rationale: *Every reasonable effort should be made to reduce the introduction of non-native organisms in the ballast water of ships that enter the Delta. Such organisms have greatly altered the zooplankton of the Delta over the past several* *decades. Further alteration could reduce the capacity of the Delta to support native fishes.*

Every reasonable effort should be made to reduce the introduction of non-native organisms at border crossings into California. Border inspections have already found zebra mussels, which, if allowed to enter Bay-Delta waters, could have devastating economic and ecological effects.

INVASIVE RIPARIAN AND MARSH PLANTS

TARGET 1: Reduce by 50% the area covered by invasive non-native woody species, such as giant reed and eucalyptus, that compete with native riparian vegetation, and eradicate invasive woody plants from restoration areas (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to remove and suppress invasive non-native plants that compete with native riparian vegetation by reducing the area occupied by these species (such as giant reed and eucalyptus) by 50%.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to eliminate invasive woody plants from restoration sites to protect native riparian vegetation.

PROGRAMMATIC ACTION 1C: Develop a cooperative program to develop control measures for perennial pepperweed.

RATIONALE: *Invasive non-native plants have altered ecosystem processes, functions, and habitats by modifying the foodweb and competing for nutrients, light, and space (Dudley and D'Antonio 1994, Madrone Associates 1980, Bay-Delta Oversight Council 1994, Cross and Fleming 1989, and Zedler 1992).*

NON-NATIVE WILDLIFE

TARGET 1: Reduce red fox and feral cat populations in and adjacent to habitat areas suitable for California clapper rail, California black rail, and salt marsh harvest mouse (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate means to reduce red fox and feral cat populations through trapping, relocation, fertility control, or other suitable measures.

PROGRAMMATIC ACTION 1B: Develop and implement a public education program that emphasizes the ecological value of maintain coyote populations.

RATIONALE: *The large-scale restoration of emergent wetlands, riparian habitat, and adjacent perennial grasslands will be the main focus of a strategy to reduce the adverse impacts of non-native wildlife on the health of the Bay-Delta ecosystem. The goal is a restored Bay-Delta and watershed where the quality, quantity, and structure of the restored habitat discourage colonization by non-native wildlife, provide a competitive advantage to native wildlife, and reduce the vulnerability of native species from predation by species such as the red fox and feral cat. A public education program to inform duck club owners of the ecological importance of native coyotes in the Suisun region may help prevent the potentially devastating spread of red fox further into the Suisun Marsh and Delta region. Coyotes are native to the region and tend to keep foxes from increasing their range.*

One of the most serious environmental problems facing California is the explosive invasion of non-native pest plants and animals. Non-native plants, wildlife, fish, and aquatic invertebrates can greatly alter the ecosystem processes, functions, habitats, species diversity, and abundance of native plants, fish, and wildlife.

Many of these invasive species spread rapidly and form dense populations primarily by out-competing native species as a result of large-scale habitat changes that tend to favor non-native species and a lack of natural controls (e.g., natural predators). These non-native species usually have a competitive advantage because of their location in hospitable environments where the normal controls of disease and natural enemies are missing. As populations of non-native species grow, they can disrupt the ecosystem and population dynamics of native species. In some cases, habitat changes have eliminated connectivity of habitats that harbor the native predators that could help to limit populations of harmful non-native species.

PREDATION AND COMPETITION

TARGET 1: Limit striped bass supplementation to life stages that minimize predation on juvenile anadromous and estuarine fish (◆◆◆).

PROGRAMMATIC ACTION 1A: Provide sufficient equipment, support staff, and operation and maintenance funds to hold juvenile striped bass longer so they can be planted at 2 years of age instead of 1 year.

PROGRAMMATIC ACTION 1B: Cooperatively develop an ecologically based approach to limit striped bass and chinook salmon stocking in the Bay to areas and periods that will not increase predation on special-status species, such as longfin smelt and delta smelt, and other native fishes.

RATIONALE: *Actions taken in this Ecological Management Zone are prescribed to protect populations of aquatic species, such as longfin smelt, and delta smelt, from excessive predation rates caused by large concentrations of stocked hatchery-reared fish. Limited studies have shown that two-year-old striped bass have less of an impact on anadromous and estuarine fish than one-year-old striped bass.*

CONTAMINANTS

TARGET 1: Reduce the input of herbicides, pesticides, fumigants, and other agents toxic to fish and wildlife in the Suisun Marsh/North San Francisco Bay Ecological Management Zone (◆).

PROGRAMMATIC ACTION 1A: Support programs already in place to regulate the discharge of pollutants or reduce pollutant toxicity in Bay waters.

RATIONALE: *Reducing the concentrations and loads of contaminants, including hydrocarbons, heavy metals, and other pollutants, in the water and sediments of the Suisun Marsh/North San Francisco Bay Ecological Management Zone will help reduce sublethal and long-term impacts of specific contaminants for which it is difficult to document population-level impacts conclusively. Reducing loading in urban runoff and modifying agricultural practices and land uses on a large scale will reduce pesticide residue concentrations through a combined approach. This approach involves reducing the amount of pesticide applied and the amount reaching the Bay's aquatic habitats. This will be done by biological and chemical processes in wetland systems that break down harmful pesticide residues. (Bay Delta Oversight Council 1994, Hall 1991, U.S. Fish and Wildlife Service 1996, San Francisco Estuary Project 1992b, Resources Agency 1976, Sparks 1992, Diamond et al. 1993, and Rost et al. 1989). Improved inchannel flows in the Delta resulting from seasonal reductions in water use and enhanced environmental water supplies will also help to reduce concentrations (San Francisco Estuary Project 1992a). Health warnings have been issued regarding human consumption of fish and wildlife because of elevated levels of substances, such as mercury and selenium. Large-scale aquatic and wetland habitats restoration may help to resolve concerns about hydrocarbons, heavy metals, and other pollutants. Addressing point sources of concern, such as the oil refineries in Suisun and San Francisco Bays, and elevated releases of selenium resulting from refining oil from sources high in selenium, can be effective elements of a strategy to achieve the desired reductions.*

HARVEST OF FISH AND WILDLIFE

TARGET 1: Reduce illegal anadromous fish and waterfowl harvest in Suisun Marsh and San Francisco Bay by increasing enforcement and public education (◆◆◆).

PROGRAMMATIC ACTION 1A: Provide additional funding to California Department of Fish and Game (DFG) for additional enforcement.

PROGRAMMATIC ACTION 1B: Provide additional funding to county sheriff's departments and State and local park agencies to support additional enforcement efforts.

PROGRAMMATIC ACTION 1C: Provide rewards for the arrest and conviction of poachers.

PROGRAMMATIC ACTION 1D: Develop and implement a public outreach/education program regarding the illegal harvest.

RATIONALE: *Actions taken to reduce stressors in this Ecological Management Zone are prescribed primarily to contribute to the recovery of aquatic species, such as winter-, spring-, and late-fall-run chinook salmon; green sturgeon; splittail; and steelhead. These actions will also contribute to the recovery of species, such as Swainson's hawk, greater sandhill crane, yellow-billed cuckoo, riparian brush rabbit, black rail, and giant garter snake (U.S. Fish and Wildlife Service 1996, San Francisco Estuary Project 1992b, Bay-Delta Oversight Council 1993, and California Department of Fish and Game 1991).*

DISTURBANCE

TARGET 1: Reduce boat wakes near California clapper and black rail nesting areas in Suisun Marsh and San Francisco Bay from March to June to prevent destruction of nests and assist in the recovery of this listed species (◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program with local agencies to establish and enforce zones prohibiting boat wakes within 50 yards of California black rail nesting areas in Suisun Marsh and San Francisco Bay from March to June.

PROGRAMMATIC ACTION 1B: Develop a cooperative program with local agencies to establish and enforce zones prohibiting motorized boats in 5 miles of dead-end channels in Suisun Marsh and San Francisco Bay from March to June.

PROGRAMMATIC ACTION 1C: Develop a cooperative program with local agencies to establish and enforce zones prohibiting motorized boats in new, small channels in restored tidal fresh emergent wetlands.

RATIONALE: *Clapper rail are particularly sensitive to disturbance and efforts to reduce jet ski traffic in critical areas for the rail would contribute to their recovery. Other actions taken to restore ecological processes and functions, increase and improve habitats, and reduce stressors in this Ecological Management Zone are prescribed primarily to contribute to the recovery of aquatic species, such as winter-, spring-, and late-fall-run chinook salmon; green sturgeon; splittail; and steelhead. These actions will also contribute to the recovery of species, such as the black rail (Madrone Associates 1980, Schlosser 1991, San Francisco Estuary Project 1992a, U.S. Fish and Wildlife Service 1978, Schlorff 1991, and Resources Agency 1976).*

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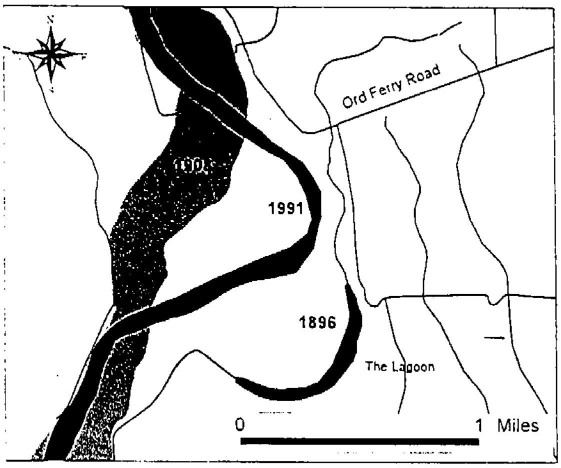
◆ SACRAMENTO RIVER ECOLOGICAL MANAGEMENT ZONE



Sacramento River channel south of Ord Ferry Bridge in 1896, 1908, and 1991 (Sacramento River Advisory Council, 1998).

INTRODUCTION

The health of the Sacramento-San Joaquin Delta is dependent on the rivers and streams that compose its watershed. They provide inflow, sediments, nutrients, spawning and rearing areas for many aquatic species, and riparian corridors that support neotropical bird and other terrestrial wildlife, such as western yellow-billed cuckoo and bank swallow, and invertebrate species. Many estuarine fish species and their foodweb depend on the input from the Sacramento River. The Sacramento River is the largest element of the Delta's watershed, providing about 80% of the inflow to the Delta.

The Sacramento River is also an essential spawning, rearing, and migratory pathway for many anadromous fish populations, such as winter-run, fall-run, late-fall-run, and spring-run chinook salmon, steelhead, white sturgeon, green sturgeon, lamprey, striped bass, and American shad. All of these populations must pass through the Delta and Bay during portions of their life cycle as they migrate to the ocean as juveniles and return as adults to spawn.

Ecological factors having the greatest influence on the anadromous fish in the Sacramento River include streamflow, coarse sediment supply (including gravel for fish spawning and invertebrate production), stream channel dynamics (meander), and riparian and riverine aquatic habitat. Stressors, including dams, legal and illegal harvest, high water temperature during salmon spawning and egg incubation, toxins from mine drainage, hatchery stocking of anadromous fish, and unscreened or poorly screened irrigation diversions, have affected the health of anadromous fish populations.

DESCRIPTION OF THE MANAGEMENT ZONE

The Sacramento River flows more than 300 miles from Lake Shasta to Collinsville in the Delta, where it joins the San Joaquin River. It is a major river of the western United States and the largest and most important riverine ecosystem in the State of California. The river corridor encompasses more than 250,000 acres of natural, agricultural, and urban lands upstream of Sacramento. Various cropland habitats occur on flat and gently rolling terrain adjacent to most of this zone. Irrigated crops are mostly rice, grains, alfalfa, and orchard crops. Most of this cropland is irrigated with water diverted from the Sacramento River or its tributaries. Five National Wildlife Refuges (Sacramento, Delevan, Colusa, Sacramento River and Sutter) are located either adjacent to or within 5 miles of the Sacramento River.

The Sacramento River Ecological Management Zone includes 242 miles of the mainstem Sacramento River from Keswick Dam near Redding to the American River at Sacramento. (The remaining 60 miles of the lower river downstream of Sacramento are included in the North Delta Ecological Management Unit.) The mainstem river planning area includes the river channel, gravel bars and vegetated terraces, the 100-year river floodplain, and the geologically defined band of historic and potential river migration (i.e., the meander belt). In the artificially narrow, leveed reach downstream of Colusa and extending to Sacramento, an approximately 1-mile-wide band of river alluvium and historic and potential forest land that borders the levees is also included in this Ecological Management Zone.

This Ecological Management Zone encompasses five Ecological Management Units:

- Keswick to Red Bluff Diversion Dam,
- Red Bluff Diversion Dam to Chico Landing,
- Chico Landing to Colusa,
- Colusa to Verona, and
- Verona to Sacramento.

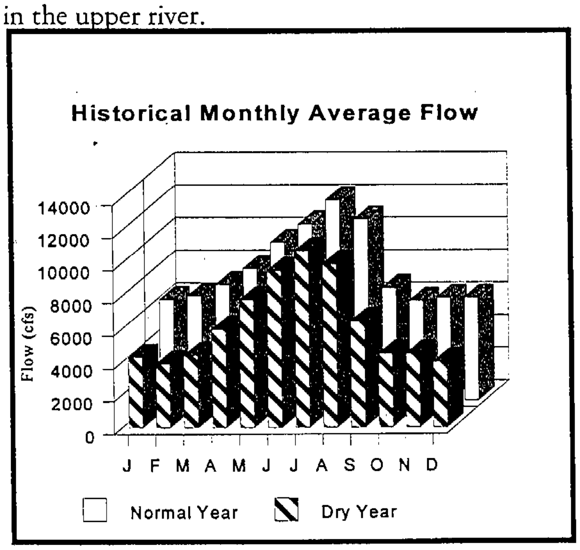
The National Marine Fisheries Service (NMFS) has determined that critical habitat for the endangered Sacramento winter-run chinook salmon includes the entire Sacramento River from Keswick Dam, river mile (RM) 302 to the Golden Gate Bridge (NMFS 1993). The NMFS has also proposed that all Central Valley stream reaches that are accessible to steelhead be designated as critical habitat, except for the San Joaquin River and tributaries upstream of the Merced River confluence.

Other fish dependent on the Sacramento River Ecological Management Zone include spring-run chinook salmon, late-fall-run chinook salmon, fall-run chinook salmon, steelhead, lamprey, green sturgeon, white sturgeon, American shad, striped bass, and a resident native fish community, including the Sacramento splittail. Due to declining populations sizes, many of these are species of special concern or listed under provisions of the state or federal endangered species acts. One of the important attributes of the zone is its riparian forest, which supports a variety of neotropical migrant bird species, the valley elderberry longhorn beetle, and many other terrestrial species. The riparian vegetation is a significant contributor to the food web and large riparian forests effectively moderate air temperatures.

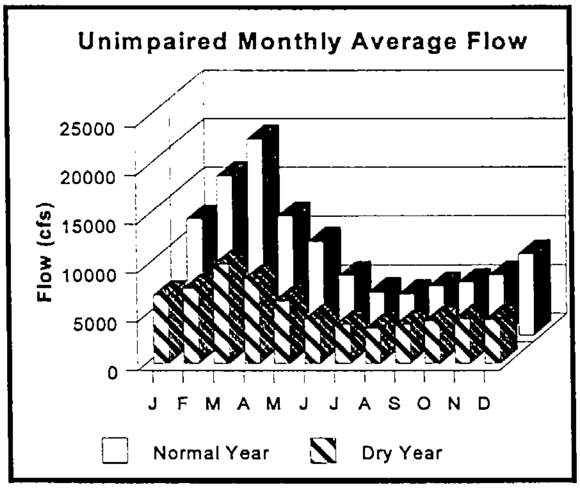
Sacramento River flow is controlled during much of the year by water releases at Keswick and Shasta dams. Tributaries, including many with no major storage dam, provide a significant quantity of flow accretion, particularly through winter and spring months. Prior to the construction of Shasta Dam, the river flows near Redding had a typical winter and spring high-flow period and a summer low-flow period. Dry-year flows typically reached a peak near a monthly average of 10,000 cubic feet per second (cfs) in March. In more normal years, peak flows reached approximately 20,000 cfs in March. Low summer flows averaged less than 5,000 cfs in dry and normal years.

Listing Status of Sacramento River Species	
Species	**Status of Listing**
Winter-run chinook	ESA: endangered CESA: endangered
Spring-run chinook	ESA: threatened CESA: threatened
Late-fall chinook	ESA: candidate
Fall-run chinook	ESA: candidate
Steelhead	ESA: threatened
Green sturgeon	Species of Special Concern
Splittail	ESA: threatened
Bank swallow	CESA: threatened
Western yellow-billed cuckoo	CESA: endangered
Valley elderberry longhorn beetle	ESA: threatened

Since completion of Shasta and Trinity dams, streamflows in the Sacramento River have changed markedly. Late-winter and spring flows in dry and normal years are stored in reservoirs and released during the late-spring through fall irrigation season. In addition to flows released for irrigation in recent years, flows in excess of 10,000 cfs have been augmented to assist in controlling temperature for survival of winter-, spring, and fall-run chinook salmon spawning, egg incubation, and early rearing in the upper river.



Historical Streamflow below Keswick Dam, 1972-1992
(Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)



Unimpaired Streamflows below Keswick Dam, 1972-1992 (Dry year is the 20th percentile year; normal is the 50th percentile or median year.)

Several water development and flood control projects have dramatically altered the river's natural flow regime, sediment transport capabilities, and riparian and riverine habitats.

These projects include the Central Valley Project (CVP), which consists of Shasta, Keswick, and Whiskeytown dams and Red Bluff Diversion Dam (RBDD). They also include the Sacramento River Flood Control Project, which extends 180 miles south from Chico Landing and consists of a series of levees, weirs, and overflow areas, and the Chico Landing to Red Bluff Comprehensive Bank Stabilization Project, which is designed to control lateral river channel migration. This project is about 54% complete but has not been worked on since 1984. The State Water Project (SWP), consisting of Oroville Dam and the associated diversion works, has altered the flow regime below the confluence with the Feather River.

Natural sediments include fine suspended material that causes elevated turbidity to coarser materials that include gravel and cobbles. Bedload sediments also contribute to ecological health by absorbing energy of water and dampen the intensity of flood effects. Gravel recruitment is limited by dams blocking downstream gravel transport, bank protection, and gravel mining on tributaries. Deficiency in spawning gravels reduces the productive capacity of the river. This is especially true in the 15- to 20-mile river reach below Keswick Dam. Spawning gravel may be adequate to support present salmon and steelhead populations. As fish populations increase, gravel replenishment will be necessary. Natural gravel recruitment from tributary streams, particularly from Cottonwood Creek, needs to be protected to ensure that the gravel deficit in the upper main stem Sacramento River does not increase. Spawning gravel needs protection from degradation caused by excessive silt entering the river from the tributaries. Watershed protection and comprehensive watershed management plans are needed in all the tributaries to reduce erosion of silts and sands that impair the quality of spawning gravels.

The Sacramento River and its tributaries above Shasta Dam have a cold temperature regime suitable for year round salmon spawning. Although the salmon cannot access this reach of the ecosystem, the cold water can be managed using the reservoir and dam to replace the inaccessible upper portions of the watershed. Water temperature in the river is influenced by water releases from Shasta and Keswick dams in drought and consecutive dry or critically dry years. Low flows, combined with warmwater releases, cause the loss of many adult salmon and eggs spawned in the river.

Sacramento River temperature control and power generation requires the installation of a multilevel outlet structure on Shasta Dam and a minimum fall carryover storage in the reservoir of about 2 million acre-feet (MAF). Water temperature in the Sacramento River near Knights Landing can be improved by redirecting the Colusa Basin drain and other agriculture return water to a receiving water other than the Sacramento River or by reuse.

The Colusa Basin drain originates north of Willows in Glenn County. The drain captures waters from the two major diverters located on the west side of the Sacramento River, the Tehama-Colusa and Glenn-Colusa Irrigation districts in Glenn, Colusa, and Yolo counties. Much of the water conveyed through the drain is recaptured and reused before being discharged into the Sacramento River at Knights Landing near RM 90. The combined volume of the water delivered by the two districts can exceed 5,000 cfs during the peak of the irrigation season.

Water temperature is also affected by overhanging vegetation, which shades and moderates heat gain by the water. This shaded riverine aquatic (SRA) habitat has been significantly altered by bank protection and flood control projects. Reestablishing this edge vegetation would significantly improve SRA habitat, woody debris, and other riparian habitat along the

Sacramento River, which, in turn, should improve production and survival of salmon and steelhead.

Historically, the riparian forest corridor along the river averaged 4 to 5 miles wide and encompassed a significantly large area. Today only 5% of the forests remain. One-third of the river length has natural banks and floodplain terraces; the other two-thirds have been modified and confined by levees, riprap, and flood control projects. These structures limit the dynamic forces that promote natural habitat succession and regeneration along the river. Channelization and bank protection between Red Bluff and the Delta eliminate and degrade many habitats by increasing the depth and velocity of flow and reducing the hydraulic and substrate diversity associated with more natural or undeveloped river systems. Bank protection also reduces the amount of fresh gravel and shaded riverine aquatic habitat normally available to the river through bank erosion.

Between Colusa and Red Bluff, natural riparian vegetation associated with the existing stream meander corridor plays a part in the natural floodplain process. In turn, the diversity of streamside vegetation and its overall condition are dependent on these same dynamic river processes. Riparian vegetation effectively creates a buffer to decrease local flood flow velocities. This increases deposits of suspended materials derived from eroding banks. This erosion-deposition process builds the midterrace and eventually the high-terrace lands that support climax forest and agriculture. Overbank flooding is essential for the continued health of the riparian system. As silt and seeds are deposited during these overbank water flow events, the native vegetation is rejuvenated.

The fragmentation of the remaining riparian habitat greatly diminishes its ability to support viable wildlife populations. This remaining habitat is being further degraded by human activity and adverse land uses. The combined loss, fragmentation, and deterioration of riparian habitat has caused, or is leading to, the extinction or elimination of several wildlife species. The drastic decline of the Swainson's hawk, once one of California's most abundant raptors, is in part a result of the loss of riparian nesting areas. In 1987, surveys documented such a low number of yellow-billed cuckoos, that the species appeared to be in danger of immediate extirpation. The elimination of the bank swallow appears likely if bank protection work continues and if mitigation measures are unsuccessful. Various other animal species and some plant species, including the rose-mallow, have population viability problems as a result of adverse human impacts on riparian habitat.

Reestablishing a viable riparian ecosystem along the upper Sacramento River region will increase the acreage and variety of riparian habitats and reverse the decline in wildlife, fishery, and human use values. The U.S. Fish and Wildlife Service (USFWS), the Wildlife Conservation Board (WCB), the National Audubon Society, The Nature Conservancy (TNC), and other private conservation groups are actively seeking to acquire conservation easements or fee ownership of high-priority riparian lands along the Sacramento River as a means to save these lands permanently.

More than 100 miles of the Sacramento River between Red Bluff and Colusa are wholly or partially intact as a dynamic alluvial river meander belt. Although about 20% of its banks are armored by riprap that protects levees and orchards, the river continues to erode its banks naturally and form new banks from gravel and sediment deposits on point bars and terraces. These fluvial geomorphic features support a time-dependent succession of young- and old-growth forest and wildlife habitat that requires 65 to 100 years to reach full maturity (climax succession to valley oak woodland). New sediment and gravel that sustain this process are supplied by a combination of eroding banks along the mainstem river and input from unregulated upstream tributaries. New fish habitat is continually created by migrating gravel riffles and deeper pools formed at bendways, and by mature trees and roots that overhang or topple into the channel as the river naturally erodes through older alluvial deposits supporting climax vegetation.

Improvements in the riparian and stream meander corridors along the Sacramento River are needed to improve spawning and early rearing habitat of splittail. Late-winter and early-spring streamflow improvements are needed to provide attraction flows for spawning adults and increased spawning habitat. Increasing flows in early spring also assists in successful migration of juvenile chinook salmon and steelhead.

Improved peak flows in late winter and early spring are needed to benefit sturgeon spawning. Improved stream meander corridors should also benefit sturgeon.

All four races of chinook salmon require improved streamflows, gravel recruitment, water temperatures, riparian and riverine aquatic habitat, and stream meander corridors, and reduction in the adverse effects of stressors, such as high water temperatures, unscreened diversions, contaminants, and harvest.

Steelhead require improved streamflows and gravel recruitment in the upper river and improved water temperature and riverine habitat in the upper, middle, and lower reaches of the river. Restoring and maintaining natural flow patterns will benefit chinook salmon, but steelhead will benefit only if the natural flows also provide suitably cold water to support year round rearing of juvenile fish. Because of the placement of impassable dams on all major tributaries, approximately 82% to 95% of historical Central Valley steelhead habitat is now inaccessible (Yoshiyama et al. 1996) hence natural populations are mostly relegated to spawning and rearing in low elevation habitats that were historically used mostly as migration corridors. Because of increased summer and fall hypolimnetic releases from reservoirs, flow and temperature conditions in the late summer and fall periods in these reaches can be more beneficial to steelhead than before the dams were built, and small numbers of natural steelhead are able to sustain themselves in these tailwater habitats because of this. Inhospitable conditions in the lower reaches in the pre-dam years was not an overriding impact to steelhead because they had access to the cooler water habitats of the mid and high elevation tributaries.

Striped bass spawning in the Sacramento River is controlled by water temperatures. Fertilized striped bass eggs require sufficient stream flows and velocities to maintain the eggs in suspension.

Improvements in late-winter and spring streamflows and stream meander corridors are needed to benefit American shad spawning and rearing in the Sacramento River.

The yellow-billed cuckoo along the Sacramento River above the Delta is not a species for which specific restoration projects are proposed. Potential habitat for the cuckoo will be improved by improvements in riparian habitat areas that result from efforts to protect, maintain, and restore riparian and riverine aquatic habitats throughout the Sacramento River Ecological Management Zone, sustaining the river meander belt, and increasing the coarse sediment supply to support meander and riparian regeneration.

Specific restoration projects are not proposed for the bank swallow populations along the Sacramento River above the Delta. Potential habitat for bank swallows will be improved by sustaining the river meander belt, and increasing the coarse sediment supply to support meander and coarse sediment erosion and deposition processes.

List of Species to Benefit from Restoration Action in the Sacramento River Ecological Management Zone

- splittail
- green sturgeon
- white sturgeon
- chinook salmon
- steelhead trout
- striped bass
- American shad
- western yellow-billed cuckoo
- bank swallow
- neotropical migratory birds
- valley elderberry longhorn beetle

Other problems in the Sacramento River affecting anadromous fish include poorly screened diversions, seasonal dams installed in rivers, small unscreened diversions, and a limited number of large diversions (>250 cfs). Two diversion dams operate on the river seasonally: Anderson-Cottonwood Irrigation District's (ACID) flashboard dam in Redding that diverts approximately 400 cfs and partially impairs the upstream and downstream migration of salmon and steelhead, and RBDD, the gates of which are in place from mid-May to mid-September to allow diversions up to 3,000 cfs into the Corning Canal and Tehama Colusa Canal. Both the dams and diversions have fish passage facilities and fish screens. Fish passage facilities are inadequate at both facilities, and the screen system at the ACID diversion is not adequate. Although predation problems associated with the dams have been lessened, they still occur.

All other water diversions along the river are shoreline diversions. The largest is GCID's Hamilton City Pumping Plant on an oxbow off of the Sacramento River. It diverts up to 3,000 cfs of water into the Glenn-Colusa Canal. Although many improvements have been made to its screening system, fish protection remains inadequate and improvement efforts continue. An environmental impact report is being prepared to describe actions involved in resolving the problem. In addition, hundreds of unscreened diversions located along the river operate primarily in the spring-through-fall irrigation season. Approximately 20 of these are large (>250 cfs). Efforts are presently being made in cooperation with the irrigators and resource agencies to screen these larger diversions.

The damage to fisheries and the riparian system associated with each of the problems in the upper river varies according to the type of water-year and water delivery operations. The diverse and cumulative nature of these variables requires a holistic remedy to achieve ecosystem restoration in the Sacramento River. The most important factors causing mortality are being addressed in various ways with interim or emergency actions.

Fish passage over the 80-year-old ACID diversion dam must be improved. A feasibility study is being conducted to identify alternatives to achieve this goal. ACID canal operations need to be standardized to protect Sacramento River chinook salmon. This involves draining canal water through waste gates only on channels with fish barriers at their confluence with the river, limiting waste-gate releases to 5 or 10 cfs to minimize attraction of salmon from the river, and providing total containment of canal waters when toxic herbicides are present.

Fish passage at RBDD is a longstanding problem that has been partially solved through reoperation. This interim fix has constrained water diversion, and the longer term resolution needs to incorporate fish passage and survival and water delivery. There is the potential that the U.S. Bureau of Reclamation (Reclamation) research pumping facility at RBDD will allow "gates up" operation at RBDD from mid-September through mid-May and allow Reclamation to fulfill its water contract commitments. With the gates raised, fewer squawfish congregate below the dam, thereby reducing predation on juvenile salmon as they pass under the dam gates. This also provides unimpaired upstream and downstream migration for all anadromous fish in the river. During the period when the gates are open, the gravels in the reach immediately above the dam are available for chinook salmon and steelhead spawning, thereby, avoiding the need to compensate for its loss. Fish losses and delayed migration, however, will still occur during the 4 months the dam gates are lowered.

Natural stream meander, river and floodplain interactions, and riparian plant communities have been damaged by levees, bridges, bank protection, and other types of inchannel structures. Where feasible, natural stream meander should be allowed. To enhance this process, it is likely that riprap would be removed in specific areas formerly subject to bank protection activities. Bridge piers and abutments restrict stream channel processes. Long-term remediation of this problem might include future redesign to accommodate river meander when bridges across the Sacramento River are replaced.

Unnatural levels of predation typically occur in the Sacramento River near instream structures, such as diversion dams, bridge piers and pilings, and support structures for diversion pumps. These provide structure and shade which attract predators. This problem can be reduced in the long term by redesigning, removing, or reoperating these structures to minimize the creation of predator habitat, and by providing escape cover in the form of shaded riverine aquatic habitat.

Competition is primarily between naturally and hatchery produced fish and is typically for food and rearing area. The extent of adverse effects of the interaction between hatchery and natural fish has not been adequately investigated in the Central Valley, although Hallock (1987) reported that yearling steelhead released into Battle Creek consumed large numbers of naturally produced chinook salmon fry. Competition may be a suitable subject for focused research and adaptive management. In the interim, hatchery release strategies and schedules should be evaluated to determine opportunities to reduce or eliminate the potential for competition. Although the potential adverse effects of hatchery fish on wild stocks of salmon and steelhead have not been adequately investigated, there is every reason to expect adverse impacts in addition to competition including predation, interference with reproduction, increased fishing mortality due to mixing in the ocean fishery, disease introduction, loss of local adaptations, and genetic introgression. Hatchery operations should be evaluated and changed to minimize all these potential problems.

Harvest will remain an important element that influences the abundance of Central Valley anadromous fish populations. Harvest strategies need to emphasize the protection of naturally produced stocks with a focus on improving spawner returns for winter-run and spring-run chinook salmon and steelhead. Harvest has been severely restricted in recent years to maximize the return of winter-run chinook spawners, at a high economic cost to fishermen in terms of lost opportunities to harvest abundant fall-run chinook.

Improved management of anadromous fish populations, particularly chinook salmon and steelhead, requires the development and implementation of a comprehensive coded-wire tagging and recovery program for hatchery stocks. Data derived from these marking programs are important to assess the contributions of hatchery fish to the fisheries and escapements. Experimental studies can be designed to evaluate the interaction of hatchery and wild fish to that future management direction can be established.

In the interim, the annual production levels of each hatchery should be evaluated to ensure that the hatchery goals are consistent with ecosystem restoration and the recovery of listed species. In the longer-term, hatcheries should not produce fish at levels which exceed the mitigation requirements and other production goals.

Toxins from mine drainage on Spring Creek, enter the river by way of Keswick Dam and threaten survival of salmon and steelhead when sufficient dilution flows are not available from Shasta Lake. Recurrent non-point discharges of agricultural pesticides and herbicides occur, which may also adversely affect juvenile fish populations, other aquatic organisms, and riparian and riverine aquatic vegetation.

Descriptions of Ecological Management Units

Keswick Dam to Red Bluff Diversion Dam Ecological Management Unit

The Keswick Dam to Red Bluff Diversion Dam reach (59 miles from RM 302 to RM 243) includes the mouths of Ash, Bear, Cow, Inks, Stillwater, Anderson, Battle, and Paynes creeks draining Mount Lassen, and of Spring, Clear, and Cottonwood creeks draining the Coast Range and Klamath Mountains. Much of the river in this reach flows through confined canyons, although portions have a broader floodplain. About 4 miles below Keswick Dam, the river widens to about 500 feet before entering the alluvial plains of the Sacramento Valley below Red Bluff. This reach includes much urbanized and residential river frontage, but is not contained by levees as is common on the downstream reach. More than 75% of naturally spawning chinook salmon in the Sacramento River use this reach, while the remaining spawners use the reach from RBDD to Princeton, near Colusa.

Red Bluff Diversion Dam to Chico Landing Ecological Management Unit

The Red Bluff Diversion Dam to Chico Landing Reach (49 miles from RM 243 to RM 194) includes the mouths of eastside tributaries of the Sacramento River that drain Mount Lassen and the northern Sierra Nevada, including Antelope, Mill, Deer, Pine, Rock, and Big Chico creeks. Westside streams that drain the upper valley and parts of the Coast Range include Elder and Thomes creeks. South of Red Bluff, the river meanders over a broad alluvial floodplain confined by older, more consolidated geologic formations (i.e., more cohesive deposits resistant to bank erosion). The extent of river floodplain and active channel meander belt from Red Bluff to Chico Landing has remained relatively unchanged and includes a significant amount of riparian forest and wildlife.

Chico Landing to Colusa Ecological Management Unit

The Chico Landing to Colusa reach (51 miles from RM 194 to RM 143) includes the mouth of Stony Creek and no other major tributaries. In this reach, most of the high flow during storm runoff events leaves the river along the east bank and enters the expansive floodplain of Butte Basin through three major flood relief outfalls at M&T Ranch, 3B's, and Parrot Ranch, and farther downstream through the Moulton and Colusa weirs near Colusa. Much of the river downstream of Chico Landing has been subject to flood control with an extensive system of setback levees, basin and bypass outflows, and streambank protective measures, such as riprap. However, considerable riparian forest remains within the levees along the active channel. Levees in this reach are 0.25 to 1.0 mile apart.

In the Butte Basin overflow segment, more extensive bank revetment projects installed during the past 30 years by landowners and the U.S. Army Corps of Engineers (Corps) attempt to halt natural channel migration by fixing the river in a static position. It was believed that natural channel migration and meander cutoff might alter flow splits that divert a major portion of river floodflow over three major weirs into Butte Basin, where flooding volumes pose less risk to levee overtopping. Recent hydraulic simulation studies of this reach appear to indicate that the river is somewhat self-adjusting to maintain similar Butte Basin overflow volumes despite specific meander cutoffs that may occur. However, bridge structures (e.g., Ord Ferry Bridge) may be more at risk to major adjustments of the channel position within the floodplain.

Colusa to Verona Ecological Management Unit

The Colusa to Verona reach (63 miles from RM 143 to RM 80) includes the mouth of Butte Creek at the Butte Slough outfall gate, but no significant tributary inflow until the Colusa Basin drain enters the river near Knights Landing at RM 90. In past years outflow at the Colusa Basin Drain has contributed to attraction of adult chinook salmon from their normal migratory pathway of the Sacramento River. Fish that stray into the Colusa Basin Drain are subject to stranding and loss from the spawning population. High flows leave the river by way of the Colusa and Tisdale weirs. Farther downstream, most flow from the Sutter Bypass/Butte Slough and Sacramento River leaves the river again at the 3-mile-long Fremont weir and flows down the Yolo Bypass to the Delta at Rio Vista. Most of the levees in this reach are built close to the main river channel, and little riparian forest or shaded riverine aquatic (SRA) habitat remains. Leveed banks are steep, with extensive riprap and routine removal of volunteer vegetation by local reclamation districts to maintain levee stability on the confined river channel. At the turn of the century, levees were built close to the banks to help move sediment down the river to prevent natural shoals that obstructed commercial river navigation reaching Colusa and Red Bluff. This unit is the most important spawning area for striped bass, and appropriate flow velocities and water temperatures are required for successful striped bass reproduction.

Verona to Sacramento Ecological Management Unit

The Verona to Sacramento Ecological Management Unit (20 miles from RM 80 to RM 60) includes important tributary inflow from the Feather River (and from Sutter Bypass and Butte Creek during high flows) at RM 80 and from the American River at RM 60. High-flow outfall from the rivers and Sutter Bypass enters the Yolo Bypass via the Fremont Weir. As with the upstream reach, most of the levees in this reach are built close to the main river channel, and little riparian forest or SRA habitat remains.

Vision for the Ecological Management Zone

The vision for the Sacramento River Ecological Management Zone is to improve, restore, and maintain the health and integrity of the Sacramento River riverine-riparian and tributary ecosystems to provide healthy conditions for sustainable fish and wildlife populations and the plant communities on which they depend.

The pathway to this vision is through preservation and restoration of erosional and depositional channel and floodplain forming processes, riparian and wetland habitats, spawning gravel recruitment, and reducing the extent and influence of stressors. It also includes managing streamflow and flow regime in ways that benefit ecosystem health. Restoring the health and integrity of the Sacramento River Ecological Management Zone will provide a productive and resilient foundation for the recovery of the Bay-Delta estuary and the associated fish, wildlife, and plant resources.

The main stem Sacramento River above Verona may be the most important sturgeon spawning and rearing habitat in the Central Valley, particularly in view of recent information regarding green sturgeon spawning in the river above Hamilton City.

In addition to the vision for the Sacramento River Ecological Management Zone, individual visions have been developed for ecological processes, habitats, stressors, species, and Ecological Management Units. These visions follow.

VISIONS FOR ECOLOGICAL MANAGEMENT UNITS

VISION FOR THE KESWICK TO RBDD ECOLOGICAL MANAGEMENT UNIT

The vision for the Keswick Dam to Red Bluff Diversion Dam Ecological Management Unit is to protect ecological processes where still intact; allow riparian forests to reach maturity; restore physical and successional processes; and protect and restore freshwater fish habitats that provide for migration, spawning, and rearing for chinook salmon and steelhead.

The potential activities include maintaining a flow pattern that emulates the seasonal hydrologic regime and provides adequate temperatures for rearing steelhead and winter-run chinook salmon to the extent possible while conserving the cool water pool in Shasta Reservoir. This must be done in consideration of the high level of development of water and flood storage in the upper section. Additional activities include cooperative efforts to restore some aspects of the natural hydrologic conditions of the upper Sacramento River. The Anadromous Fish Restoration Plan's (AFRP's) targets of 3,250 to 5,500 cfs from October 1 to April 30 are similar to the rates of unimpaired average flows. In addition to the AFRP base flow minimums, reservoir inflows should be released to the river to provide 8,000 to 10,000 cfs and 15,000 to 20,000 cfs flow events for approximately 10 days in March of dry and below normal years, respectively. Such flow events would support natural processes in the upper river, such as erosion, sediment transport and sediment deposition, and stream channel meander, that depend on natural flow regimes. In addition, this reach contains important year-round spawning and incubation habitat for anadromous salmonids.

The vision highlights the restoration of ecological processes that naturally create and sustain habitats needed to support and restore the endangered Sacramento winter-run chinook salmon, the threatened Central Valley steelhead, the threatened spring-run chinook populations; and species of special concern such as fall-run chinook, late-fall-run chinook, and green sturgeon. Important ecological functions of flow include maintaining and supplementing the natural stream meander and gravel recruitment processes, transporting and depositing sediment, protecting the limited riparian corridor, providing cool water for all species of fish, and preventing potential catastrophic fish losses resulting from an uncontrolled spill of toxic materials from Iron Mountain Mine (IMM) and Spring Creek debris dam overflows.

Because this Ecological Management Unit encompasses a significant portion of critical holding, spawning, and nursery area required by the endangered winter-run chinook salmon, most of the water diversions in this reach require positive-barrier fish screens installed to protect juvenile salmon and steelhead. A primary concern in this Ecological Management Unit is protecting and enhancing instream gravel resources supplied to the mainstem river by the tributaries.

Nursery areas for juvenile salmon would be improved by restoring or enhancing riparian and riverine aquatic vegetation throughout this unit, particularly in areas immediately up- and downstream of the mouths of some of the tributaries described above.

VISION FOR THE RED BLUFF TO CHICO LANDING ECOLOGICAL MANAGEMENT UNIT

The vision for the Red Bluff Diversion Dam to Chico Landing Ecological Management Unit is to protect and expand the quantity and quality of the stream meander corridor; protect the associated riparian forest and allow it to reach maturity; install positive barrier fish screens to protect young fish; maintain flows that emulate the natural hydrology to the extent possible; and recover or contribute to the recovery of threatened, endangered, and special concern species.

The existing meander belt should be protected and improved to sustain the riparian and riverine aquatic habitat component that is important habitat for winter-run chinook salmon and steelhead, other anadromous fish species, riparian forest dependent species, such as yellow-billed cuckoo, other neotropical migrant bird species, and the valley elderberry longhorn beetle. This reach also provides important spawning habitat for anadromous salmonids, particularly fall-run chinook salmon.

Restoring endangered species and species of special concern requires that water management activities be consistent with maintaining ecological processes. These include flows that emulate the natural hydrologic regime to the extent possible and are compatible with the high level of development of water in the upper section. Important considerations include flows needed to maintain natural stream meander processes, gravel recruitment, transport, deposition, and establishment and growth of riparian vegetation.

Because this Ecological Management Unit encompasses an important portion of critical nursery and emigration area required by the endangered winter-run chinook salmon, water diversions in the section will require positive-barrier fish screens to protect juvenile fish. In addition, recent research on non-natal rearing in secondary and ephemeral tributaries indicates that these streams are important rearing habitat and refuges for young chinook salmon and steelhead in the Sacramento River system.

The broad riparian corridors throughout the unit should be connected and should not be fragmented. These corridors connect larger blocks of riparian habitat, typically greater than 50 acres. The riparian corridors should generally be greater than 100 yards wide and would support increased populations of neotropical migrants, such as the yellow-billed cuckoo, and unique furbearers, such as the ring-tail and river otter. Species such as the bank swallow will benefit from the restoration of processes that create and maintain habitat within this unit.

Nursery areas for juvenile salmon should be improved through the restoration of waterside emergent and riparian vegetation throughout the unit and particularly up- and downstream of the mouths of some of the tributaries described above.

VISION FOR THE CHICO LANDING TO COLUSA ECOLOGICAL MANAGEMENT UNIT

The vision for the Chico Landing to Colusa Ecological Management Unit is to improve habitat and increase survival of many important fish and wildlife resources by preserving, managing and restoring a functioning ecosystem that provides a mosaic of varying riparian forest age classes and canopy structure; maintaining a diversity of habitat types, including forest and willow scrub, cut banks and clean gravel bars, oxbow lakes and backwater swales with marshes, and floodplain valley oak/sycamore woodlands with grassland understory; maintaining uninterrupted gravel transport and deposition; supporting a complexity of shaded and nearshore aquatic substrate and habitats with well-distributed instream woody cover and organic debris; setting back levees; and the installing positive barrier fish screens.

Restoring endangered species and species of special concern requires that water management activities be consistent with maintaining ecological processes. These include flows that emulate seasonal patterns typical of the natural hydrologic regime, consistent with the high level of water development in the upper section. Important considerations include flows needed to maintain natural stream meander processes and gravel recruitment, transport and deposition, and maintenance of the limited riparian corridor in this section. A long-term goal would be to set back levees in this section consistent with flood control requirements. This important concept should be integrated into any future flood control planning efforts.

Closing gaps in the shoreline riparian vegetation and nearshore aquatic habitat will be accomplished by several means. These include natural colonization or active restoration of expanded floodplain along channels; reduction of vegetation management by local reclamation districts (consistent with flood control requirements); and enhancement of channel banks by modifying levees and berms to incorporate habitat structures, such as fish groins and low waterside berms that support natural growth and woody debris. However, in the long-term, it may be more beneficial and more cost effective to construct set back levees.

Important elements needed to attain the vision for this unit include specific processes that maintain high-quality habitat for chinook salmon and steelhead, as well as the other anadromous fish species. The continuance of the natural river migration within its meander zone is essential to create and maintain most of these habitats. A mix of solutions will be employed to reduce the need for future additional bank protection or separation of the channel from its floodplain. Floodplain management and detention measures that expand flood protection for valley residents by reducing peak flood stage within the leveed channel will also permit more undisturbed habitat to thrive within the river corridor. Measures will most likely include strategic levee setbacks, expanding flood basin outflow capacity, and new flood easements in basin lands that detain additional flood flows, thereby reducing river stage.

In this unit, broad riparian corridors should be interconnected with narrower corridors that are not subject to fragmentation. These corridors should connect larger blocks of riparian habitat, typically larger than 50 acres. These blocks should be large enough to support the natural cooling of the river by convection currents of air flowing from the cool, humid forests and across the river water. The wider riparian corridors should generally be greater than 100 yards wide to support neotropical migrants better, such as the yellow-billed cuckoo. Cavity-nesting species, such as the wood duck, and special-status species, such as the bank swallow, will benefit from restoring the processes that create and maintain habitat within this unit. The narrower corridors would be 10 to 25 yards wide.

Nursery areas for juvenile salmon should be improved by restoring waterside emergent and riparian vegetation throughout this unit.

Because this Ecological Management Unit encompasses a significant portion of the critical migration habitat required by the endangered winter-run chinook salmon, positive-barrier fish screens should be used at water diversions in this section to protect juvenile fish.

Vision for the Colusa to Verona Ecological Management Unit

The vision for the Colusa to Verona Ecological Management Unit is to improve habitat and increase survival of many important fish and wildlife resources; set back levees to improve conditions for riparian vegetation and limited stream meander; provide flows that emulate the natural flow patterns; and install positive barrier fish screens to protect young fish.

Important elements needed to attain the vision for this unit include specific processes that allow the recovery of riparian forest and nearshore aquatic habitats and maintain high-quality habitat for chinook salmon and steelhead and other anadromous fish species. Because this reach is an important seasonal component of the critical migration habitat required by the endangered winter-run chinook salmon, positive-barrier fish screens should be used at water diversions in this section to protect juvenile fish. Adverse environmental effects of the Colusa Basin Drain will be eliminated so that there are no future problems with high water temperatures, contaminants, or fish stranding.

The lack of channel capacity and proximity of levees to the river in the lower two units in this zone are the primary reasons that many habitats are degraded, discontinuous, or absent from this part of the river. There is simply no more room to restore large habitat nodes or corridors without contributing to the flood risk. This is an area where flood control, the potential for set back levees, and ecosystem restoration requirements must be carefully evaluated and integrated. While the potential for meander restoration is less feasible here than on other sections of the river, some degree of restoration is possible.

Vision for the Verona to Sacramento Ecological Management Unit

The vision for the Verona to Sacramento Ecological Management Unit is to recover, contribute to the recovery, or maintain many important fish and wildlife resources that depend on partially operational ecological processes and functions. Elements of this vision include actions to maintain a natural flow pattern; maintain high-quality nursery and migration habitat for adult and juvenile winter-run chinook salmon and steelhead and other anadromous fish species; emulate the natural hydrologic regime to the extent possible; maintain natural stream meander processes and gravel recruitment and deposition; maintain a limited but continuous riparian corridor; provide water temperatures suitable to support chinook salmon, steelhead, and other anadromous fish; reducing potential fish losses resulting from toxic residues from agricultural tailwater; and install positive barrier fish screens to protect young fish.

Closing gaps in the shoreline riparian vegetation and nearshore aquatic habitat will be accomplished (consistent with flood control requirements) by reducing vegetation management by_ local reclamation districts and by enhancing channelbanks. The latter entails modifying levees and berms that incorporate habitat structures (such as fish groins and low waterside berms), which support natural growth and woody debris. This section presents the greatest potential for adding oxbows and arms back into the river system. These modification would enhance valley-wide flood control because an increased floodplain would disperse and carry more water. Nursery areas for juvenile salmon, splittail, and other native resident fish species would be improved by restoring waterside emergent and riparian vegetation nodes throughout this unit, particularly in areas immediately downstream of the mouth of the American River.

In this unit, narrower riparian corridors should be connected and should not be fragmented. These corridors would connect larger blocks of riparian habitat, typically greater than 50 acres. These blocks would be large enough to support the natural convection currents of air flowing from the forests across the river, causing evaporative cooling of the river. The riparian corridors would generally be 10 to 25 yards wide and would support cavity-nesting species, such as the wood duck, and provide perch and nest sites for raptors, such as the Swainson's hawk. Significant expansion of riparian habitat is only possible if lower river peak floodflow can be reduced, or where levees can be set back several hundred feet at constricted bends to create expanded floodplain nodes within the levees.

Visions for Ecological Processes

Central Valley Streamflows: Healthy streamflows are natural seasonal patterns in late winter and spring, which include peak flow events that support many ecological processes and functions essential to the health of floodplains, riparian systems, and anadromous and resident native fish populations. The Sacramento River has only a marginally healthy streamflow, because storage reservoirs in the upper watershed reduce flood peaks during the winter and spring, releasing the stored water during the summer months. The vision for these flow patterns can be attained by supplemental short-term releases from the major storage reservoirs to provide flows that emulate natural peak flow events.

Coarse Sediment Supply: The supply of sediments, including gravel, on the Sacramento River is severely impaired by reduced inputs from tributaries and blockage of upstream sources by Shasta Dam and Keswick Dam. Spawning habitat of native resident and anadromous fishes and the production of aquatic invertebrates are dependent on the amount of suitable gravel in the river. Two major sources of sediments include Cottonwood Creek and natural bank erosion. The vision is to use natural processes to provide sediments to the system and to supplement sediment introductions to the extent necessary to emulate natural conditions.

Stream Meander: The meandering river process in the Sacramento River provides much of the habitat required by anadromous fish populations that depend on the river for spawning, rearing, and migration. Meander also provides the steep-sided cut banks required for bank swallows. The meander belt of the upper portion of the river above Chico Landing is reasonably healthy and functioning, while the meander belt of the lower reaches of the river has been greatly limited by river channelization, by a network of confining levees, and associated development in the river floodplain. The vision is to maintain and preserve existing areas of meander and to reactivate meander in other areas that are impaired by bank protection activities.

Natural Floodplain and Flood Processes: Natural floodplains above Chico Landing are present, but much of the floodplains below are no longer accessible due to levee construction. Maintaining existing and restoring inaccessible floodplains are important ecological components needed to improve the health of the Sacramento River and the Delta. Actions proposed for protecting the natural stream meander corridor along the Sacramento River will contribute to improved connectivity of the river with its floodplain. The vision is to maintain existing areas where the Sacramento River seasonally inundates its floodplain and to reestablish this seasonal inundation in smaller areas that will be subject to adaptive management and focused research.

CENTRAL VALLEY STREAM TEMPERATURES: High summer and fall water temperatures continue to threaten the health of anadromous fish populations in the river. Although actions have been taken to reduce high water temperatures, low flows and the release of warm water from reservoirs in drought years remain as very serious threats to the anadromous fish populations of the Sacramento River. The vision is that stream temperatures will be manipulated to the extent possible to meet the biological requirements of aquatic organisms and that a healthy riparian and riverine aquatic corridor will contribute to shading and moderating temperatures gains in the river. Summer and fall stream temperatures are more critical for steelhead than they are for most races of chinook salmon because steelhead juveniles must rear for more than one year in fresh water, hence the vision is also to provide adequate water temperatures year-round.

VISION FOR HABITATS

RIPARIAN AND RIVERINE AQUATIC HABITATS: The vision is to maintain and restore extensive areas of riparian and riverine aquatic habitats. The primary area for this is along the Sacramento River above Colusa. However, contiguous riparian habitats are extremely important to fish and wildlife throughout all reaches of the Sacramento River, including the 143 miles below Colusa.

FRESHWATER FISH HABITAT: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native and anadromous fish species. The upper sections of the Sacramento is a fall chinook salmon spawning stream of low gradient while the remainder is a valley floor low elevation stream (Moyle and Ellison 1991). The vision is that the quality of freshwater fish habitat in the Sacramento River will be maintained through actions directed at streamflows, coarse sediment supply, stream meander, natural floodplain and flood processes, and maintaining and restoring riparian and riverine aquatic habitats.

ESSENTIAL FISH HABITAT: The Sacramento River has been identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). The vision for EFH is to maintain or restore substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

VISION FOR REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS: Water diversions ranging from several cfs to several thousand cfs lead to the loss of millions of juvenile anadromous and resident fish. Significant progress has been made in screening the larger diversions, but screens are needed on the remaining unscreened largest, many medium-sized, and small diversions. Losses at these diversions continue to threaten the health of the anadromous fish populations. The vision is to consolidate, relocate, and screen diversions along the Sacramento River to the extent that they no longer impair other efforts to restore anadromous and resident fishes.

DAMS AND OTHER STRUCTURES: Diversion dams and other structures in the Sacramento River directly and indirectly impair the survival of adult and juvenile anadromous fish. Structures delay or prevent the upstream migration of adult fish during their spawning run, which lowers the reproductive success and viability of the entire population. These diversion structures can injure young fish as they migrate downstream or cause disorientation, making them more susceptible to predation. Predator fish that are not able to migrate upstream may congregate below these structures during times when prey species are abundant. The vision is to modify, remove, or reoperate structures in a manner that greatly lessens adverse affects on aquatic organisms.

LEVEES, BRIDGES, AND BANK PROTECTION: Most of the biological productivity in large river ecosystems occurs in the floodplain. Levees tend to sever the river from its floodplain and thereby reduce this productivity. Bridges and bank protection limit the lateral migration of the river channel. The vision is to modify or remove structures in a manner that greatly lessens adverse affects on ecological processes, habitats and aquatic organisms.

PREDATION AND COMPETITION: Predation and competition are natural ecological functions. For example, Sacramento pikeminnow are a large native predatory minnow which evolved along with other fishes in the Sacramento River system. Predation by this species under natural environmental conditions is a natural ecological function. However, large-scale alterations of habitat, streamflow, and the construction of instream structures has provided an advantage to predatory species by eliminating escape cover for young fish and providing types of habitat that harbor predatory fish. Unnatural levels of predation or competition can result in adverse effects to important sport and commercial fisheries and species of concern. The vision is that predation and competition will be lessened by removing, redesigning, or reoperating inwater structures and diversion dams, altering hatchery practices, and restoring riparian and riverine aquatic habitats.

CONTAMINANTS: Heavy metals from Spring Creek are a continuing problem for fish in the upper Sacramento River, as well as non-point sources of contaminants in the lower river reaches, such as agricultural return flow at Knights Landing. The vision is that contaminant effects will be reduced to levels that will not impair efforts to restore anadromous and resident fish populations and other aquatic and terrestrial species.

HARVEST OF FISH AND WILDLIFE: The legal and illegal harvest of anadromous fish within the river, estuary, and ocean constrains recovery of wild populations of anadromous fish in the Sacramento River. Reducing the fraction of the wild population harvested will most likely be necessary to allow recovery of populations to a healthy condition. The vision is that harvest strategies will complement efforts to rebuild anadromous fish populations.

ARTIFICIAL PROPAGATION OF FISH: Stocking hatchery-reared salmon and steelhead in the Sacramento River and some of its tributaries supports important sport and commercial fisheries and mitigates loss of chinook salmon and steelhead from the construction of large dams and reservoirs. Hatchery fish also supplement the numbers of naturally spawning chinook salmon and steelhead in the river. However, hatchery salmon and steelhead may impede the recovery of wild populations by competing with wild stocks for food and space. Hatchery-raised stocks, because of interbreeding, may not be genetically equivalent to wild stocks or may not have the instincts to survive in the wild. If these stocks breed with wild populations, overall genetic integrity suffers. Improvements in hatchery practices are necessary to ensure recovery of wild salmon and steelhead populations. The vision is to operate hatcheries in a manner that is fully integrated into ecosystem management and restoration of naturally spawning anadromous fish.

STRANDING: Chinook salmon and other native fish species remain susceptible to stranding as a result of entering the lower end of the Colusa Basin Drain. The vision is to provide a long-term remedy to prevent adult fish, particularly chinook salmon, from entering the drain.

VISIONS FOR SPECIES

SPLITTAIL: The vision for splittail is to recover this federally listed threatened species. Improvements in the riparian and stream meander corridors along the Sacramento River will improve spawning and early rearing habitat of splittail. Late-winter and early-spring streamflow improvements will provide attraction flows for spawning adults and increased spawning habitat. The vision is that restoration of ecological processes and habitats, along with a reduction of stressors, will contribute to a stable and larger splittail population.

Because of its distribution, restoration actions implemented in the following Ecological Management Zones will contribute to the recovery of splittail: Sacramento River, East San Joaquin, San Joaquin River, Sacramento-San Joaquin Delta, Suisun Marsh/North San Francisco Bay, Colusa Basin, Feather River/Sutter Basin, American River Basin, and Yolo Basin. Many of the related actions include restoring ecological processes linked to natural floodplains and flood processes.

WHITE STURGEON AND GREEN STURGEON: The vision for green sturgeon is to recover this California species of special concern and restore population distribution and abundance to historic levels. The vision for white sturgeon is to maintain and restore population distribution and abundance to historic levels to support a sport fishery. Improved peak flows in late winter and early spring will benefit sturgeon spawning. Improved stream meander corridors should also benefit sturgeon. The vision is that restoration of ecological processes and habitats, along with a reduction of stressors, will contribute to stable and larger sturgeon populations.

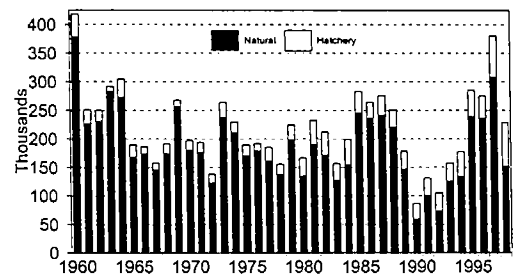
Green sturgeon is a legal sport fish in California, Oregon, and Washington. The Bay-Delta system constitutes the southernmost reproducing populations of green sturgeon. There is no direct evidence that green sturgeon have declined in the Sacramento River, but the population is quite small, and a collapse could occur under some conditions. Green sturgeon require additional focused research on life history, distribution and abundance.

Similar to restoration actions for white sturgeon, actions that will contribute to the protection and restoration of green sturgeon will occur in the Sacramento River, Feather River, Sacramento-San Joaquin Delta, and Suisun Marsh/North San Francisco Bay Ecological Management Zones.

Although the California Department of Fish and Game and USFWS have set population and harvest goals, actions to accomplish the Ecosystem Restoration Program Plan (ERPP) target will be achieved by restoration actions undertaken and completed in the Sacramento River, Feather River, Sacramento-San Joaquin Delta, and Suisun Marsh/North San Francisco Bay Ecological Management Zones.

CHINOOK SALMON: The vision for Central Valley chinook salmon is to recover all stocks presently listed or proposed for listing under ESA and CESA, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and use fully existing and restored habitat.

Four races of chinook salmon will benefit from improved streamflows, gravel recruitment, water temperatures, riparian and riverine aquatic habitat, and stream meander corridors. The vision is that restoration of ecological processes and habitats, along with a reduction of stressors, will contribute to stable and larger chinook salmon populations.



Sacramento Valley Fall-run Chinook Salmon Returns, 1960-1998 (CDFG 1999).

Each of the major chinook salmon restoration /recovery programs has developed specific goals for Central Valley chinook salmon stocks. ERPP embraces each of the restoration/recovery goals and will contribute to each agency's program by restoring critical ecological processes, functions, and habitats, and by reducing or eliminating stressors. ERPP's approach is to contribute to managing and restoring each stock with the goal of maintaining cohort replacement rates of much greater than 1.0 while the individual stocks are rebuilding to desired levels. When the stocks approach the desired population goals, ERPP will contribute to maintaining a cohort replacement rate of 1.0.

STEELHEAD TROUT: The vision for steelhead trout is to recover this species listed as threatened under ESA and achieve naturally spawning populations of sufficient size to support inland recreational fishing and that use fully existing and restored habitats.

Steelhead will benefit from improved streamflows and gravel recruitment in the upper river and improved water temperature and riverine habitat in the upper, middle, and lower reaches of the river. The vision is that restoration of ecological processes and habitats, along with a reduction of stressors, will contribute to stable and larger steelhead populations.

Operation of the water storage and conveyance systems throughout the Central Valley for their potential ecological benefits can be one of the more important elements in restoring a wide spectrum of ecological resources, including steelhead trout.

STRIPED BASS: The vision for striped bass is to restore populations to levels of abundance consistent with the Fish and Game Commission striped bass policy. This will support a sport fishery in the Bay, Delta, and tributary rivers and reduce the conflict between protection of striped bass and other beneficial uses of water in the Bay-Delta. Striped bass spawning in the Sacramento River is controlled by water temperatures. Fertilized striped bass eggs require sufficient stream flows and velocities to maintain the eggs in suspension. Striped bass will benefit from management of streamflow, water velocities, and water temperatures. The vision is that restoration of ecological processes and habitats, along with a reduction of stressors, will contribute to a stable and larger striped bass population.

Most of the broader restoration actions for striped bass are centered in the Delta. However, the Sacramento River near Colusa is the primary spawning area for adult striped bass. A water temperature of 61°F is required to trigger striped bass spawning in the spring. Therefore, in some years it may be possible to manipulate water temperatures to reach the threshold for spawning.

AMERICAN SHAD: The vision for American shad is to maintain an naturally spawning population, consistent with restoring native species, that supports a sport fishery similar to the fishery that existed in the 1960s and 1970s. Improvements in late-winter and spring streamflows and stream meander corridors will benefit American shad spawning and rearing in the Sacramento River. The vision is that restoration of ecological processes and habitats, along with a reduction of stressors, will contribute to a stable and larger American shad population.

Although American shad is an introduced species, it supports a highly seasonal and popular sport fishery in the Sacramento, Feather, Yuba, and American Rivers. This species will benefit from actions implemented to restore and maintain ecological processes related to streamflow, floodplain processes, and improved nearshore habitat and cover provided by shaded riverine aquatic and woody debris. These actions are being developed throughout the Central Valley and will provide benefits to numerous species and species communities.

WESTERN YELLOW-BILLED CUCKOO: The vision for the yellow-billed cuckoo is to contribute to the recovery of this State-listed endangered species. The yellow-billed cuckoo along the Sacramento River above the Delta is not a species for which specific restoration projects are proposed. Potential habitat for the cuckoo will be expanded by improvements in riparian habitat areas. These improvements will result from efforts to protect, maintain, and restore riparian and riverine aquatic habitats throughout the Sacramento River Ecological Management Zone, thus sustaining the river meander belt, and increasing the coarse sediment supply to support meander and riparian regeneration.

Yellow-billed cuckoos inhabit extensive deciduous riparian thickets or forests with dense, low-level or understory foliage that abuts rivers, backwaters, or seeps. This species is found in the American River Basin, Colusa Basin, Sutter Basin, Butte Basin, and North Sacramento Valley Ecological Management Zones. Overall, the decline of the cuckoo has resulted from the loss of dense riparian habitat along the lower floodplains of larger streams, including those found within the Sacramento-San Joaquin Delta. Conversion of land to agriculture, urbanization, and flood control projects have caused the loss of habitat.

The yellow-billed cuckoo is listed as endangered by the State of California. This listing charges the state with the responsibility to conserve, protect, restore, and enhance the species as well as to acquire lands for its habitat.

Rebuilding the yellow-billed cuckoo population to a healthy state will require a coordinated approach to restoring ecosystem processes and functions, restoring habitat, and reducing or eliminating stressors. Within the broad context of ecosystem restoration, restoration of the cuckoo populations will include a wide variety of efforts, many of which are being implemented for other ecological purposes or which are nonspecific to the cuckoo. For example, restoration of riparian woodlands along the Sacramento River will focus on natural stream meander, flow, and natural revegetational/successional process. These will be extremely important to providing shaded riverine aquatic habitat, woody debris, and other habitat values that contribute to the health of yellow-billed cuckoo populations.

BANK SWALLOW: The vision for the bank swallow is to contribute to the recovery of this State-listed threatened species. Potential habitat for bank swallows will be improved by sustaining the river meander belt and increasing the coarse sediment supply to support meander and natural sediment erosion and deposition processes.

NEOTROPICAL MIGRATORY BIRDS: The vision for neotropical migratory birds is to maintain their diversity and abundance by restoring habitat upon which they depend. Protecting and restoring riparian and riverine aquatic habitats will be critical to maintaining population abundance and distribution. The creation of wide riparian corridors or patches will help reduce brown-headed cowbird predation.

VALLEY ELDERBERRY LONGHORN BEETLE: The vision for the valley elderberry longhorn beetle is to recover this federally listed threatened species by increasing its populations and abundance through restoration of riparian systems.

PLANT SPECIES AND COMMUNITIES: The vision for plan species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland and riparian and riverine aquatic habitats.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Attaining the vision for the Sacramento River Ecological Management Zone requires near-term funding and implementing actions to achieve the targets. This includes managing water project operations, purchasing title or easements of land from willing sellers, cooperatively developing and implementing a phased fish screening program, acquiring and placing gravel, and performing engineering studies to improve fish passage at diversions and dams. Significant areas of the Sacramento River between Red Bluff and Colusa actively meander. Management actions should aim to protect this functioning process where it is intact, in addition to restoring channel migration within the meander belt.

Several major restoration efforts are either being developed or implemented by state and federal agencies. They will greatly contribute to the success of effort to restore ecological health to the Sacramento River.

CENTRAL VALLEY PROJECT IMPROVEMENT ACT

The U.S. Fish and Wildlife Service (USFWS) and the Bureau of Reclamation (Reclamation) are implementing the Central Valley Project Improvement Act (CVPIA), which provides for restoration of habitats and species and elimination of many stressors. Key elements of the CVPIA program include the Anadromous Fish Restoration Program (USFWS 1997) and the Anadromous Fish Screening Program. Other elements are directed at spawning gravel replenishment, fish passage, water temperature control in the reach between Keswick Dam and RBDD, water acquisition, and other measures that will contribute to health of the Sacramento River and Sacramento-San Joaquin Delta Ecological Management Zones.

The vision for the Sacramento River Ecological Management Zone will contribute to and benefit from the Anadromous Fish Restoration Program, which strives to double the natural production of anadromous fish in the system over the average production from 1967 through 1991.

In addition to the Anadromous Fish Restoration and Anadromous Fish Screening programs, the CVPIA requires the Secretary of the Interior to implement a wide variety of Central Valley Project (CVP) operation modifications and structural repairs in the Central Valley for the benefit of the anadromous fish resources. Sections 3406(b)(1) through (21) of the CVPIA authorize and direct the Secretary, in consultation with other state and federal agencies, Indian tribes, and affected interests to take the following actions, all of which will ultimately assist in protecting and restoring a wide variety of fish and wildlife resources, habitats, and ecological function associated with the Sacramento and other rivers in the Central Valley.

- Modify CVP operations to protect and restore natural channel and riparian values
- Modify CVP operation based on recommendations of the USFWS after consultation with the CDFG.
- Manage 800,000 acre-feet of CVP yield for fish, wildlife, and habitat restoration purposes after consultation with USBR and CDWR and in cooperation with the CDFG.

- Acquire water to supplement the quantity of water dedicated for fish and wildlife water needs including modifications of CVP operations; water banking; conservation; transfers; conjunctive use; and temporary and permanent land fallowing, including purchase, lease, and option of water, water rights, and associated agricultural land.
- Mitigate for Tracy Pumping Plant operations.
- Mitigate for Contra Costa Pumping Plant operations.
- Install temperature control device at Shasta Dam.
- Meet flow standards that apply to CVP.
- Use pulse flows to increase migratory fish survival.
- Eliminate fish losses due to flow fluctuations of the CVP.
- Minimize fish passage problems at Red Bluff Diversion Dam.
- Implement Coleman National Fish Hatchery Plan and modify Keswick Dam Fish Trap.
- Provide increased flows and improve fish passage and restore habitat in Clear Creek.
- Replenish spawning gravel and restore riparian habitat below Shasta Reservoir.
- Install new control structures at the Delta Cross Channel and Georgiana Slough.
- Construct, in cooperation with the State and in consultation with local interests, a seasonally operated barrier at the head of Old River.
- In cooperation with independent entities and the State, monitor fish and wildlife resources in the Central Valley.
- Resolve fish passage and stranding problems at Anderson-Cottonwood Irrigation District Diversion Dam.
- Reevaluate carryover storage criteria for reservoirs on the Sacramento and Trinity rivers
- Participate with the State and other federal agencies in the implementation of the on-going program to mitigate for the Glenn-Colusa Irrigation District's Hamilton City Pumping Plant.
- Assist the State in efforts to avoid losses of juvenile anadromous fish resulting from unscreened or inadequately screened diversions.

In addition to the aforementioned CVPIA actions, Section 3406(e)(1 through 6) directs the Secretary to investigate and provide recommendations on the feasibility, cost, and desirability of implementing the actions listed below. When completed, these actions will provide additional understanding of the overall ecosystem problems and provide additional measures which will benefit anadromous fish.

- Measures to maintain suitable temperatures for anadromous fish survival by controlling or relocating the discharge of irrigation return flows and sewage effluent, and by restoring riparian forests.
- Opportunities for additional hatchery production to mitigate the impacts of water development and operations on, or enhance efforts to increase Central Valley fisheries: provided, that additional hatchery production shall only be used to supplement or to re-establish natural production while avoiding adverse effects on remaining wild stocks.
- Measures to eliminate barriers to upstream and downstream migration of salmonids.
- Installation and operation of temperature control devices at Trinity Dam and Reservoir.
- Measures to assist in the successful migration of anadromous fish at the Delta Cross Channel and Georgiana Slough.
- Other measures to protect, restore, and enhance natural production of salmon and steelhead in tributary streams of the Sacramento River.

Section 3406(g) of the CVPIA directs the Secretary to develop models and data to evaluate the ecological and hydrologic effects of existing and alternate operations of public and private water facilities and systems to improve scientific understanding and enable the Secretary to fulfill requirements of the CVPIA.

Upper Sacramento River Fisheries and Riparian Habitat Advisory Council

Established in 1986 by Senate Bill 1086, this council has develop a restoration plan and undertaken efforts to eliminate structural problems related to fish passage and entrainment (Resources Agency 1989). The present focus of the Council is to develop and implement a program to protect and preserve the stream meander corridor and establish a riparian conservation area from Keswick Dam to Verona.

The vision for this important Ecological Management Zone will assist the Upper Sacramento River Advisory Council's Riparian Habitat Committee (SB 1086 committee) as it progresses with its plan to restore a naturally sustained riparian corridor, including a designated meander belt and extensive forests, between Keswick Dam and Verona.

Sacramento and San Joaquin Basins Comprehensive Study

As a result of State and Federal legislation, the U.S. Army Corps of Engineers and The Reclamation Board of California are conducting the Sacramento and San Joaquin River Basins Comprehensive Study. The Study will identify and evaluate measures to correct system deficiencies and will formulate a Master Strategy for Flood Damage Reduction and Environmental Restoration. This Master Strategy will identify immediate and staged implementation objectives for resolving flooding and interrelated ecosystem problems in the two basins. A cornerstone of this study is a system-wide evaluation to determine the existing capabilities of the flood management systems with an assessment of ecosystem functions intricately linked with the flood conveyance functions of the river systems.

Endangered Species Recovery Plan Implementation

The ERPP will be an important, if not major, component in the successful implementation of recovery measures for species listed under either the State or Federal ESAs. For example, many of the targets and programmatic actions listed later in this section are derived from existing recovery plan. Two plans that have had major influences on the development of programmatic actions include the Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes (U.S. Fish and Wildlife Service 1996) and the NMFS Proposed Recovery Plan for the Sacramento River Winter-run Chinook Salmon (National Marine Fisheries Service 1997).

Because the ERPP addresses endangered species from a broader ecosystem perspective, many restoration actions will benefit broad species communities and the habitats upon which they depend. These include actions to benefit aquatic and terrestrial fish and wildlife species as well as special plants and plant communities.

State and federal agencies responsible for flood control and natural river resources should collaborate with local jurisdictions, landowners, and river conservation organizations to seek systemize solutions, particularly those that emphasize non-structural solutions to flood control and floodplain protection and restoration. In particular, the U.S. Army Corps of Engineers (Corps) should develop a physical model of the river system and its floodplain (similar to the Butte Basin study, but on a larger scale) to test hypotheses for complex rerouting, detention, and bypassing of floodwater. A Sacramento Valley hydraulic and sediment transport model will be integrated with an evaluation of ecological functions dependent on these physical processes and on the interaction of elements of the ecosystem recovery and land use with floodway capacity.

Completion of studies and subsequent implementation of the U.S. Environmental Protection Agency (EPA) remedies for the IMM Superfund site are needed to attain the safe metal concentrations identified in the basin plan. Pollution control remedies are required at the IMM portal for discharges of remaining sulfide ore deposits inside the mountain, the discharges from tailing piles, and the metal sludge in Keswick Reservoir.

In reaching the vision for this Ecological Management Zone, many cooperative programs need to be developed with federal, state, and local agencies, as well as local interests, such as watershed groups and individual landowners. The cooperative approach also applies to efforts to redirect some industries, such as the aggregate resource industry, to areas outside the active stream channel. These efforts require support from the industry and counties to undertake new programs.

CALFED Bay-Delta Program

CALFED has funded nearly 20 ecosystem restoration projects along the Sacramento River. Most projects screen diversions for irrigated agriculture. Four projects acquire and restore riparian habitat, in conjunction with the SB1086 program. Three projects plan, design, and will construct a new fish ladder at the Anderson-Cottonwood diversion to improve access for winter-run chinook salmon to spawning habitat upstream of the dam.

Linkage to Other Ecological Management Zones

The Sacramento River Ecological Management Zone is dependent on virtually all of its adjacent Ecological Management Zones, which cumulatively contribute to the maintenance of important ecological processes and functions, particularly water, sediments, and nutrients. However, many large, westside streams no longer provide significant sediment and gravel to the mainstem river because of the placement of large reservoirs or sediment control basins, and instream gravel mining that depletes gravel sources in the channel for downstream transport.

Restoring and maintaining ecological processes and functions in the Sacramento River Ecological Management Zone are highly dependent on actions and conditions in adjacent zones. For example, maintaining the riparian forests and stream meander quality of the Sacramento River above Chico Landing is dependent on input of largely unregulated flow and sediments from Cottonwood Creek and several undammed tributaries draining Mount Lassen and the northern Sierra Nevada. Therefore, restoring and maintaining important ecological processes in Cottonwood Creek and other nonregulated tributaries is absolutely essential to maintaining the ecosystem health of the Sacramento River.

Cottonwood Creek is the most important watershed component in the upper river downstream of Shasta Reservoir and controls and supports the maintenance of ecological processes and functions in the upper Sacramento River. The Cottonwood Creek Ecological Management Zone is discussed separately, but its importance to the ecological health of the upper Sacramento River is emphasized here, because it is the largest remaining undammed tributary with natural hydrologic conditions and sediment characteristics. In the winter 1986 flood, more than half the flow (and presumably gravel and sediment) in the Sacramento River originated in Cottonwood Creek, greater than the volume represented by all other north-valley streams combined.

Likewise, some fish species depend exclusively on the Sacramento River for migration, spawning, and nursery habitat, while some species that use other Ecological Management Zones for spawning use the Sacramento River as primary migration, nursery, and emigration habitat. Other important Ecological Management Zones dependent on the resources of the Sacramento River include the Sacramento-San Joaquin Delta Ecological Management Zone and the Suisun Marsh/San Francisco Bay Ecological Management Zone. These zones, in turn, provide essential foodweb prey species and critical rearing habitat for outmigrating anadromous fish that spawn in the Sacramento River and its major tributaries.

Additionally, stressors important to fish and wildlife species using the Sacramento River during at least part of their life cycle occur outside the identified Ecological Management Zones. For example, ocean recreational and commercial salmon fisheries remove a large portion of the potential spawning adults from the population each year. New harvest management strategies for the ocean fisheries will be needed to augment improvement to inland ecological processes and functions that maintain key habitats for salmon. Water quality of agricultural tailwater throughout the Colusa Basin that reenters the Sacramento River at Knights Landing or Prospect Slough (Yolo Bypass) affects the health and survival of juvenile fish and prey species in the river, depending on the temperature, toxicity level, dilution ratios, and contaminant concentrations and presence of loadings.

Restoration Targets and Programmatic Actions

Ecological Processes

Central Valley Streamflows

Target 1: More closely emulate the seasonal streamflow patterns in dry and normal year- types by allowing a late-winter or early-spring flow event of approximately 8,000 to 10,000 cfs in dry years and 15,000 to 20,000 cfs in below normal water-years to occur below Keswick Dam (◆◆).

PROGRAMMATIC ACTION 1A: Provide a flow event by supplementing normal operating flows from Shasta and Keswick Dams in March during years when no flow event has occurred during winter or is expected to occur. Flow events would be provided only when sufficient inflow to Lake Shasta is available to sustain the prescribed releases. This action can be refined by evaluating its indirect costs and the overall effectiveness of achieving objectives.

TARGET 2: Maintain base flows of 6,000 to 8,000 cfs during fall (◆).

PROGRAMMATIC ACTION 2A: Provide flow releases from Shasta Lake and Keswick Dam when necessary to provide the target base flows. Releases would be made only when inflows equal or exceed prescribed releases.

RATIONALE: *The proposed March supplemental flows were selected as a representative value for impact analysis in the Programmatic EIS/EIR. Throughout the ERP, the need to determine optimal streamflow for ecological processes, habitats, and species is repeated. The issues of supplemental flows are complex in term of ecosystem improvements. The frequency, magnitude, duration, timing and rate of change of streamflows that form channels, create and maintain riparian habitat (including all species of vegetation), and promote all life stages of the various aquatic species dependent on a particular stream will never occur within a single year. An optimal flow regime will have to vary, perhaps significantly, from year to year. The supplemental flow recommendations will be an intensive exercise in adaptive management and must be based on credible scientific underpinnings.*

Increasing releases from Shasta Reservoir are the only means of maintaining base flows in the upper river. Late-winter or early-spring flow events of sufficient magnitude attract and sustain adult salmon, steelhead, sturgeon, and American shad; improve transport of juvenile fish downstream; sustain riparian habitat; and sustain gravel recruitment, transport, and cleansing processes. The target flows are consistent with historic and unimpaired flows for the Sacramento River in dry and normal years. These flows may not occur in some years under the present level of project development and operation. Implementing the target level of the flow event must necessarily be on a conservative basis because of the potential cost to water supply. The fall flow pattern needs to be carefully evaluated to ensure protection for incubating chinook salmon eggs. The chinook salmon that spawn in the fall have eggs in the river that incubate into the winter season. Incubating eggs can be severely damaged when wintertime releases from Keswick Dam are dropped below the fall release levels. Other concerns include maintaining high base flows during the fall would cause temperature control problems in the following year under conditions of low carryover storage in Shasta Reservoir or low inter inflow conditions. The fall flow needs to consider the need for carryover storage to provide temperature control in the following year.

If a flow event of equal or greater magnitude has not occurred between Keswick Dam and Red Bluff by March, then supplementing base flows or augmenting small natural releases or reservoir spills with additional reservoir releases is the only means to provide flow events. Such releases would be used only if there is an equivalent or greater inflow to Lake Shasta. March is the logical month to provide such flows, because it is the month when "natural" flow events occurred historically in dry and below normal years, and because opportunities for such flow to occur "naturally" as a function of normal project operation would have been exhausted by then. Water forecasts of the water-year type (critically dry, dry, below normal, above normal, or wet) are available by February and March. The flow event in March would be expected to proceed unimpaired downstream to the Delta, because few or no diversions from the Sacramento River occur during March. (Note that additional flow events are prescribed for the Feather River in March, which will further enhance Sacramento River flows below its confluence with the Feather River.) A March flow event could also help satisfy Delta outflow requirements.

Maintaining natural base flows will help promote natural channel forming, riparian vegetation, and foodweb functions. Base flows also serve to attract steelhead and fall-run and late-fall-run chinook salmon. Unimpaired base flows in fall are approximately 4,000 cfs to 6,000 cfs in dry years, and up to 8,000 cfs in wetter years. Natural base flows *are prescribed only for fall, because, under present project operation, flows in excess of 10,000 cfs are maintained in summer for irrigation and to lower water temperatures for winter-run salmon.*

COARSE SEDIMENT SUPPLY

TARGET 1: Increase gravel recruitment in the upper Sacramento River between Keswick Dam and the RBDD by 10,000 to 20,000 cubic yards annually to provide adequate spawning habitat for targeted levels of salmon and steelhead and to sustain stream meander processes below Red Bluff. (This is the estimated amount of spawning-sized gravel captured annually by Shasta Dam.) (◆◆)

PROGRAMMATIC ACTION 1A: Develop a cooperative program to stockpile gravel at strategic locations along the Sacramento River below Keswick Dam where riverflow will move gravel into the river channel to mimic natural gravel recruitment into the upper river. Determine the adequacy of this action and adjust amount and locations as necessary.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to reactivate gravel recruitment to the river by exposing existing sources of river gravel on islands, bars, and banks that have become armored to riverflows. This action should be implemented on a conservative basis, because the availability of such inchannel gravel, costs of activating the gravel, indirect impacts, and potential effectiveness have not been determined.

RATIONALE: *Replenishing gravel supplies to a level sufficient to support target populations of salmon and steelhead will help to improve populations to desirable levels and to maintain such levels once achieved. Replenishing gravels to maintain channel-forming processes and stream meanders in the upper Sacramento River will help to maintain fish and wildlife habitats, aquatic algae and invertebrate production, and streamside vegetation (California Department of Water Resources 1980). A predevelopment level of gravel recruitment should be adequate to restore the natural ecological processes supported by gravel recruitment, but may require experimenting, monitoring, and experience to determine the exact amount of gravel supplies necessary to meet the objective. Implementation of gravel supplementation projects above RBDD will be subject to adaptive management, with elements that include focused research on sediment transport processes, and monitoring of gravel quality and quantity. Sediment supplementation programs need to be integrated with downstream channel forming processes, which will be subject to adaptive management, as well as to a different set of indicators, monitoring, and focused research.*

On the river side of natural levees in alluvial valleys, fluvial processes typically create dynamic river meander patterns, including oxbow lakes from bend cutoffs, secondary channels that carry flow only during high stage, and nonvegetated point bars where new deposits of sand and gravel collect in low-energy zones of inside bends and bendway crossovers (riffles). In cross section, natural alluvial streams are typically terraced and asymmetrical, with steep banks on eroding outside bends, low-angle banks on inside bends, and several nearly horizontal surfaces corresponding to river floodplain elevations of various magnitude and frequency. If a river has incised (i.e., eroded down below the original channelbed surface) as a result of natural or human-induced factors, the abandoned upper floodplain may become a "terrace" (former floodplain) where riparian forest may then convert to valley oak woodlands or grassland-oak savannah.

The characteristic three-dimensional shape of a river described above (its "fluvial geomorphology" or landforms created by flowing water) is indicative of a river that is in dynamic balance with the interaction of its flood regime, sediment supply, vegetation patterns, climate, and valley slope. Rivers with a natural shape and hydrologic condition generally support the most diverse mixture of habitats and fish and wildlife species and are the most resilient to natural or human disturbance.

STREAM MEANDER

TARGET 1: Preserve and improve the existing stream meander belt in the Sacramento River between Red Bluff and Chico Landing by purchase in fee or through easements of 8,000 to 12,000 acres of riparian lands in the meander zone (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate the feasibility of removing riprap from banks to the extent possible, consistent with flood management requirements, and reduce effects of other structures, such as bridges, to provide a sustainable meander corridor.

PROGRAMMATIC ACTION 1B: Purchase easements to offset losses to property owners for land lost to meander process.

TARGET 2: Preserve and improve the existing stream meander belt in the Sacramento River between Chico Landing and Colusa by purchase in fee or through easements of 8,000 to 12,000 acres of riparian lands in the meander zone (◆◆◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to evaluate the feasibility of removing riprap from banks to the extent possible, consistent with flood control management, and reduce effects of other structures, such as bridges, to provide a sustainable meander corridor.

PROGRAMMATIC ACTION 2B: Purchase easements to offset losses to property owners for land lost to meander process.

RATIONALE: *Preserving and improving the stream meander belt below Red Bluff will ensure that this important natural process is maintained in the Sacramento River. This reach is important for spawning and rearing salmon and steelhead. A natural meander process will provide near-optimal habitat for spawning (through gravel recruitment), rearing (channel configuration, cover, and foodweb), and migration. There is limited potential natural channel above Red Bluff. Below Chico Landing, flood control levees limit the potential of restoring the natural meander of that reach. Overall, the program must be consistent with flood control requirements and in the longer-term, should reduce need for future flood control efforts by using natural system resilience and flood control characteristics.*

During the selection process and during implementation, additional benefits will accrue by looking for land within or adjacent to the meander belt which support special status species and to include these areas whenever available in the acquisition. Some the species to be considered include the valley elderberry longhorn beetle, bank swallow, western yellow-billed cuckoo, and giant garter snake.

NATURAL FLOODPLAIN AND FLOOD PROCESSES

TARGET 1: Increase and maintain floodplains in conjunction with stream meander corridor restoration (◆◆).

PROGRAMMATIC ACTION 1A: Develop and implement a cooperative program, consistent with flood control requirements, to evaluate the feasibility of altering river channel configurations in leveed reaches of the Sacramento River to increase the areal extent of floodplains inundated during high flow periods.

RATIONALE: *Floodplain inundation is the seasonal flooding of floodplain habitats, including riparian and riverine aquatic habitats. Flooding of these lands provides important seasonal habitat for fish and wildlife and provides sediment and nutrients to both the flooded lands and aquatic habitats that receive the returning or abating floodwater. The flooding also shapes the plant and animal communities in the riparian, wetland, and upland areas subject to flooding. Floodplain flooding is a secondary ecosystem process related to water and sediment flow through the Sacramento-San Joaquin basin and their landforms. Opportunities to restore or enhance this process are possible by changing landscape features, landforms, and seasonal distribution of flow volume through the system.*

Channelizing and shortening rivers; removing instream vegetation and gravel; and creating symmetrical, trapezoidal channels sandwiched between narrow, steep-sided levees diminish the natural tendency of alluvial rivers to form characteristic compound dimensions and patterns. A channelized river may be relatively stable if the potential for major flood events has been eliminated, sediment input is minimal, vegetation does not naturally grow along the banks, and the channelbed is incapable of incising. The absence of river floodplains and adequate meander width for bar and riffle formation within levee-confined channels prevents or depresses the formation of natural river morphology that is the structural framework for riverine and estuarine fish and wildlife habitats. Stabilizing artificial banks with rock riprap and clearing vegetation further degrades habitat and diminishes natural channel-forming processes.

An important exception here is the existence of the Sacramento River basin overflow system: the Butte basin and Sutter and Yolo Bypasses. Although considerably smaller than their original extent, these three floodplains move and detain floodwaters in volumes and patterns similar to those of presettlement flow, while reducing the risk of *overtopping levees near populated areas. At flood peak, there is approximately five times more flow in the Sacramento River bypass floodplain system than in the main river channel it drains. However, the floodplain bypass system does not exist in the largest historic flood basin of the Sacramento River, the Colusa basin, which is disconnected by levees from the river. Also, the lowest areas of the Sutter basin are outside of the levees and the Sutter Bypass traverses slightly higher ground on a portion of the historical basin floodplain.*

CENTRAL VALLEY STREAM TEMPERATURES

TARGET 1: Maintain mean daily water temperatures at levels suitable for maintaining all life-history stages of chinook salmon and steelhead in the Sacramento River between Keswick Dam and RBDD in above normal and wet years, and between Keswick Dam and RBDD in other year types (◆◆◆).

PROGRAMMATIC ACTION 1A: Cooperatively develop and implement a balanced river regulation program that provides sufficient carryover storage at Shasta Dam to ensure that suitably low water temperatures are reached to protect chinook salmon and steelhead spawning, incubating eggs, and young fish, particularly in consecutive dry and critically dry years.

RATIONALE: *The temperature objective for the upper Sacramento River is less than or equal to 56°F from Keswick Dam to RBDD for operation of CVP in the State Water Resources Control Board's (SWRCB's) Order 90-5. However, these criteria cannot be met consistently, and other structural facilities and operation measures are needed. These facilities and operational measures must be developed and implemented to enable the long-term attainment of the SWRCB-required temperature criteria.*

A temperature control or "shutter device" has been installed to permit the selective withdrawal of water from Shasta Reservoir over a wide range of depths and temperatures. With this device, warm water could be withdrawn from the upper lake levels when needed, while conserving the deeper, cold water for release when it would most benefit chinook salmon. Operation criteria for temperature criteria needs to include temperature requirements of steelhead trout which spawn in the late-winter/early spring. Controlling temperatures solely for chinook salmon would have serious impacts to naturally spawning steelhead. Operating the temperature control device allows Reclamation greater effectiveness and flexibility in temperature control operations while maintaining hydroelectric power generation. The temperature control device also provides a secondary benefit to anadromous fish by controlling turbidity. Because the temperature control device is installed and operational, operations and carryover storage requirements must be reassessed and new criteria established to optimize attainment of water temperature objectives.

In the long term, Sacramento River water temperatures can be moderated by restoring a healthy riparian forest. Implicit in restoring an extensive riparian forest is a need to reconnect the river with its floodplain to promote natural riparian succession.

HABITATS

RIPARIAN AND RIVERINE AQUATIC HABITATS

TARGET 1: Provide conditions for riparian vegetation growth along channelized portions of the Sacramento River (◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to plant vegetation on unvegetated, riprapped banks consistent with flood control requirements. Implementation will occur in phases, results will be monitored and restoration approach will be adjusted as necessary under adaptive management.

PROGRAMMATIC ACTION 1B: Setback levees may be constructed on leveed reaches of the river to provide a wider floodplain and greater development of SRA habitat. Because of the potential indirect impacts on land use and uncertainty of cost and technical feasibility of setback levees, such development will be experimental and conservative, and will depend on adaptive management.

PROGRAMMATIC ACTION 1C: Cooperatively develop and implement a study to determine appropriate conditions for the germination and establishment of riparian woody plants along the river.

TARGET 2: Increase the ecological value of low-to moderate-quality SRA habitat by changing land use and land management practices (◆◆).

PROGRAMMATIC ACTION 2A: Purchase property or easements and allow habitat to improve naturally. Properties to be considered should be developed through a prioritizing process that considers habitat quality and importance, technical feasibility and cost of purchase and improvement, and consent of landowners.

PROGRAMMATIC ACTION 2B: Provide incentives and technical support for private landowners to protect and improve existing SRA habitat.

TARGET 3: Maintain existing streamside riparian vegetation (◆◆◆).

PROGRAMMATIC ACTION 3A: Through purchase, conservation easement, and voluntary participation of landowners, protect SRA habitat from development. Where high-priority properties are already in government ownership or available for purchase or easement, preservation efforts should be undertaken as experiments to develop technical details, cost-effectiveness, and overall approach and consensus for the program. Full implementation of this program would depend on results of experiments and would be subject to adaptive management.

RATIONALE: *Riprapped banks in the leveed section of the river below Chico Landing downstream to Sacramento are the greatest cause of SRA fragmentation. Restoring vegetation will benefit juvenile salmon rearing by providing cover and food, spawning substrate for other fish, such as Sacramento splittail, and refuge for juvenile fish during periods of high water. Improving low- to moderate-quality SRA habitat will benefit juvenile salmon and steelhead by providing improved shade, cover, and food. Wildlife will also benefit from improved habitat. Protecting and improving existing SRA habitat may involve changes in land use. Limited available funds may require that priorities be set, with high-priority, low-cost sites developed initially. For sites where consensus exists, immediate experimental action can be taken. Because of the importance and limited distribution and abundance of SRA habitat, all existing quality habitat should be protected.*

In developing this element of the restoration plan, it is important not to develop just a very long, narrow band of riparian vegetation. Although it needs further development, a "string-of-pearls" approach should be considered. In this concept the long, narrow band of riparian vegetation would be interspersed with larger patches of riparian vegetation. This concept would mesh well with nodes of setback levees to provide a minimal floodplain, seasonal floodplain inundation, and natural or supplemented riparian revegetation.

FRESHWATER FISH HABITAT AND ESSENTIAL FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination (◆◆).

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitat and essential fish habitat. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of the Sacramento River and its floodplain, and in maintaining and restoring riparian and riverine aquatic habitats.*

REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS

TARGET 1: Reduce entrainment of juvenile salmon, steelhead, sturgeon, and splittail into water diversions to levels that will not impair stock rebuilding or species restoration (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to screen all diversions greater than 250 cfs and one- to two-thirds of all smaller unscreened diversions. This programmatic level of action should be sufficient to provide the data necessary to modify this target through adaptive management.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to upgrade screening at diversions with ineffective screening. Where existing screening has proven less than effective and entrainment problems continue, immediate action should be taken to upgrade screens.

PROGRAMMATIC ACTION 1C: Develop a cooperative program to reduce diversions when and where juvenile salmon are present in large or significant numbers. Even with screens, some diversions may pose a threat to young salmon and steelhead, and it may be necessary to modify operations of the diversion. Such determinations will be made after necessary monitoring and evaluation, and on a case-by-case basis. Decisions will be made with agency and stakeholder involvement and with consideration given to appropriate alternatives.

PROGRAMMATIC ACTION 1D: Promote and support relocating water diversions and developing alternate methods of supplying water from the Sacramento River that protect fish but also minimize conflict with maintaining dynamic fluvial processes.

RATIONALE: *Juvenile chinook salmon, steelhead, green and white sturgeon, Sacramento splittail, and American shad are lost at water diversion sites all along the Sacramento River during the spring-to-fall irrigation season. (Note that diversion losses include direct loss into unscreened diversions and other losses associated with the screened and unscreened intake facilities, such as from predators, including squawfish and striped bass.) Reducing entrainment losses to minimal levels is a reasonable target for the short term, given the existing poor health of many of the fish populations that use the Sacramento River and its tributaries for spawning and rearing of young. Emphasis should be on the upper river above Chico Landing, because this is the reach where winter-run chinook young rearing coincides with the spring-to-fall irrigation season.*

Determining which diversions need to be screened will be based on appropriate monitoring and evaluation, with decisions made with agency and stakeholder involvement, and with consideration given to appropriate alternatives. Actions will be taken on a case-by-case basis, with consideration given to results of pilot experiments to determine technical feasibility and cost-effectiveness of screening diversions of different size, type, and location. Priority will be given to screening diversions that pose the most threat and where screening has been determined to be effective. Emphasis should be given to projects that include the consolidation of several diversion points to a single location.

In application, priority for screening diversions will be based on several criteria including but not limited to the geographical location, the volume of water diverted, the location of the intake in the water column, and the cost effectiveness of the installation. Alternatives to screening will be considered. When a fish screen is installed, it should be tested to determine that it can perform to the criteria of the fish regulatory agencies. After testing has indicated that the screen meets the criteria, monitoring should be conducted to ensure that the screen can meet the criteria under the range of hydrologic conditions expected at the site. When operation monitoring indicates that everything is working satisfactorily, the diverter should routinely inspect the screen to ensure that the facility is undamaged.

DAMS AND OTHER STRUCTURES

TARGET 1: Minimize survival problems for adult and juvenile anadromous fish at RBDD by permanently raising the gates during the non-irrigation season and improving passage facilities during the irrigation season (◆◆◆).

PROGRAMMATIC ACTION 1A: Upgrade fish passage facilities at the RBDD.

TARGET 2: Reduce blockage to fish migrations at the ACID dam (◆◆).

PROGRAMMATIC ACTION 2A: Upgrade fish passage facilities at the ACID dam.

RATIONALE: *At present, the RBDD gates are in the raised position from September 15 through May 14, allowing free passage to about 85% of the spawning run (based on average run timing from 1982-1986). This may have reduced the number of redds (spawning nests created by salmon) being built below the dam. The remaining portion of the run migrating upstream after May 15 is likely to be delayed or blocked from passing the dam.*

Adults that are obstructed from passing the dam are forced to spawn downstream where temperature *conditions are typically unsuitable during the spawning and incubation period. Temperatures of 56°F usually cannot be maintained below RBDD without severely depleting Shasta carryover storage during the winter-run chinook incubation period; eggs and larvae usually have 100% mortality.*

Adults that must make repeated attempts to pass the dam, but eventually are successful, undergo physiological stress that may contribute to their reduced fecundity. Because migration of these adults is delayed, the fish are likely to spawn farther downstream where suitable temperatures for spawning and incubation may not be attainable.

Adult chinook salmon must negotiate fish ladders at the ACID dam during the irrigation season (typically April through November) to reach upstream spawning habitat. However, an antiquated ladder on the east abutment of the dam is ineffective in providing safe passage, and a recently installed denil ladder on the west abutment has proved only marginally successful. The ladders at this facility do not provide suitable flows to attract adults, and the ladders are not easily adjustable to compensate for varying flow conditions. A feasibility study is being conducted by the ACID to identify, develop, and evaluate alternatives to resolve adult passage problems.

LEVEES, BRIDGES, AND BANK PROTECTION

TARGET 1: Construct setback levees along leveed reaches of the river as part of the stream meander corridor (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program, consistent with flood control requirements, to evaluate potential sites for establishing setback levees along leveed reaches of the Sacramento River.

RATIONALE: *Levees, bridges, and bank protection structures inhibit overland flow and erosion and depositional processes that develop and maintain floodplains and allow stream channels to meander. Levees prevent flood flows from entering historic floodplains behind levees, stopping evolution of floodplain habitats dependent on overbank flows. Confinement of flood flows to channels by levees and bank protection structures also increases the fluvial energy of flows that scour or incise channel beds and reduces or halts the rate of channel migration and oxbow formation.*

INVASIVE RIPARIAN AND MARSH PLANTS

TARGET 1: Reduce the area of invasive non-native woody species, such as giant reed (i.e., Arundo or false bamboo) and salt cedar (Tamarisk), that compete with native riparian vegetation (◆◆).

PROGRAMMATIC ACTION 1A: Implement a program along the length of the Sacramento River to remove and suppress the spread of invasive non-native plants that compete with native riparian vegetation.

PROGRAMMATIC ACTION 1B: Implement a program eliminates invasive woody plants that could interfere with the restoration of native riparian vegetation.

RATIONALE: *Invasive non-native plants have altered ecosystem processes, functions, and habitats through a combination of changes such as those to the foodweb and those of competition for nutrients, light, and space. The prescribed actions are primarily to improve habitat for many fish and wildlife species and to support foodweb functions by establishing extensive riparian habitat along the Sacramento River. In most cases, the removal of invasive plants will require the replanting of native vegetation to maintain adequate levels of herbaceous cover, canopy closure, habitat structure, and to limit exotic recolonization.*

PREDATION AND COMPETITION

TARGET 1: Reduce the adverse effects of predatory fish by identifying and eliminating human made in-stream structures or operational conditions that allow unnatural predation rates (◆◆).

PROGRAMMATIC ACTION 1A: Selectively evaluate areas and make physical changes to structures in the Sacramento River, such as bridge abutments, diversion dams, rip-rap banks, and water intakes, that currently may attract predators and provide them with additional advantages in preying on juvenile salmon and steelhead. Pilot studies and evaluations are needed to determine the types of changes required and the potential degree of implementation.

RATIONALE: *Upgrading fish passage facilities at the two diversion dams will reduce delays to upstream migrating winter-run chinook salmon and hindrance of downstream migrating juvenile winter-run chinook salmon. This will contribute to a reduction in predation rates on young fish.*

During operation of RBDD, juvenile chinook are adversely affected while approaching the dam, passing the dam, and moving downstream of the dam. As juveniles migrate toward the dam, they experience increased predation in Lake Red Bluff from predatory fish and birds. Juveniles passing under the lowered dam gates become disoriented because of high water velocities and turbulence, and are subject to heavy predation downstream by squawfish and striped bass. Juveniles bypassed around the dam through the Tehama-Colusa fish bypass system may have improved survival rates because of new facilities and positive-barrier fish screens, but complete evaluations are needed.

To help protect winter-run chinook from predation and other losses associated with passage at RBDD, the dam gates have been raised for varying durations since the end of 1986. Juvenile chinook suffer mortality in passing the dam from squawfish and striped bass predation and disorientation or injury when passing beneath the dam gates or through the fish bypass system. Under the present schedule of gate operations, about 26% of the juvenile outmigrants must pass the dam when the gates are lowered and are susceptible to mortality associated with that passage. In a 1988 study, juvenile hatchery salmon were released above and below the dam to estimate total mortality during dam passage. In all, 16% to 55% fewer fish were recaptured from the releases made above dam than those made below. USFWS determined predation, primarily by squawfish, as the major cause of mortality to juvenile salmon migrating past the dam, whereas the number of deaths from physical injury received while passing under the dam were minor.

CONTAMINANTS

TARGET 1: Reduce losses of fish and wildlife resulting from pesticide, hydrocarbon, heavy metal, and other pollutants in the Sacramento River (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to remedy heavy metal pollution from IMM to meet basin plan standards, and implement reliable and proven remedies that ensure continued treatment and control of heavy metal waste before water is discharged to the Sacramento River.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to eliminate scouring of toxic, metal-laden sediments in the Spring Creek and Keswick Reservoirs.

PROGRAMMATIC ACTION 1C: Control contaminant input to the Sacramento River system by constructing and operating stormwater treatment facilities and implementing industrial best management practices (BMPs) for stormwater and erosion control.

PROGRAMMATIC ACTION 1D: Develop a cooperative program to assess and monitor contaminant input from agricultural drainages in the Sacramento River watershed.

RATIONALE: *Note: Actions proposed here to reduce the adverse effects of contaminants in the Bay-Delta system will be coordinated with recommendations and actions developed by the CALFED Water Quality Common Program.*

The drainage from inactive mines on the IMM Superfund site represents the largest source of pollutant discharge to the Sacramento River. This discharge is at least equal to all the combined industrial and municipal discharges of dissolved metals to the San Francisco Bay and estuary system. This mine water is among the most acidic in the world and contains extremely elevated concentrations of copper, zinc, cadmium, and other metals known to be toxic to fish and wildlife. On occasion, fish deaths (including salmon) may have occurred as toxicity levels have been exceeded and documented in the upper Sacramento River as a result of IMM waste. More frequently, there are documented instances of metal concentrations that exceed toxic levels considered safe for early life stages of salmon.

The wastes from IMM, located in the Spring Creek watershed, are collected in the Spring Creek Reservoir and metered out into the releases of clean water from Shasta and Whiskeytown Reservoirs to achieve the best water quality possible. However, because of the extremely large waste load (averaging more than 1 ton of copper and zinc per day), it has not always been possible to consistently attain the water quality *objectives for copper, cadmium, and zinc in the basin plan, and interim criteria have been established until pollution control is completed. Highly toxic conditions are exacerbated when heavy winter rains induce uncontrolled spills from Spring Creek Reservoir, and flows from Shasta and Whiskeytown Reservoirs are not made available for dilution because of other CVP constraints.*

Within the lower portion of the IMM site, remediation must be developed for the metal sludge deposits in Spring Creek Reservoir and in Keswick Reservoir adjacent and downstream of the Spring Creek power plant tailrace. Preliminary monitoring in the Keswick Reservoir has documented that the sludge is highly toxic and that the deposits are extensive and up to 15 feet thick. Under certain conditions, flows from the Spring Creek power plant can mobilize large quantities of the sludge into the river, creating an acute toxicity risk to aquatic species. The sludge deposits can also contribute to chronic toxicity when combined with other sources.

Major sources of pollution include industries, municipalities, and agriculture, which discharge such contaminants as herbicides, pesticides, organic compounds, inorganic compounds, and warm water. Pollution is described as originating from point sources, such as discharge pipes or other localized sources, or from nonpoint sources, which are dispersed. Individual sources of nonpoint pollution may be insignificant, but the cumulative effects can be significant and can contribute high levels of pathogens, suspended solids, and toxins. Major contributors of nonpoint-source pollution to the Sacramento River, Sacramento-San Joaquin Delta, and San Francisco Bay include sediment discharge, stormwater and erosion, and agricultural drainage. Mandatory performance standards are needed for these sources, with flexibility granted to landowners to adopt whatever management practices are best suited for local conditions.

A primary point source of pollution is from municipal treatment plants, which release heavy metal contaminants, thermal pollution, pathogens, suspended solids, and other constituents. Implementing enhanced treatment, pretreatment programs, and tertiary treatment should help to reduce contaminant input.

Sediments constitute nearly half of the materials introduced into rivers from nonpoint sources, such as plowed fields, construction and logging sites, and mined land, and are mainly generated during storm events. Stormwater runoff in urban and developing areas is another major source of sediments and contaminants. Sedimentation from nonpoint sources should be reduced by implementing BMPs for urban and nonurban pollution, and implementing appropriate treatment and technological options that reduce pollutant loads.

An assessment of water quality and impacts from various other agricultural drainages to the Sacramento River is needed. Results from these evaluation programs should generate recommendations for corrective actions. Top priority should be given to the Sutter Bypass, which receives drainwater from rice growing areas and has outflows equivalent to those from the Colusa Basin drain. Assessments should also be conducted on Butte Slough, Reclamation District 108, and Jack Slough.

HARVEST OF FISH AND WILDLIFE

TARGET 1: Reduce illegal harvest of fish species to a minimum to maintain or increase populations by increasing enforcement efforts by 50 to 100% (◆◆◆).

PROGRAMMATIC ACTION 1A: Increase enforcement efforts.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to educate the public on the threats to populations from illegal harvest. Various actions include ad campaigns, signs along streams, and various types of outreach programs to schools, watershed conservancies, and groups.

PROGRAMMATIC ACTION 1C: Provide additional funding for the poaching hotline and rewards for arrest and convictions of poachers.

TARGET 2: Manage the legal harvest of chinook salmon, steelhead, and sturgeon by shifting harvest from natural stocks to hatchery-reared stocks, where possible, or reducing harvest of wild stocks until the naturally produced populations recover (◆◆◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to mark all hatchery salmon, allowing selective harvest of hatchery fish, while limiting harvest of wild fish. This action should be implemented on a short-term and experimental basis to ensure that it meets its objective and is cost-effective.

PROGRAMMATIC ACTION 2B: Encourage regulatory agencies to change fishing regulations (i.e., by restricting seasons, limits, and gear and reducing harvest of wild fish) to reduce legal harvest and any ancillary effects of fishing gear or techniques further. Restrictions should be severe in the short term. Long-term restrictions would depend on response of populations and effectiveness of restrictions and the degree of effectiveness of the action.

RATIONALE: *Some populations of salmon and steelhead in the Sacramento River are at such depressed levels that drastic reductions in any factors that contribute to mortality are necessary. Harvest management policies have been established by state and federal agencies to minimize mortality on natural chinook stocks, including severe harvest restrictions and size limits. Illegal harvest is known to occur along the Sacramento River. This target will be subject to adaptive management. Mass marking of hatchery steelhead began in 1997 and it should be continued.*

ARTIFICIAL FISH PROPAGATION

TARGET 1: Minimize the likelihood that hatchery-reared salmon and steelhead in the upper Sacramento River will stray into non-natal streams to protect naturally produced salmon and steelhead (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate the costs and benefits of limiting stocking of hatchery-reared salmon and steelhead in the upper Sacramento River. Stocking may be reduced in years when natural production is high in selected populations.

TARGET 2: Limit hatchery stocking to populations that cannot be sustained through natural production (◆◆◆).

PROGRAMMATIC ACTION 2A: Augment winter-run, spring-run, and late-fall-run chinook salmon and steelhead with hatchery-produced smolts during the short-term rebuilding phase of restoration efforts and only when alternative measures are deemed insufficient to provide recovery of the populations. Stocking of hatchery-reared fish will be undertaken as experiments and adjusted or terminated as necessary, depending on results.

TARGET 3: Employ methods to limit straying and loss of genetic integrity of wild and hatchery supported stocks (◆◆◆).

PROGRAMMATIC ACTION 3A: Rear salmon and steelhead in hatcheries on natal streams to limit straying. If hatchery augmentation of Sacramento River populations of salmon and steelhead is necessary, then hatcheries should be built on the Sacramento River for that purpose.

PROGRAMMATIC ACTION 3B: Limit stocking of salmon and steelhead fry and smolts to natal watersheds to minimize straying that may compromise the genetic integrity of naturally producing populations.

TARGET 4: Minimize further threats of hatchery fish contaminating wild stocks of salmon and steelhead (◆◆◆).

PROGRAMMATIC ACTION 4A: Where hatchery production is underway and continues, methods should be adopted and improved for the selection of an appropriate cross section of the adult population for spawning at the hatchery.

PROGRAMMATIC ACTION 4B: Select spawning adults of appropriate genetic makeup to minimize genetic contamination of existing hatchery and naturally producing stocks of salmon and steelhead. Given the present difficulty of determining genetic makeup of spawning adults selected for hatcheries, this action will necessarily be experimental. Hatchery-reared adults may be preferentially selected or not selected if they are adequately marked or tagged, or have other identifiable feature. Other methods may be developed to genetically categorize naturally produced or hatchery fish.

RATIONALE: *In watersheds such as the Sacramento River, where dams and habitat degradation have limited natural spawning, some hatchery supplementation may be necessary to sustain fishery harvest at former levels and to maintain a wild or natural spawning population during adverse conditions, such as droughts. However, hatchery augmentation should be limited in extent and to levels that do not inhibit recovery and maintenance of wild populations. Hatchery-reared salmon and* *steelhead may directly compete with and prey on wild salmon and steelhead. Straying of adult hatchery fish into non-natal watersheds may also threaten the genetics of wild stocks. Hatchery fish may also threaten the genetic makeup of stocks in natal rivers. Some general scientific information and theory from studies of other river systems indicate that hatchery supplementation may limit recovery and long-term maintenance of naturally producing populations of salmon and steelhead. Further research and experimentation are necessary to determine the degree to which this issue is addressed. Long-term hatchery augmentation of healthy wild stocks may genetically undermine that stock and threaten the genetic integrity of other stocks. Spawning and rearing habitats are limited, and adverse conditions may occur in drought or flood years that would undermine the population without additional hatchery production.*

Release of hatchery-reared fish into the upper Sacramento River and its tributaries could lead to a loss of the genetic integrity of wild salmon and steelhead populations. Adults straying into non-natal streams may interbreed with a wild population specifically adapted to that watershed, possibly leading to the loss of genetic integrity in the wild population. Although some irreversible contamination has occurred in salmon and steelhead populations, measures are necessary to minimize further deterioration of contaminated populations and to protect populations that are not contaminated.

Recent returns to CNFH of fall-run chinook salmon seem to indicate that the hatchery is heavily supporting the entire fall-run population, particularly in Battle Creek, all of which probably originated from CNFH. A recent estimate for the rest of the Sacramento River above RBDD, excluding Battle Creek, was only 40,000 fish, which may also have been heavily supported by CNFH production.

Some stocking of hatchery-reared fish may be necessary in the short term to rebuild naturally spawning populations; however, there is a lack of consensus among agencies and stakeholders as to the degree of stocking that is detrimental or necessary to sustain sport and commercial fisheries. This action will necessarily be short term and experimental, with subsequent efforts dependent on results and effectiveness.

Additionally, the relationship of the resident rainbow trout of the mainstem Sacramento River below Keswick (a.k.a. "river trout") with hatchery and naturally spawning steelhead populations should be investigated. There is a substantial number of large, steelhead-sized resident rainbow trout in the upper Sacramento River, and it is unknown if these fish comprise a discreet population, are a component of the steelhead/rainbow trout population, or an artifact of artificial production. The large number of non-migratory rainbow trout may be a result of ecological conditions that exist in the tailwater reaches below dams, and this needs to be investigated.

STRANDING

TARGET 1: Eliminate the straying, stranding, and loss of adult chinook salmon and other species along the Sacramento River (◆◆).

PROGRAMMATIC ACTION 1A: Evaluate the feasibility of preventing adult chinook salmon from straying into the Colusa Basin Drain.

RATIONALE: *The straying of adult chinook salmon into the Colusa Basin Drain has long been recognized as a problem. Recent water use practices in the basin have greatly reduced the volume of discharged water, which has reduced the high water temperature and contaminant problems. Still, fish have direct access to the drain under certain flow conditions. This action is consistent with actions described in the Proposed Recovery Plan for the Sacramento River Winter-run Chinook Salmon (National Marine Fisheries Service 1997) and the Department of Fish and Game anadromous fish restoration plan (California Department of Fish and Game 1993). The feasibility should evaluate water use practices, redirection of waste water, and alternative structures to eliminate entry into the drain.*

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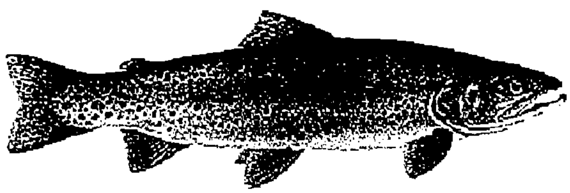
◆ North Sacramento Valley Ecological Management Zone



Introduction

The health of the North Sacramento Valley Ecological Management Zone contributes to the health of the Sacramento-San Joaquin Delta in many ways. Ecological processes within this zone contribute sediment, nutrients, and streamflow to the Sacramento River. They also provide important migration, holding, spawning, and rearing areas for spring-, fall-, and late-fall-run chinook salmon steelhead, lamprey, and native resident fish species. Many streams in this zone also provide seasonal non-natal rearing for juvenile steelhead and chinook salmon. Riparian and shaded riverine aquatic habitats provide for many terrestrial species, including neotropical birds, amphibians, and invertebrates.

The North Sacramento Valley Ecological Management Zone encompasses the geographic area and tributary streams generally surrounding the City of Redding and includes the following ecological management units:

- Clear Creek Ecological Management Unit
- Cow Creek Ecological Management Unit
- Bear Creek Ecological Management Unit, and
- Battle Creek Ecological Management Unit.

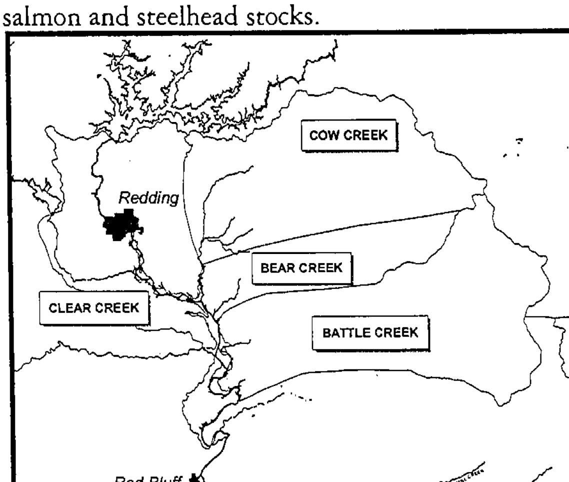
Description of the Management Zone

This ecological management zone provides habitats for a significant variety of fish, wildlife, and plant communities, including spring-, fall-, and late-fall-run chinook salmon, steelhead trout, lamprey, native resident fish, neotropical migratory birds, and native anuran amphibians.

Important ecological processes and functions shared by the individual ecological units of the North Sacramento Valley Ecological Management Zone include their respective streamflow patterns and capacity for natural sediment transport; stream meander; gravel recruitment; and stressors, such as water conveyance structures, water diversion, and invasive plant species.

Opportunities to maintain or reactivate these processes and functions are constrained to varying degrees because of past and existing human activities, such as dam construction and gravel extraction from the active stream channel. Many of these constraints are described as stressors that impair ecological function and the creation and maintenance of habitats or that cause direct mortality to important species.

The construction and operation of Whiskeytown and McCormick-Saeltzer dams and past large-scale gravel extraction activities constrain ecological processes and functions in the Clear Creek Ecological Management Unit. Ecological processes and functions on Cow and Bear creeks are impaired by alterations to the runoff pattern resulting from water diversions and land use practices. Small hydropower projects, water diversion and water diversion structures constrain ecological processes and functions on Battle Creek. Past and current operation of Coleman National Fish Hatchery on the lower section of the creek further impairs opportunities to improve the distributions of wild salmon and steelhead stocks.



Location Map of the North Sacramento Valley Ecological Management Zone and Units.

LIST OF SPECIES TO BENEFIT FROM RESTORATION ACTIONS IN THE NORTH SACRAMENTO VALLEY ECOLOGICAL MANAGEMENT ZONE

- spring-run chinook salmon
- winter-run chinook salmon
- fall-run chinook salmon
- late-fall-run chinook salmon
- steelhead trout
- lamprey
- native anuran amphibians
- native resident fishes
- neotropical migratory birds

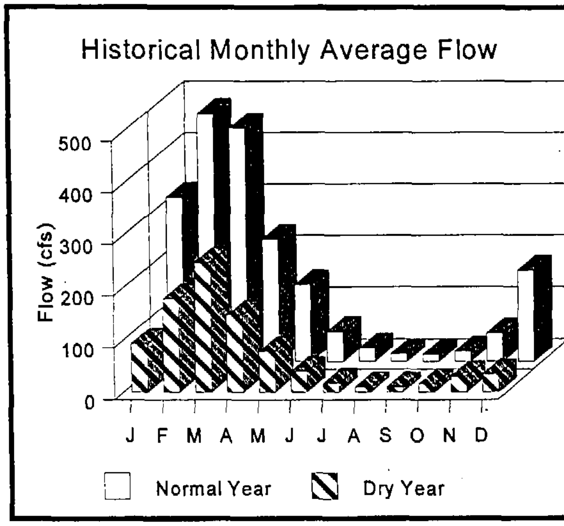
DESCRIPTIONS OF ECOLOGICAL MANAGEMENT UNITS

CLEAR CREEK ECOLOGICAL MANAGEMENT UNIT

Clear Creek is a major tributary to the Sacramento River and drains approximately 238 square miles. It originates in the mountains east of Trinity Lake and flows into the Sacramento River near Redding. Whiskeytown Reservoir stores natural creek flows and water diverted from the Trinity River at Lewiston Dam through the Clear Creek Tunnel. Whiskeytown Dam, constructed in 1963, is 10 miles upstream of McCormick Dam. Whiskeytown Dam diverts more than 80% of Clear Creek's average natural flow to the Spring Creek Powerhouse at Keswick Reservoir on the Sacramento River.

The Clear Creek watershed has a natural flow pattern of high winter and low summer-fall flows, typical of many Sacramento Valley streams that originate from foothills instead of the Cascade or Sierra crests. The stream is nearly dry during summer and fall months of low rainfall years. In wettest years, flows in winter months average 1,000 to 2,500 cubic feet per second (cfs). In winter months of dry years, average monthly flows reach only 100 to 250 cfs. In the driest years, winter monthly average flows reach only 20 to 35 cfs. Whiskeytown Dam, at the lower end of the watershed, receives water diverted from the Trinity River by way of the Clear Creek Tunnel.

A value planning study by the U.S. Bureau of Reclamation (1999) found that from 1941 through 1963, Clear Creek, prior to the construction of Whiskeytown Dam, experienced floods of 6,000 cfs or greater at least every 3 to 5 years. Larger floods of 9,000 cfs or greater were experienced about four times, and three times floods occurred greater than 14,000 cfs. After completion of the dam in 1963, flood flows of 6,000 cfs were experienced twice, 8,500 cfs once, and one flood of 14,000 cfs occurred once (U.S. Bureau of Reclamation 1999).



Clear Creek Streamflow, 1952-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Most of the Clear Creek and Trinity River water is conveyed from Whiskeytown Lake to Keswick Reservoir on the Sacramento River through the Spring Creek Tunnel. Flows in Clear Creek below Whiskeytown Lake are maintained at 50 cfs from January through October and 100 cfs in November and December, regardless of flow in the upper watershed. Approximately 10 cfs are diverted from the lower river at McCormick Dam, 8 miles upstream of the confluence with the Sacramento River.

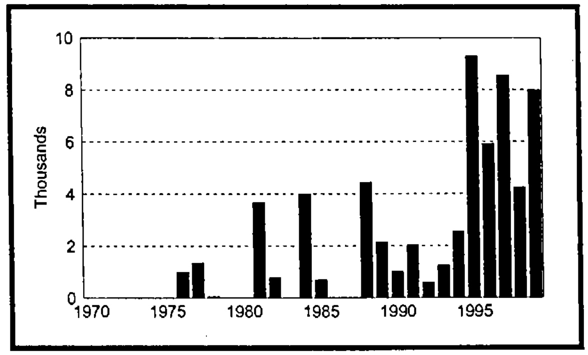
Spawning gravel in the lower Clear Creek drainage has been significantly depleted by mining. Because recruitment of new gravel into this area is restricted by McCormick and Whiskeytown dams, Shasta County adopted an ordinance in 1977 prohibiting new gravel mines in Clear Creek below McCormick Dam. Although the future of this ordinance is uncertain, it constitutes the best protection for spawning gravel. The existing gravel mining operations have refrained from mining in the floodplain for more than 4 years, allowing some riparian reforestation to occur naturally.

Before the construction of Whiskeytown Lake, Clear Creek delivered large amounts of gravel to the lower alluvial reaches and the Sacramento River. Flow regulation since 1963 has greatly reduced the frequency of floodflows capable of moving bedload. The instream gravel is not renewable, because gravel from the upper reaches is trapped in the reservoir. Flow regulation has also allowed dense stands of vegetation to encroach on the main channel, particularly the lower 3 miles before the confluence. This vegetation further reduces velocities and the gravel transport capacity of the stream.

In 1980, the California Department of Water Resources (DWR) estimated that the average annual instream extraction rate of sand and gravel was approximately 75,000 tons per year, equivalent to 20 times the natural transport rate. Subsequent field observations in 1980 and 1994 suggest that gravel mining, flow regulation, and vegetative encroachment combined to reduce the available gravel in Clear Creek. The average annual contribution of gravel to the Sacramento River was estimated to be approximately 5,000 tons per year. In recent year years, gravel operators have halted the practice of instream mining. During this same period, gravels were distributed to the spawning area from tributary stream sources, stream meander, and artificially introduced gravel stockpiles. At this time there are two completed gravel injection projects and one in progress.

Spawning habitat restoration work in Clear Creek is necessary. The work will require placing spawning gravel at appropriate locations. Implementing this restoration will require monitoring spawning gravel to determine whether it successfully meets the needs of adult salmon and steelhead. The CVPIA Clear Creek Restoration Program is addressing poor instream spawning habitat resulting from gravel mining and blockage by Whiskeytown Dam. Habitat is being improved with spawning gravel introduction. Gravel is being placed below Whiskeytown and Saeltzer dams every years. This gravel injection program is expected to continue indefinitely.

The abundance of fall-run chinook salmon spawners in Clear Creek has increased during recent years when the fall flows have been increased by a factor of three. During this interim flow increase, the spawning population estimates have been between 7,000 and 9,000 representing 5% to 8% of the upper Sacramento River salmon population. In 1998, the entire AFRP recommended flows from Whiskeytown Reservoir were provided. This resulted in significant benefits to chinook salmon escapements, habitat availability, and water quality. In 1998, the fall-run chinook salmon escapement was estimated at 4,258 fish. Since flows were first increased in 1995, the average fall-run chinook return has increased 400 percent.



Clear Creek Fall-run Chinook Salmon Returns, 1970-1999 (CDFG 1999).

Spring-run chinook could have historically migrated to the uppermost reaches of Clear Creek above the town of French Gulch (Yoshiyama et al. 1996). In 1956, Azevedo and Parkhurst (1958) saw spring-run chinook in Clear Creek for the first time since 1949. Passage to the upper watershed was severely restricted by the construction of McCormick-Saeltzer Dam around the turn of the century, then completely eliminated by the construction of Whiskeytown Dam in 1964. It is likely the steelhead also ascended Clear Creek at least as far as French Gulch.

In spite of improved conditions, there are no spring-run chinook salmon in Clear Creek (California Department of Fish and Game 1998) and the status of the steelhead population is unknown. Habitat in Clear Creek has the potential to support spring-run chinook and steelhead if passage at McCormick-Saeltzer Dam is improved to allow adult fish access to the stream reach immediately below the Whiskeytown Dam. Operation of the dam can provide suitable cold-water habitat downstream to allow adult spring-run chinook to oversummer and then spawn in the fall. The cold water would also support juvenile salmon and steelhead rearing through the summer.

Restoring habitat and increasing flow releases from Whiskeytown Reservoir could significantly improve the present production of chinook salmon in Clear Creek. Steelhead populations would similarly benefit.

Restoring the Clear Creek chinook salmon and steelhead populations has been the focus of fishery management efforts in the upper Sacramento River drainage below Shasta Dam for most of the Twentieth Century. Interest and concern regarding the status of salmon and steelhead in this stream began shortly after the 1903 construction of the McCormick Dam, located 6 miles upstream of the Sacramento River. Early restoration efforts attempted to provide suitable adult fish passage at McCormick Dam, but as watershed and instream habitats continued to decline, the need for additional habitat restoration efforts increased. The cumulative effects of water export, gold mining, gravel extraction, timber harvest, road building, and the construction of Whiskeytown Dam have contributed to the decline of the Clear Creek anadromous fishery. Only in recent years has there been a recognition of the complexity of the problem and a multiagency cooperative effort to seek corrective actions designed to restore habitat and fish passage in Clear Creek. Local environmental groups and individuals have also been seeking solutions to the problems limiting Clear Creek's fishery potential.

The California Department of Fish and Game (DFG) manages Clear Creek for fall- and late-fall-run chinook salmon and steelhead trout. The stream is uniquely suited for intensive management because of its ability to provide cool temperatures in the upper reach and adequate flows in fall. The stream below McCormick Dam is most suitable for fall- and late-fall-run chinook salmon spawning, but unsuitable for oversummering spring-run chinook salmon or for year-round rearing of steelhead. Conditions above the dam are suitable for steelhead and spring-run chinook salmon.

McCormick Dam impairs the up- and downstream passage of juvenile and adult anadromous fish. Removal of the dam would improve passage and survival of chinook salmon and steelhead and improve the transport of natural sediments from the stream reach above the dam to the lower reach.

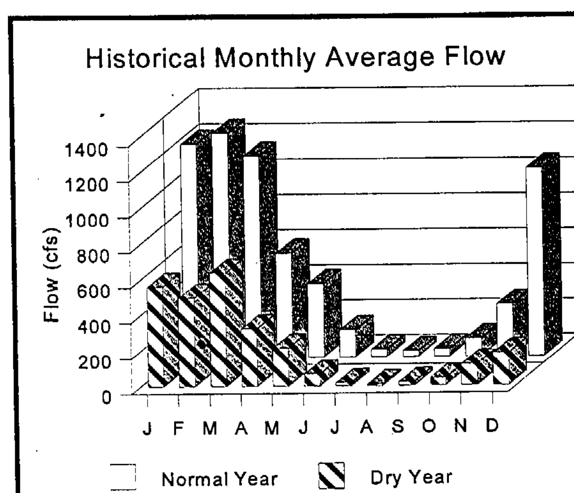
An important component of the Clear Creek Restoration Program is the improvement of fish passage at McCormick-Saeltzer Dam. The U.S. Bureau of Reclamation and the Townsend Flat Water Ditch Company are negotiating the removal of Saeltzer Dam and the transfer of water rights to nearby location.

COW CREEK ECOLOGICAL MANAGEMENT UNIT

Cow Creek flows through the southwestern foothills of the Cascade Range and enters the Sacramento River 4 miles east of the town of Anderson in Shasta County. Cow Creek encompasses five major tributaries: Little (North) Cow, Oak Run, Clover, Old Cow, and South Cow creeks. The drainage area is approximately 425 square miles, and the average discharge is 501,400 acre-feet per year.

Cow Creek has a natural flow pattern of high winter and low summer-fall flows, typical of many Sacramento Valley streams that originate from foothills rather than from the Cascade or Sierra crests. Near its mouth (where the gaging station is located), the stream is nearly dry during the summer and fall months of dry years. USGS surface water records show the mean August flow of 35 cfs, September at 45 cfs, and October at 131 cfs with a maximum August flow of 115 cfs and a minimum of 1 cfs.

In wetter years, flows in winter months average 2,600 to 6,000 cfs. In winter months of dry years, average monthly flows peak at 500 to 650 cfs. In the driest years, winter monthly average flows reach only 80 to 120 cfs. Small agricultural diversions contribute to lower flows in summer and fall. A Pacific Gas and Electric Company (PG&E) hydropower project

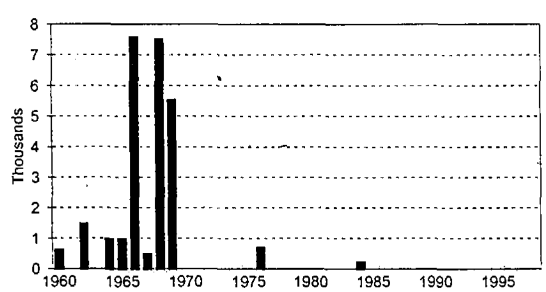


Cow Creek Streamflow, 1953-1993 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

diversion reduces flow on a 10-mile section of the South Fork.

In the past, Cow Creek has supported eight small gravel mining operations. The lower 10 miles of channel is approximately 50% exposed bedrock. Where bedload is deposited, it is generally only a thin veneer. Instream mining was eliminated with the passage of a Shasta County gravel mining ordinance. There has been no instream gravel mining in Cow Creek for at least 12 years. Because of the limited availability of gravel, the bedload transport rate was estimated to be 19,000 tons per year.

Fall-run and late-fall-run chinook salmon spawn in the creek on the valley floor and in all five tributaries. Adult steelhead trout have been observed in South Cow, Old Cow, and North Cow Creeks. Previous management plans have estimated the potential of fall-run salmon in Cow Creek at 5,000 spawners; however, fall-run chinook salmon populations have been as high as 7,600. The average run size from 1953 to 1969 was 2,800 salmon. In recent drought years, there have been too few salmon in Cow Creek to make population estimates. No major diversions exist in the fall-run spawning reach, and the average monthly flow from October through December has actually increased since 1969. The decline in the Cow Creek fall-run salmon population coincides with salmon population declines throughout the Sacramento River basin. There are no estimates for late-fall-run chinook in Cow Creek.



Cow Creek Fall-run Chinook Salmon Returns, 1960-1999 (CDFG 1999).

In 1992, DFG conducted stream surveys of four of the five Cow Creek tributaries. Emphasis was placed on evaluating habitat for spring-run chinook salmon and steelhead trout holding, spawning, and rearing. The survey results concluded that Cow Creek is not suitable for spring-run chinook salmon because of warm summer water temperatures and lack of large holding pools. Steelhead, however, could survive if provided access to the tributaries above the valley floor. North Cow, Clover, and Old Cow Creeks have natural bedrock falls that are either complete or partial barriers to anadromous fish.

Land use activities in the Cow Creek drainage include agriculture, timber harvest, livestock grazing, and hydropower production. Loss of habitat and water diversions are largely the result of activities associated with livestock production. The only laddered dams and screened diversions are part of hydropower facilities. Agricultural diversions are unscreened, ditches are unlined and poorly maintained, and grazing is destroying some of the riparian corridor and causing excessive erosion.

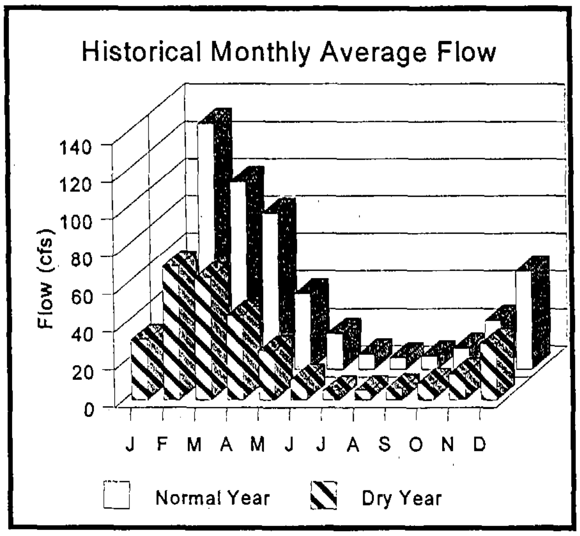
Population growth in the towns of Palo Cedro, Bella Vista, Oak Run, and Millville is resulting in increased demand for domestic water and is affecting riparian habitat in the Cow Creek watershed. Measures are required to protect the existing habitat from further damage associated with gravel extractions, water diversions, creek-side development, and livestock grazing. Cow Creek presents a unique opportunity to maintain and preserve fall- and late-fall-run salmon and steelhead habitat while nearby development increases.

Bear Creek Ecological Management Unit

Bear Creek is a small, eastside tributary entering the Sacramento River 5 miles below Anderson. The stream has low streamflow in spring through fall months of most years and flows year round at the Highway 44 bridge in dry years. All steelhead habitat is above this bridge. During spring and summer, the limited natural streamflow is further reduced by irrigation diversions in the lower reaches, where the stream enters the valley floor. Adequate streamflows in fall and spring are prerequisites for anadromous fish migration and reproduction.

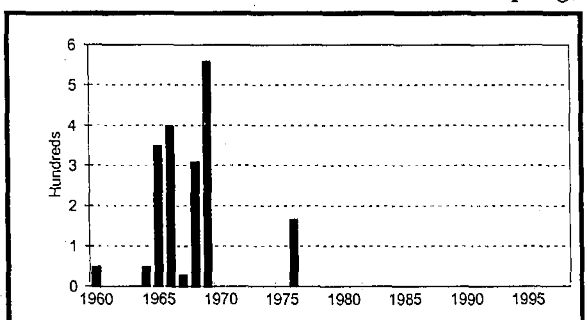
The limited runoff in this small stream makes it difficult to meet the limited agricultural water demands and instream flow needs of anadromous fish simultaneously, especially in below-normal water years. During above normal water years, there is a reduced risk to juvenile salmon and steelhead during the spring diversion season, because irrigation water demands are reduced and the diversion rates are relatively small compared to the total streamflow.

Bear Creek has a natural flow pattern of high winter and low summer-fall flows, typical of many Sacramento Valley streams that originate from foothills rather than the Cascade or Sierra crests. Near its mouth (where the gaging station is located) the stream is nearly dry during summer and fall months of low rainfall years. In wettest years, flows in winter months average 1,100 to 2,000 cfs. In winter months of dry years, average monthly flows reach only 30 to 70 cfs. In the driest years, winter monthly average flows reach only 20 to 35 cfs. Small agricultural diversions contribute to lower flows in summer and fall.



Bear Creek Streamflow, 1960-1967 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Bear Creek is able to support populations of fall-run chinook salmon only when early fall rains create suitable conditions for passage over shallow riffles and allow access to the limited spawning habitat. Because of low and warm streamflow conditions in spring, juvenile salmon and steelhead must emigrate early in the season to survive.



Bear Creek Fall-run Chinook Salmon Returns, 1960-1999 (CDFG 1999).

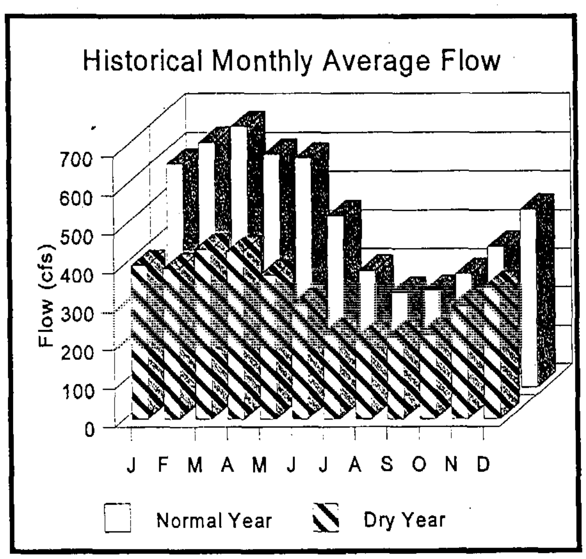
Salmon spawning surveys conducted during years with sufficient flows to attract adult salmon indicate that Bear Creek can support 150-300 spawning salmon. Steelhead have been observed in the creek, but no population estimates have been made.

Unscreened irrigation diversions operating during the juvenile emigration period for chinook salmon and steelhead can significantly reduce survival rates.

BATTLE CREEK ECOLOGICAL MANAGEMENT UNIT

Battle Creek enters the Sacramento River approximately 5 miles southeast of the Shasta County town of Cottonwood. It flows into the Sacramento Valley from the east, draining a watershed of approximately 360 square miles.

Battle Creek has a natural flow pattern of high winter and moderate summer-fall flows, typical of Mount Shasta-Cascade spring-fed streams. Near its mouth (where the gaging station is located), the stream has average flows of 240 to 260 cfs in summer and fall. Even in the drier years, flows are more than 150 cfs. In wettest years, flows in winter months average 1,200 to 2,400 cfs. Battle Creek has the best connection between the river and mountainous areas of any Sacramento River ecological management unit. PG&E operated a series of small run-of-the-river hydroelectric diversions that divert up to 98% of the



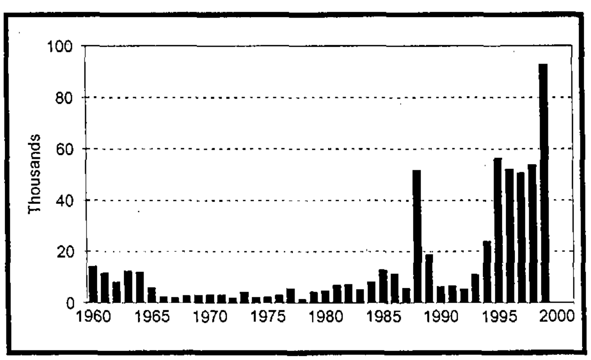
Battle Creek Streamflow, 1963-1993 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

stream's baseflow and a much smaller portion of the wet season flow. Under and interim agreement, the required minimum fishery releases to the creek are increased by a factor of 10 at three diversions in a 17-mile section of the creek system.

PG&E owns and operates the Battle Creek project, which consists of two small storage reservoirs, four unscreened hydropower diversions on the North Fork Battle Creek, three unscreened hydropower diversions on South Fork Battle Creek, a complex system of canals and forebays, and five powerhouses.

ERP proposes to restore important ecological functions and processes and habitats in a step-by-step approach over several years. Restoration of these ecosystem elements will permit the restoration of anadromous fish in the basin. In addition, restoration will require disease management measures for the fish hatchery water supply. As the range of anadromous fish in the watershed is increased, additional efforts will be directed at fish screens, fish ladders, hatchery water supply management, and increased releases of water from hydroelectric diversions. The approach will first restore the stream reach capable of supporting all types of anadromous fish. This approach will restore approximately one-half of the available anadromous fish habitat without subjecting the hatchery to increased disease risk or degrading the quality of the hatchery water supply.

Before development, Battle Creek was one of the most important chinook salmon spawning streams in the Sacramento Valley. Runs of fall-, winter-, and spring-run chinook salmon and steelhead were found there. Natural spawning of salmon and steelhead in Battle Creek between the Coleman National Fish Hatchery weir and the mouth is still significant but



Fall-run Chinook Salmon Returns to Battle Creek Below Coleman National Fish Hatchery, 1960-1999 (CDFG 1999).

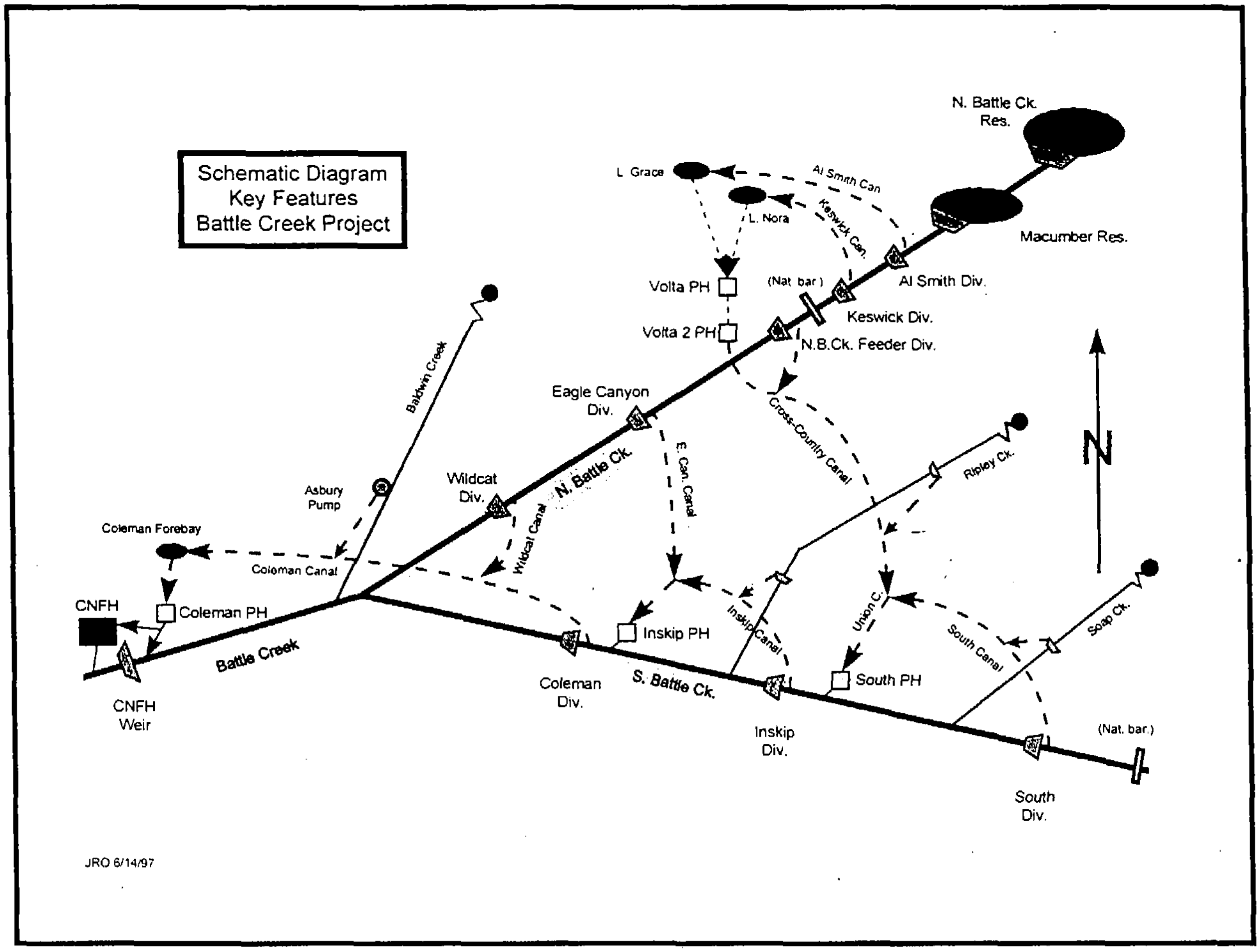
suffers from spawning populations too large for available habitat. The blockage of the fall-run chinook salmon migration at the hatchery and the effect of low flows caused by PG&E's hydropower operations have combined to reduce salmon and steelhead populations above the hatchery to remnant status.

There is one large, unscreened agricultural diversion (Battle Creek Diversion). DFG constructed a screen for this diversion, but because of landowner concerns, installation of the screen was delayed. The screen has recently been installed.

Restoring the remnant populations of naturally spawning chinook salmon and steelhead located above the fish hatchery barrier dam to a healthy status can be done in a manner that integrates the beneficial uses of hydropower production and aquaculture in the watershed. Physical and operational changes of PG&E's projects include screening or removing the diversions on the North Fork and South Fork of Battle Creek, increasing releases from project diversions, and stopping removal of stream gravel that accumulates at project diversions.

Anadromous fish have historically migrated above the hatchery during minor and major storm events each year which flood out the hatchery barrier dam and when the fish ladder at the barrier dam has been opened for four to five months during past years. The Coleman Hatchery Development Plan proposes a phased installation of an ozone sterilization system. The present level of ozonation at Coleman Hatchery (10,000 g.p.m.) is sufficient to sterilize all the water needed to produce the early life stages of chinook salmon and steelhead and one-third of the water necessary to produce juvenile fish. The environmental documents and preliminary funding arrangements have been completed to begin the construction of the remaining two-thirds of the water supply needed for juvenile fish production.

The restoration of naturally produced runs of anadromous fish in Battle Creek can be conducted in a manner compatible with the phasing in of the ozone treatment plant. If those races of salmon that represent a significant disease risk are restricted through seasonal fish ladder closures to the first 17-mile reach of Battle Creek above the hatchery for the initial phase of restoration, a hatchery water supply



can be maintained and the capacity to supply the balance of the hatchery water supply that will not be treated with ozone can be reached. It will be necessary to improve the reliability of the Coleman Canal water supply.

The fish hatchery, located approximately 6 miles upstream of the mouth of Battle Creek, is operated by the U.S. Fish and Wildlife Service (USFWS). It was constructed by Reclamation as partial mitigation for the construction of Shasta Dam and produces fall-run chinook salmon, late-fall-run chinook salmon, and steelhead trout. Winter-run chinook salmon, a federally and State-listed endangered species, was also successfully propagated in small numbers at the hatchery to supplement the wild population. The winter-run chinook artificial propagation program at Coleman was stopped and is in the process of being moved to a new facility at the base of Shasta Dam. This is scheduled to be operational in early 1998.

Restoration of Battle Creek's anadromous fish habitat above the valley floor will focus on restoring spring-run chinook salmon and steelhead trout. These actions will be sufficient to provide for the requirements of winter-run chinook salmon that may return to Battle Creek.

Surveys conducted before the construction of Shasta Dam indicate that, with sufficient water, the stream reaches above the fish hatchery could provide spawning habitat for more than 1,800 pairs of salmon. The stream reaches up to MacCumber Dam are not reachable by anadromous fish because of barriers. The anadromous reach in the North Fork Battle Creek extends up to approximately two miles above the North Fork Battle Feeder Dam. The recent (1991) evaluation of spawning habitat in the portions of Battle Creek watershed accessible to anadromous fish above Coleman Hatchery Fish Barrier estimate 166,000 square feet of spawning gravel. Potentially, this much spawning habitat could accommodate

3,500 spawning pair. The North Fork of Battle Creek, Eagle Canyon in particular, contains deep, cold, and isolated pools ideal for holding spring-run chinook salmon throughout summer. Because of the critically low numbers of spring-run chinook salmon and steelhead in the Sacramento River drainage, any expansion of available habitat for these fish has a high priority.

From 1985 through 1989, adult fall-run chinook salmon, surplus to the fish hatchery egg-taking needs, were released into Battle Creek above the hatchery weir to spawn naturally. Because of potential disease problems at the hatchery related to decomposing carcasses, the fish ladders on PG&E's two lowermost diversions (Wildcat Diversion on the North Fork and Coleman on the South Fork) were closed. This action prevented fish from ascending into the area above the hatchery water supply intake and eliminated the possibility of salmon migrating into the middle or upper reaches of those streams.

VISION FOR THE ECOLOGICAL MANAGEMENT ZONE

The vision for the North Sacramento Ecological Management Zone is to restore important fishery, wildlife, and plant communities to a healthy condition. To attain this vision, the Ecosystem Restoration Program Plan recommends developing and implementing comprehensive watershed management plans for the streams in this zone, which will restore important ecological processes that create and maintain habitats for fish, wildlife, and plant communities.

The vision focuses on restoring spring-run chinook salmon and steelhead to population levels of the late 1960s and early 1970s. To achieve this vision, ERP recommends increased protection for naturally produced chinook salmon and steelhead as they rear and migrate downstream from the natal areas to the mainstem Sacramento River. This would involve improving passage at water diversion structures; installing positive-barrier fish screens to protect juveniles; and providing sufficient flows for migration, holding, spawning, and rearing.

Gravel extraction is a significant problem in many areas of this ecological management zone, and a cooperative effort is needed to relocate this activity to sites away from the active stream channels. ERP also recommends reestablishing floodplains in the lower stream reaches to allow stream channel meander, sediment transport and deposition, and a healthy riparian corridor. Actions to maintain and restore healthy riparian zones include providing shaded riverine aquatic habitat and woody debris and maintaining biologically productive gravel beds for fish spawning and invertebrate production.

ERP envisions that the fish, wildlife, and riparian needs of the North Sacramento Valley Ecological Management Zone will be met and an acceptable level of ecosystem health will be achieved when the following visions have been satisfactorily attained.

VISIONS FOR ECOLOGICAL MANAGEMENT UNITS

CLEAR CREEK ECOLOGICAL MANAGEMENT UNIT

The vision for the Clear Creek Ecological Management Unit is to restore flows from Whiskeytown Dam to allow successful upstream passage of chinook salmon and steelhead to historical habitat, restore sediment transport and gravel recruitment in the stream channel, and establish a clearly defined stream meander zone, and riparian and riverine aquatic plant communities.

The potential of providing sustainable and resilient ecological processes and habitats will be enhanced by developing a locally sponsored watershed management planning process for this unit.

CLEAR CREEK WATERSHED DEMONSTRATION PROGRAM: Clear Creek has tentatively been selected as a demonstration watershed for the CALFED Stage 1 (first seven years) Implementation Program. During Stage 1, CALFED will support and bolster ongoing efforts to implement a successful management and rehabilitation effort within this watershed so that lessons learned in this watershed can be applied to similar watersheds.

Clear Creek has some interesting attributes that have contributed to its selection.

- The upper watershed is in mixed private and federal ownership and is included in the President's Northwest Forest Planning effort.

- The watershed is addressed by the Northwest Sacramento Province Advisory Committee comprised of representatives of federal agencies such as the U.S. Forest Service, U.S. Fish and Wildlife Service, Bureau of Land Management and others.
- Streamflows in Clear Creek below Whiskeytown Dam are controlled largely by the U.S. Bureau of Reclamation.
- Restoration of Clear Creek is specified in the Central Valley Project Improvement Act.
- Clear Creek supports chinook salmon and with restoration could support spring-run chinook salmon and steelhead.
- Strong local interest in the watershed.
- Many ongoing restoration activities and efforts such as land acquisition, water acquisition, and passage improvement.

Cumulatively, an investment in Clear Creek during Stage 1 will provide direct benefits to the creek and provide the types of restoration information needed to move the Ecosystem Restoration Program into subsequent implementation phases successfully. A few of the lessons to be learned in the Clear Creek watershed include how to improve overall watershed health; how to integrate local, state, federal, and private efforts in a large-scale restoration program; how to design and implement actions to benefit spring-run chinook salmon and steelhead; and how best to manage ecological processes such as sediment transport and stream meander in a highly modified stream system.

Cow Creek Ecological Management Unit

The vision for the Cow Creek Ecological Unit includes reducing adverse effects of timber harvest, erosion, and cattle grazing on the stream and riparian system and maintaining or restoring streamflows during important periods of the year to allow fish migration, spawning, and rearing of fall-run chinook salmon and steelhead trout. A comprehensive watershed management plan developed and implemented at the local level would assist in restoring this creek. In addition, sediment in the creek is limited, and ERP recommends a cooperative program to relocate gravel extraction operations to areas outside the active stream channel.

Actions on Cow Creek include obtaining flow agreements, screening diversions to protect all life stages of anadromous fish, improving fish passage at agricultural diversion structures, and fencing selected riparian corridors in the watershed to exclude livestock and promote riparian regeneration.

Bear Creek Ecological Management Unit

The vision for the Bear Creek Ecological Management Unit will emphasize restoring and maintaining important ecological processes, such as streamflow and sediment supply. Steelhead trout is an important species that will benefit from improvements related to fish passage and immigration and holding, spawning, and rearing habitats. The individual value of Bear Creek is small, but, cumulatively, the values of streams such as this can be integral and valuable in restoring ecological health to the Bay-Delta system, particularly for the steelhead trout and fall-run chinook salmon resources. Recent, but limited field studies, have shown that in some years lower Bear Creek can provide valuable non-natal rearing habitat for juvenile salmonids.

ERP recommends a cooperative program with water users for a mutually acceptable flow schedule that would not only provide protection for downstream migrating salmon and steelhead but recognize the needs of agriculture. This could be accomplished through conjunctive use of groundwater.

Battle Creek Ecological Management Unit

The vision for the Battle Creek Ecological Management Unit includes support for a local watershed conservancy and developing and implementing a comprehensive watershed management plan, increasing flows, improving the water supply to Coleman National Fish Hatchery, removing diversion dams or installing new ladders, and installing positive-barrier fish screens to protect juvenile chinook salmon and steelhead.

Improving water management operations and installing positive-barrier fish screens will provide large benefits to many aspects of the ecological processes and fish and wildlife in the watershed. ERPP also envisions that Battle Creek will provide much-needed habitat for steelhead trout and spring-run chinook salmon, in addition to maintaining its existing importance to fall- and late-fall-run chinook.

Visions for Ecological Processes

Central Valley Streamflow: Healthy instream flows are sustained to restore ecological processes and functions that maintain habitats and support aquatic species. Streamflows shape channels, support riparian vegetation, provide habitat for fish, and transport young fish downstream. Healthy streamflow patterns in the streams tributary to the upper reach of the Sacramento River below Keswick Dam would emulate natural flow patterns, with late-winter/ early-spring flow events and sustained flow well into the summer. The vision is that streamflow will be provided at levels that activate ecological processes that shape the stream channels and sustain riparian and riverine aquatic habitat, transport sediments, and sustain juvenile anadromous fish during the summer.

Coarse Sediment Supply: The supply of sediments to the streams in the North Sacramento Valley Ecological Management Zone support stream channel maintenance and sustain riparian and riverine aquatic habitats. This sediment includes gravel for fish spawning and invertebrate production The vision is that processes to provide a continual supply of coarse sediments will be restored, reactivated, or supplemented.

Stream Meander: Streams in the North Sacramento Valley Ecological Management Zone exhibit a natural tendency to meander. This provides for the continual supply of coarse sediments, regeneration of the riparian corridor, and the rejuvenation of gravels used for fish spawning and invertebrate production. The vision is that stream meander corridors will be established or maintained to provide much of the needed sediments and habitats for fish, wildlife, and plant communities.

Natural Floodplain and Flood Processes: River-floodplain interactions are important ecological events that occur at varying intervals, ranging from annual inundation of some of the floodplain to flow or flood events that inundate most of the floodplain. The larger events occur within 5-, 10-, 50-year or longer intervals. This recurrent flood cycle maintains the stream channel, allows the stream to contact higher gravel terraces, supports riparian regeneration, and allows the stream channel to migrate. The vision is that the floodplains of streams in the North Sacramento Valley Ecological Management Zone will be maintained at levels that permit recurrent floodplain inundation.

Central Valley Stream Temperatures: Chinook salmon and steelhead are dependent on specific stream temperatures. Optimum spawning and egg incubation typically occurs at 52°F while optimum rearing temperatures are slightly higher. Temperature requirements also vary among chinook runs, species, and life stage. The vision for stream temperatures is to provide sufficient flows to sustain cool water during important life stages to support all life stages of chinook salmon, steelhead, and other aquatic organisms.

Vision for Habitats

Riparian and Riverine Aquatic: Riparian and riverine aquatic habitats support a wide diversity of aquatic and terrestrial species. Healthy riparian corridors provide a migratory pathway between lower and higher elevation habitats for terrestrial species, such as mammals and birds. Shaded riverine aquatic habitat provides important habitat complexity in the stream, which includes shade and escape cover for juvenile fish. The vision for riparian and riverine aquatic habitat is that riparian corridors will be maintain and restored by improvements in sediment transport, stream meander, reconnecting streams with their floodplains, improved grazing and other land use practices, and by the creation of extensive riparian protection zones.

Freshwater Fish Habitat: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native and anadromous fish species. The upper sections of these creeks are typical of salmon-steelhead streams while the lower sections are typical of fall chinook salmon spawning streams (Moyle and Ellison 1991). The vision is that the quality of freshwater fish habitat in these creeks will be maintained through actions directed at streamflows, coarse sediment supply, stream meander, natural floodplain and flood processes, and maintaining and restoring riparian and riverine aquatic habitats.

ESSENTIAL FISH HABITAT: Clear, Cow, Bear, and Battle creeks have been identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). The vision is for EFH is to maintain or restore substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

VISIONS FOR REDUCING OR ELIMINATING STRESSORS

WATER DIVERSION: Water diversions reduce the quantity of flow below the diversion point and cause direct mortality by entraining young fish. The vision for water diversion and unscreened diversion in the North Sacramento Valley Ecological Management Zone is that sufficient flow will remain below diversion points to permit the successful up- and downstream migration of adult and juvenile fish, and that water will be diverted through state-of-the-art positive barrier fish screens to reduce loss of juvenile fish.

DAMS AND OTHER STRUCTURES: Instream structures frequently impair the upstream and downstream passage of anadromous fish. The vision for the North Sacramento Valley Ecological Management Zone is that the connections between upstream holding, spawning, rearing, and migration habitats and the Sacramento River will be reestablished, improved, maintained, and reestablished on some streams to permit unobstructed fish passage.

GRAVEL MINING: Gravel mining can greatly reduce the quality and quantity of coarse sediments in the streams of the North Sacramento Valley Ecological Management Zone. The vision is that gravel mining operations in the active stream channel will be reduced and relocated to alluvial deposits outside the active stream channel.

INVASIVE RIPARIAN AND MARSH PLANTS: Invasive riparian plants can outcompete and displace native vegetation. Often, these invasive plants have little or no value to native fish or wildlife species. The vision for reducing invasive riparian plants in the North Sacramento Valley Ecological Management Zone is to establish cooperative and coordinated eradication programs that allow the regeneration of native plant species and communities.

HARVEST OF FISH AND WILDLIFE: The legal and illegal harvest of chinook salmon and steelhead can reduce the number of spawning fish and impair other efforts to restore and rebuild spawning populations. The vision for illegal harvest in the North Sacramento Valley Ecological Management Zone is to implement a stronger enforcement and public education program. The vision for legal harvest is to develop harvest strategies that assist in the restoration of anadromous fish species.

ARTIFICIAL PROPAGATION OF FISH: The production of chinook salmon and steelhead at Coleman National Fish Hatchery on Battle Creek supports important sport and commercial fisheries and mitigates loss of salmon and steelhead habitat that resulted from the construction of Shasta Dam. Due to release practices, hatchery fish from Battle Creek and other Central Valley hatcheries supplement the numbers of naturally spawning salmon and steelhead in the Sacramento River and its tributaries. Hatchery salmon and steelhead may impede the recovery of wild populations by competing with wild stocks for resources. Hatchery-raised stocks, because of interbreeding, may not be genetically equivalent to wild stocks or may not have the instincts to survive in the wild. If these stocks breed with wild populations, overall genetic integrity suffers. The vision for artificial production in the North Sacramento Valley Ecological Management Zone is to implement hatchery practices that contribute to the recovery of naturally spawning populations of salmon and steelhead.

VISIONS FOR SPECIES

SPRING-RUN CHINOOK SALMON: The vision for spring-run chinook is to recover this State and federally listed threatened species, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that fully use existing and restored habitats. Spring-run chinook are dependent on late-winter/early-spring flows for upstream passage, deep pools and cool water for oversummer survival, and quality gravel for successful spawning in the fall. The vision for spring-run chinook salmon in the North Sacramento Valley Ecological Management Zone is that stream flows, stream temperatures, and habitat quality will be maintained or restored to a level that will support adult and juvenile populations.

WINTER-RUN CHINOOK SALMON: The vision for winter-run chinook salmon is to establish a self-sustaining population in Battle Creek to accelerate the recovery of this State and federally listed endangered species. The vision includes improved adult passage to upstream holding and spawning areas, high quality rearing of juvenile fish, limited interactions with hatchery produced fish, and no threat of disease contamination from the operation of Coleman National Fish Hatchery.

FALL-RUN CHINOOK SALMON: The vision for the fall-run chinook salmon is to recover all stocks. Fall-run chinook depend on late-summer and fall streamflow for access to spawning areas in the lower stream reaches. Habitat suitability is influenced by water temperatures. The vision for fall-run chinook salmon in the North Sacramento Valley Ecological Management Zone is that stream flows, stream temperatures, and habitat quality will be maintained or restored to a level that will support spawning and juvenile rearing through late spring.

LATE-FALL-RUN CHINOOK SALMON: The vision for late-fall-run chinook salmon is to recover this run which, along with fall-run chinook, is a candidate species under the ESA. Late-fall-run chinook typically depend on winter stream flows and quality spawning gravel. The vision for late-fall-run chinook salmon in the North Sacramento Valley Ecological Management Zone is to improve ecological processes that create and maintain spawning habitat and reduce sources of mortality that diminish survival of juvenile and adult fish.

STEELHEAD: The vision for Central Valley steelhead is to recover this federally listed threatened species and achieve naturally spawning populations of sufficient size to support inland recreational fishing at that use fully existing and restored habitats. Juvenile steelhead are dependent on cool water for oversummer survival, late-winter/early-spring flows for downstream passage, and quality gravel for successful spawning in the late winter/early spring. The vision for steelhead in the North Sacramento Valley Ecological Management Zone is that stream flows, stream temperatures, and habitat quality will be maintained or restored to a level that will support adult and juvenile populations.

LAMPREY: The vision for lamprey is to maintain and restore population distribution and abundance to higher levels than at present. The vision is also to understand life history better and identify factors in the North Sacramento Valley Ecological Management Zone which influence abundance. Lamprey are a California species of special concern. Because of limited information regarding their status, distribution, and abundance, the vision is that additional monitoring or research will provide the data necessary to manage these species and their habitat better.

NATIVE ANURAN AMPHIBIANS: The vision for the native anuran species is to stop habitat loss and the introduction of other species that prey on the different life stages of these amphibians. Ongoing surveys to monitor known populations and find additional populations is essential to gauge the health of the species in this group. To stabilize and increase anuran populations, non-native predator species should be eliminated from historic habitat ranges. Increasing suitable habitat and maintaining clean water supplies that meet the needs of the various species in this group is essential.

NATIVE RESIDENT FISH: The vision for native resident fish species is to maintain and restore by distribution and abundance of species such as Sacramento blackfish, hardhead, tule perch, Sacramento sucker, and California roach.

NEOTROPICAL MIGRATORY BIRDS: The vision for neotropical migratory birds is to maintain and increase populations through restoring habitats on which they depend.

PLANT SPECIES AND COMMUNITIES: The vision for plan species and communities is to protect and restore these resources in conjunction with efforts to protect and restore riparian and riverine aquatic habitats.

VALLEY ELDERBERRY LONGHORN BEETLE: The vision fr the valley elderberry longhorn beetle is to recover this federally listed threatened species by increasing its populations and abundance through restoration of riparian systems.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

LOCAL WATERSHED PLANNING GROUPS

Maintaining and restoring the ecological health of the ecological units in the North Sacramento Valley Ecological Management Zone will depend heavily on local watershed groups, including local landowners, concerned individuals, and local resource experts. The watershed planning groups in this Ecological Management Zone include the Clear Creek Coordinated Resources Management Program fostered by the Western Shasta Resource Conservation District, the Battle Creek Watershed Conservancy, and the Battle Creek Working Group. Additional groups are needed to sponsor watershed planning and restoration on Cow and Bear Creeks.

Ecosystem restoration efforts in the North Sacramento Valley Ecological Management Zone will be linked to cooperation from resource agencies, such as DFG, DWR, USFWS, and the National Marine Fisheries Service (NMFS), as well as participation and support from Reclamation, the U.S. Natural Resources Conservation Service, and private organizations, water districts, and individual landowners. These groups are expected to work together to maintain and restore streamflows and fish and wildlife habitat, reduce the impacts of diversions, and minimize poaching and habitat and water quality degradation in basin streams. In support of this effort, cooperating agencies should seek funding for enhancing streamflows, reducing fish passage problems, screening diversions, restoring habitats, and increasing Fish and Game Code enforcement to protect recovering populations of salmon and steelhead.

SALMON, STEELHEAD TROUT AND ANADROMOUS FISHERIES PROGRAM ACT

Established in 1988 by Senate Bill 2261, this Act directs the California Department of Fish and Game to implement measures to double the numbers of salmon and steelhead present in the Central Valley (DFG 1993, 1996). The DFG's salmon and steelhead restoration program includes cooperative efforts with local governments and private landowners to identify problem areas and assist in obtaining funding for feasibility studies, environmental permitting, and project construction. The vision will help DFG as it progresses toward doubling the number of anadromous fish over the number present in 1988.

CENTRAL VALLEY PROJECT IMPROVEMENT ACT

The U.S. Fish and Wildlife Service and the Bureau of Reclamation (Reclamation) are implementing the Central Valley Project Improvement Act (CVPIA), which provides for restoring habitats and species and eliminating many stressors. Key elements of the CVPIA program include the Anadromous Fish Restoration Program (USFWS 1997) and the Anadromous Fish Screening Program. Other elements are directed at spawning gravel replenishment, fish passage, water temperature control in the reach between Keswick Dam and the Red Bluff Diversion Dam (RBDD), water acquisition, and other measures that will contribute to health of the Sacramento River and Sacramento-San Joaquin Delta Ecological Management Zones.

The vision for the North Sacramento Valley Ecological Management Zone will contribute to and benefit from the Anadromous Fish Restoration Program (AFRP), which strives to double the natural production of anadromous fish in the system over the average production from 1967 through 1991.

Reclamation is willing to assist in restoring Clear Creek fish habitat by providing additional water from Whiskeytown Reservoir. The amount of water committed to maintain salmon and steelhead in this creek is presently recommended not to exceed 200 cfs from October 1 through June 1 and 150 cfs from June 2 to September 30. Flows are being evaluated to determine the instream flow necessary to achieve the strategic objective. Because passage and McCormick-Saeltzer Dam has not yet been achieved, AFRP recommended flows had not been implemented for Clear Creek until 1999. (USBR and DWR 1999).

CALFED BAY-DELTA PROGRAM

CALFED has funded eight ecosystem restoration projects in the North Sacramento Valley. Most projects improve fish passage. One project improves fish passage on Clear Creek by removing McCormick Seltzer Dam. The most significant project in the Zone will re-open 42 miles of fish habitat on Battle Creek by removing five diversion dams and laddering and screening another three dams.

Linkage to Other Ecological Management Zones

The North Sacramento Valley Ecological Management Zone is most closely linked to the Sacramento River Ecological Management Zone and exhibits a high degree of connectivity through the confluences of Clear, Cow, Bear, and Battle creeks with the Sacramento River Ecological Management Zone.

Restoration Targets and Programmatic Actions

Ecological Processes

Central Valley Streamflows

PROGRAMMATIC TARGET: More closely emulate the seasonal streamflow patterns in Clear, Cow, and Battle Creeks in most year types by providing or maintaining flows that mobilize and transport sediments, allow upstream and downstream fish passage, create point bars, and contribute to stream channel meander and riparian vegetation succession.

TARGET 1: Increase flow in Cow Creek by 25 to 50 cfs, corresponding to the natural seasonal runoff pattern, and maintain 25 to 75 cfs during October (◆◆).

PROGRAMMATIC ACTION 1A: Increase flow in Cow Creek by purchasing water from willing sellers or implementing a conjunctive groundwater program.

TARGET 2: Increase flow in Clear Creek to 150 to 200 cfs from October 1 to May 31 and to 100 to 150 cfs from June 1 to September 30 (◆◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to improve flow in Clear Creek by increasing releases from Clair Hill and Whiskeytown Dams.

Target 3: Augment flow in Battle Creek by 25 to 50 cfs (◆◆).

PROGRAMMATIC ACTION 3A: Increase flow in Battle Creek by purchasing water from willing sellers or providing compensation for forgone power production. This includes negotiating and renewing an existing interim flow agreement between the Department of the Interior and PG&E, and includes a provision for the release of 10 cfs at the Asbury Pump on Baldwin Creek, a dewatered Battle Creek tributary that provides steelhead habitat. In the longer-term, this action also include increasing flows at the Inskip Diversion Dam and South Diversion Dam.

TARGET 4: Augment flow in Bear Creek by 10 to 20 cfs (◆).

PROGRAMMATIC ACTION 4A: Increase Bear Creek flow by purchasing water from willing sellers or providing alternative sources of water to diverters during important fish passage periods in spring and fall.

RATIONALE: *The streams in the North Sacramento Valley Ecological Management Zone provide extremely valuable habitat for spring-run chinook salmon and steelhead trout. One of the key attributes of streamflow in this ecological zone is providing for successful upstream passage of adult fish. Water is diverted from the streams in this zone during periods that impair upstream passage conditions and prevent fish from reaching important oversummering or spawning habitats. Acquiring water from willing sellers and implementing programs to provide alternative sources of water during important periods are direct approaches to solving this problem. For example, natural flow in Bear Creek is often less than the combined water rights of diverters, resulting in total dewatering of the creek in the valley reach during critical periods for chinook salmon.*

The recommended AFRP flows for Clear Creek, as specified in Target 2, should be implemented immediately. Because steelhead and spring-run chinook salmon do not have access to the better quality habitat upstream of McCormick-Saeltzer Dam, it is all the more imperative that adequate flows be provided to restore some conditions in the reach immediately below McCormick-Saeltzer Dam.

Central Valley Stream Temperatures

TARGET 1: Maintain suitable water temperatures in Clear Creek for spring-run chinook and steelhead holding, spawning, and rearing (◆◆◆).

PROGRAMMATIC ACTION 1A: Maintain 56° F to approximately 3 miles downstream of McCormick-Saeltzer Dam from June through September.

RATIONALE: *Whiskeytown Dam provides an excellent opportunity to provide cold water releases from the lower depths of the reservoir to maintain adequate temperatures in downstream reaches. Because salmon and steelhead cannot access the higher quality habitat in Clear Creek because of the blockage at McCormick-Saeltzer Dam, greater releases will need to be made from Whiskeytown Dam to provide adequate temperatures in the reach below McCormick-Saeltzer Dam. Preliminary results from an ongoing temperature modeling study indicate that the AFRP recommended flows have the potential to provide adequate temperatures for spring-run chinook and steelhead in most of the reach between Whiskeytown and McCormick-Saeltzer dams. However, higher releases are necessary to achieve adequate temperatures below McCormick-Saeltzer Dam, and should be provided until McCormick-Saeltzer Dam is removed or modified to allow passage.*

COARSE SEDIMENT SUPPLY

TARGET 1: Maintain existing levels of erosion and gravel recruitment in streams of the North Sacramento Valley Ecological Unit and, where necessary, supplement gravel recruitment through adaptive management and monitoring (♦♦).

PROGRAMMATIC ACTION 1A: Cooperatively develop appropriate land use plans that allow the natural recruitment of sediments to streams in the North Sacramento Valley Ecological Management Zone.

TARGET 2: Increase existing levels of erosion and gravel recruitment in Clear Creek by 25 to 50 tons per year (♦♦♦).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to improve gravel quality and quantity in lower Clear Creek to maintain high-quality spawning conditions for fall-run and late-fall-run chinook salmon by evaluating the addition of 5,000 to 10,000 cubic yards annually as needed. Evaluate the need to acquire or relocate existing mining operations. Alter McCormick Dam so that it no longer serves as a sediment trap.

TARGET 3: Increase existing levels of erosion and gravel recruitment in Cow Creek by 5 to 10 tons per year (♦♦).

PROGRAMMATIC ACTION 3A: Develop a cooperative program to protect existing gravel and bedload movement in Cow Creek to maintain and increase future spawning gravel and sediment input to the Sacramento River by 5 to 10 tons per year by evaluating the need or opportunity to acquire or relocate existing gravel mining operations.

RATIONALE: *Replenishing gravel supplies to a level sufficient to support target populations of salmon and steelhead will help to improve populations to desirable levels and to maintain such levels once achieved. Replenishing gravels to maintain channel-forming processes and stream meanders will help to maintain fish and wildlife habitats, aquatic algae and invertebrate production, and streamside vegetation (California Department of Water Resources 1980). A predevelopment level of gravel recruitment should be adequate to restore the natural ecological processes supported by gravel recruitment, but may require experimenting, monitoring, and experience to determine the exact amount of gravel supplies necessary to meet the objective. Sediment supplementation programs, particularly in Clear Creek, need to be integrated with downstream channel forming processes, which will be subject to adaptive management, as well as to a different set of indicators, monitoring, and focused research.*

Rivers with a natural shape and hydrologic condition generally support the most diverse mixture of habitats and fish and wildlife species and are the most resilient to natural or human disturbance.

STREAM MEANDER

PROGRAMMATIC TARGET: Preserve or restore the 50- to 100-year floodplain and existing channel meander characteristics of Clear Creek, particularly in low-gradient areas where most sediment deposition occurs and where stream channel meander is most pronounced.

TARGET 1: Create a more defined stream channel in the lower 8 miles of Clear Creek to facilitate fish passage (♦♦♦).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to improve lower Clear Creek by maintaining flow connection with the Sacramento River and by regrading the channel and controlling vegetative encroachment.

RATIONALE: *Gravel deposits in Clear and Cow Creeks are essential to maintaining spawning and rearing habitats of spring-run and fall-run chinook salmon, steelhead trout, and other native fishes. Whiskeytown Dam and extensive gravel extraction in the lower section of Clear Creek continue to reduce the amount of gravel transport to near zero; Cow Creek has only a limited natural supply and has been adversely affected by gravel mining in its lower reach near the Sacramento River. Although small, Cow Creek provides an important source of sediments to the Sacramento River, particularly for the 8- to 10-mile reach between its confluence with the river and the mouth of Cottonwood Creek.*

The Clear Creek stream meander belt is the area in which natural bank erosion and floodplain and sediment bar accretions occur. Natural stream meander belts in alluvial systems function dynamically to transport and deposit sediments and provide transient habitats important to algae, aquatic invertebrates, and fish, as well as surfaces that are colonized by natural vegetation that support wildlife. The flow regime in Clear Creek has recently been improved by adding supplemental water under provisions of the CVPIA. This improved flow will assist in reactivating or reestablishing the natural stream channel. Because of low flow releases from Whiskeytown Lake in the past, vegetation has encroached into the lower 3 miles of the active stream channel on Clear Creek, prevented meander, and fixed stream sediments so that they no longer contribute to sediment load or provide substrate for fish spawning.

NATURAL FLOODPLAIN AND FLOOD PROCESSES

TARGET 1: Increase and maintain the Clear Creek floodplain in conjunction with stream meander corridor restoration (◆◆◆).

PROGRAMMATIC ACTIONS 1A: Develop a cooperative program, consistent with flood control requirements, to evaluate the feasibility of altering stream channel configuration in the lower reach of Clear Creek to increase the areal extent of floodplains inundated during high flow periods.

TARGET 2: Reestablish natural floodplain and stream channel meander in the lower 8 miles of Clear Creek (◆◆◆).

PROGRAMMATIC ACTION 2A: Acquire floodplains by direct purchase or easement from willing sellers.

RATIONALE: *Floodplain inundation is a secondary ecosystem process related to water and sediment flow through the Sacramento-San Joaquin Basin in combination with geomorphology. Floodplain inundation is the seasonal flooding of floodplain habitats, including riparian and riverine aquatic habitats. Flooding of these lands provides important seasonal habitat for fish and wildlife and provides sediment and nutrients to both the flooded lands and aquatic habitats that receive the returning or abating floodwater. The flooding also shapes the plant and animal communities in the riparian, wetland, and upland areas subject to flooding. Opportunities to restore or enhance this process are possible by changing landscape features, geomorphology, and seasonal distribution of flow volume through the system.*

HABITATS

RIPARIAN AND SHADED RIVERINE AQUATIC HABITATS

TARGET 1: Develop a cooperative program to establish riparian habitat zones along streams in the North Sacramento Valley Ecological Management Zone through conservation easements, fee acquisition, or voluntary landowner measures (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to establish, restore, and maintain riparian habitat on Clear Creek through conservation easements, fee acquisition, or voluntary landowner cooperation.

PROGRAMMATIC ACTION 1B: Encourage the development of long-term measures in the comprehensive watershed management plan to improve water temperatures further. Develop a cooperative approach with counties and local agencies to implement land use management that protects riparian vegetation along the streams and develop programs to restore lost riparian vegetation

PROGRAMMATIC ACTION 1C: Cooperatively negotiate long-term agreements with local landowners to maintain and restore riparian communities along the lower reaches of Cow, Bear, and Battle Creeks.

RATIONALE: *Many species of fish and wildlife in the North Sacramento Valley Ecological Management Zone depend on or are closely associated with riparian habitats. Of all the habitat types in California, riparian habitats support the greatest diversity of wildlife species. Degradation and loss of riparian habitat have substantially reduced the habitat area available for associated wildlife species. Loss of this habitat has reduced water storage, nutrient cycling, and foodweb support functions.*

FRESHWATER FISH HABITAT AND ESSENTIAL FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination (◆◆).

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitat and essential fish habitat. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of creeks in the Ecological Management Zone and their floodplains, and in maintaining and restoring riparian and riverine aquatic habitats.*

Successful implementation of theses actions will improve conditions for anadromous fish and native resident fish species such as roach and Sacramento suckers, as well as a variety of riparian dependent avian species.

ELIMINATING OR REDUCING STRESSORS

WATER DIVERSIONS

TARGET 1: Reduce or eliminate conflicts between the diversion of water and chinook salmon and steelhead populations at all diversion sites on Battle Creek (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative approach to improve conditions for anadromous fish in Battle Creek by installing fish screens at diversions on the North Fork, three diversions on the South Fork, and one diversion on the mainstem, or acquire water rights to eliminate the need for diversion and screening.

PROGRAMMATIC ACTION 1B: Improve the survival of adult salmon and steelhead in Battle Creek by installing a rack at the head of Gover Diversion Canal to prevent straying.

TARGET 2: Reduce or eliminate conflicts between the diversion of water and chinook salmon and steelhead populations at all diversions on Clear Creek (◆◆◆).

PROGRAMMATIC ACTION 2A: Acquire water rights on Clear Creek at the McCormick Dam to eliminate the need for diversion.

RATIONALE: *Diversion, storage, and release of water in the Clear and Battle Creek watersheds directly affect fish and other aquatic organisms and indirectly affect habitat, foodweb production, and species abundance and distribution. Diversions cause consumptive loss of water, nutrients, sediment, and organisms. Seasonal and daily patterns of water released from storage may affect habitat, water quality, and aquatic organism survival. In both Clear and Battle Creeks, water diversion and water diversion structures have caused direct mortality by removing juvenile fish from the population. Water diversion also reduces the quantity and quality of stream habitats and the resiliency of fish populations. Where possible, it is more desirable to acquire water rights and eliminate the diversion than to install positive-barrier fish screens.*

Coleman National Fish Hatchery receives its water supply directly from Battle Creek. Because of past incidences of disease at the hatchery, adult salmon and steelhead were blocked from ascending the creek *to prevent disease contamination of the hatchery water supply. Restoring naturally spawning fish in the upper watershed will be limited until water can be supplied to the hatchery in a manner that will not contribute to disease outbreaks.*

DAMS AND OTHER STRUCTURES

PROGRAMMATIC TARGET: Eliminate or reduce water uses that conflict with increasing the success of spawning adults and survival of juvenile chinook salmon and steelhead by managing or reconstructing facilities and structures that impair fish passage and fish survival.

TARGET 1: Work with landowners and diverters on Cow Creek to reduce the adverse effects of 13 seasonal diversion dams in South Cow Creek, 10 diversion dams in Old Cow Creek, two diversion dams in North Cow Creek, and one diversion dam in Clover Creek that are barriers to migrating chinook salmon and steelhead. This would allow access to 100% of the habitat below any natural bedrock falls (◆◆◆).

PROGRAMMATIC ACTION 1A: Improve passage conditions on Cow Creek by acquiring water rights from willing sellers, removing diversions, or providing alternative sources of water during important periods.

TARGET 2: Work with landowners and diverters on Bear Creek to reduce the adverse effects of dewatering the stream channel at seasonal diversion dams, which results in no passage for migrating chinook salmon (◆◆◆).

PROGRAMMATIC ACTION 2A: Improve passage and habitat conditions in Bear Creek by acquiring water rights from willing sellers, evaluating the removal of diversion dams, or providing alternative sources of water during important periods.

TARGET 3: Work with landowners, diverters, and other state or federal agencies managing Battle Creek to improve fish passage (◆◆◆).

PROGRAMMATIC ACTION 3A: Develop a cooperative program to upgrade or replace existing fish ladders or evaluate the removal of diversion dams and other impediments to passage.

TARGET 4: Work with landowners and diverters on Clear Creek to improve fish passage between its mouth and Whiskeytown Dam (◆◆◆).

PROGRAMMATIC ACTION 4A: Develop a cooperative program to improve fish passage on Clear Creek by upgrading or replacing the fish ladder at McCormick-Saeltzer Dam or removing or modifying the dam.

TARGET 5: Reduce or eliminate conflicts in Battle Creek that require excluding anadromous fish from the upper section to protect the Coleman National Fish Hatchery water supply (◆◆◆).

PROGRAMMATIC ACTION 5A: Develop an alternative or disease-free water supply for Coleman National Fish Hatchery to allow naturally spawning salmon and steelhead access to the full 41-mile reach of Battle Creek above the Coleman National Fish Hatchery weir.

TARGET 6: Investigate possibility of providing access for steelhead to streams above Whiskeytown Dam (◆).

PROGRAMMATIC ACTION 6A: Develop a cooperative program to investigate the feasibility/desirability of providing access to tributaries above Whiskeytown Dam.

RATIONALE: *Dams and their associated reservoirs block fish movement, alter water quality, remove fish and wildlife habitat, and alter hydrological and sediment processes. Fish passage in the North Sacramento Valley Ecological Management Zone is impaired in Clear, Cow, Bear, and Battle Creeks by a variety of permanent and seasonal dams used to divert water for irrigation or power production. Other human-made structures may block fish movement or provide habitat or opportunities for predatory fish and wildlife, which could be detrimental to fish species of special concern, such as spring-run chinook salmon and steelhead, as well as the other stocks of chinook salmon. Improved fish passage will allow anadromous fish to reach the habitat they require to oversummer or to spawn in good health, which will increase their chances of successfully spawning. Improved fish passage will allow anadromous fish to reach the habitat they require to oversummer or to spawn and rear in good health, which will increase their chances of successful spawning.*

HARVEST OF FISH AND WILDLIFE

TARGET 1: Develop harvest management strategies that allow wild, naturally produced fish spawning populations to attain levels that fully use existing and restored habitat, and focus harvest on hatchery-produced fish (◆◆◆).

PROGRAMMATIC ACTION 1A: Control illegal harvest by providing increased enforcement efforts.

PROGRAMMATIC ACTION 1B: Develop harvest management plans with commercial and recreational fishery organizations, resource management agencies, and other stakeholders to meet the target.

PROGRAMMATIC ACTION 1C: Continue the mass-marking program and selective harvest regulations for hatchery steelhead.

PROGRAMMATIC ACTION 1D: Evaluate a marking and selective fishery program for chinook salmon.

RATIONALE: *Restoring and maintaining populations of chinook salmon and steelhead to levels that fully take advantage of habitat may require restricting harvest during and even after the recovery period. Involving the various stakeholder organizations should help to ensure a balanced and fair allocation of available harvest. Target population levels may be such that existing harvest levels of wild, naturally produced fish cannot be sustained. For populations supplemented with hatchery fish, selective fisheries may be necessary to limit the harvest of wild fish, while hatchery fish are harvested at a level to reduce their potential to disrupt the genetic integrity of wild populations.*

ARTIFICIAL PROPAGATION OF FISH

TARGET 1: Minimize the likelihood that hatchery-reared salmon and steelhead produced in the Coleman National Fish Hatchery will stray into non-natal streams, thereby protecting naturally produced salmon and steelhead (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate the benefits of stocking hatchery-reared salmon and steelhead in the Sacramento River and Battle Creek. Stocking may be reduced in years when natural production is high.

TARGET 2: Limit hatchery stocking if populations of salmon or steelhead can be sustained by natural production (◆◆◆).

PROGRAMMATIC ACTION 2A: Augment populations of fall chinook salmon and steelhead only when alternative measures are deemed insufficient to provide recovery of the populations.

TARGET 3: Minimize further threats of hatchery fish contaminating naturally produced stocks of chinook salmon and steelhead (◆◆◆).

PROGRAMMATIC ACTION 3A: Adopt methods for selecting adult spawners for the hatchery from an appropriate cross-section of the adult population available to the hatchery.

RATIONALE: *In watersheds such as the Sacramento River and Battle Creek, where dams and habitat degradation have limited natural spawning, hatchery supplementation may be necessary. This would sustain fishery harvest at former levels and maintain a wild or naturally spawning population during adverse conditions, such as droughts. Hatchery augmentation, however, should be limited so as not to inhibit recovery and maintenance of wild populations. Hatchery-reared salmon and steelhead may directly compete with and prey on wild salmon and steelhead. Hatchery fish may also threaten the genetic integrity of wild stocks by interbreeding with the wild fish. Although irreversible contamination of the genetics of wild stocks has occurred, additional protective measures are necessary to minimize further degradation of genetic integrity. Because of the extent of development on the Sacramento River and Battle Creek, chinook salmon and steelhead stocking may be necessary to rebuild and maintain stocks to sustain sport and commercial fisheries.*

SPECIES

STEELHEAD TROUT

SUPPLEMENTAL TARGET 1: Investigate the feasibility of using native rainbow trout currently isolated above dams to rebuild or recreate a steelhead run (◆).

PROGRAMMATIC ACTION 1A: Conduct a comprehensive, basin-wide genetic evaluation of Central Valley steelhead stocks that includes analysis of self-sustaining populations of rainbow trout isolated above dams for purposes of identifying a suitable broodstock.

PROGRAMMATIC ACTION 1B: Conduct hatchery/release investigations to determine if progeny of native resident rainbow trout raised in a hatchery will emigrate to the ocean.

RATIONALE: *Resident rainbow trout and anadromous steelhead likely comprise a single, interbreeding population in specific stream systems (IEP Steelhead Project Work Team 1999). Native, resident rainbow trout presently isolated above dams could possess the genetic traits that would allow their use as an experimental broodstock to restore steelhead. Planned and ongoing genetic analyses, conducted through the Comprehensive Central Valley Steelhead Genetic Evaluation (see ERPP Vol. 1, Species Vision for Steelhead Trout) and the Fish and Wildlife Service Upper Sacramento River Rainbow Trout Genetic Analysis, should be able to elucidate genetic relationships of resident and anadromous rainbow trout. If it is determined that native populations exist, experiments could be undertaken to determine if anadromous steelhead could be derived from an experimental hatchery population. If this is successful, then restoration of some stocks of native Central Valley steelhead thought to be extinct may be achievable through this method.*

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◆ COTTONWOOD CREEK ECOLOGICAL MANAGEMENT ZONE

INTRODUCTION

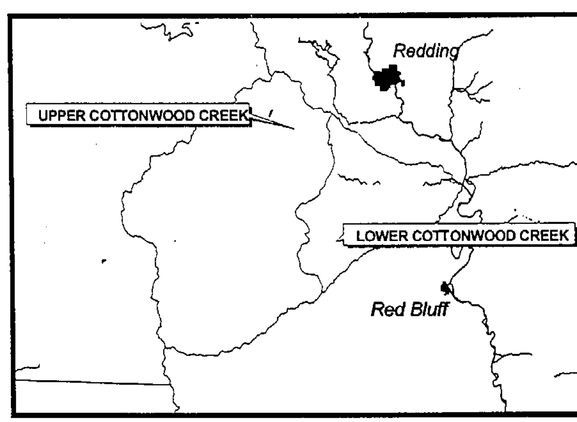
The health of the Sacramento-San Joaquin Delta is influenced by the interdependence and connectivity of the component ecosystem elements, particularly the 14 ecological management zones. The Cottonwood Creek Ecological Management Zone is located many miles from the Delta, but its status and health are ultimately reflected in the health of the Delta. The intermediate zone between the Delta and Cottonwood Creek is the Sacramento River. The Sacramento River Ecological Management Zone and its respective habitats and fish, wildlife, and plant assemblages depend on Cottonwood Creek, primarily for its ability to supply sediments and gravel to the river, but also for its seasonal contributions of flow.

DESCRIPTION OF THE MANAGEMENT ZONE

Cottonwood Creek drains an area of 930 square miles on the west side of the Central Valley and enters the Sacramento River a short distance downstream of the Redding-Anderson area, approximately 16 miles north of Red Bluff. One of the outstanding attributes of Cottonwood Creek is its status as the largest undammed tributary on the westside of the Sacramento Valley.

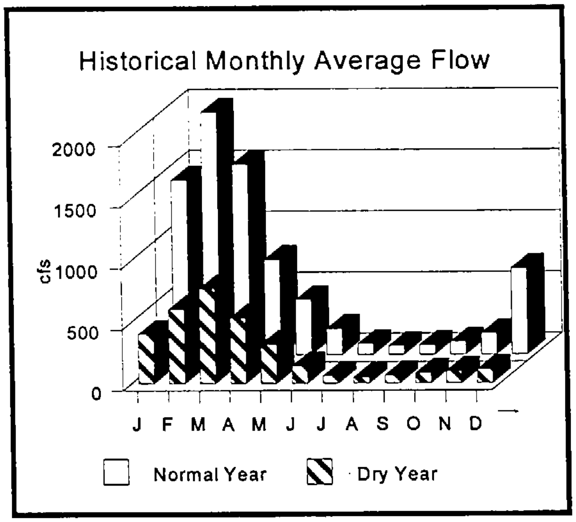
The creek spans a broad elevational range and functions as an important regional wildlife corridor and neotropical bird habitat. Well-developed montane, foothill, and valley riparian forests are found throughout the Cottonwood Creek Ecological Management Zone, and these forests have good connectivity with the Sacramento River Ecological Management Zone. One of the most important ecological attributes of Cottonwood Creek is its role as the primary source of coarse sediments and spawning gravel for the Sacramento River. Cottonwood Creek supplies almost 85% of the gravel introduced into the Sacramento River between Redding and Red Bluff.

Attributes that affect the ecological health of the Cottonwood Creek Ecological Management Zone include streamflow, coarse sediment supply, gravel recruitment and transport, stream meander, and vegetation succession. Important fish and wildlife habitats include freshwater fish habitat, essential fish habitat, gravel substrate for invertebrate production and chinook salmon and steelhead spawning, riparian scrub and woodlands, and shaded riverine aquatic habitat.



Location Map of the Cottonwood Creek Ecological Management Zone and Units.

Cottonwood Creek has a natural flow pattern of high winter and low summer and fall flows, which is typical of many Sacramento Valley streams that originate in the foothills rather than at higher elevations in the Cascade or Sierra Nevada mountain ranges. In summer and fall months of low rainfall years, flows average 40 to 80 cubic feet per second (cfs). In the wettest years, flows in winter average 5,000 to 11,000 cfs. In winter months of dry years, average monthly flows reach only 400 to 800 cfs. In the driest years, average winter monthly flows reach only 50 to 150 cfs.



Historical Streamflow of Cottonwood Creek, 1952-1992
(Dry year is the 20th percentile year; normal year is the 50th percentile year.)

In the past, streamflow in Crowley Gulch, a tributary to lower Cottonwood Creek, was intermittently augmented by the release of water from a waste gate on the Anderson-Cottonwood Irrigation District (ACID) canal. Waste gate releases during fall have attracted chinook salmon into an area where they became stranded and subsequently died without having spawned. This problem has been eliminated by operational changes by ACID personnel.

The estimated mean annual suspended sediment load transported from the Cottonwood Creek basin is second only to that of Cache Creek in the Sacramento River basin below Shasta Dam. The U.S. Army Corps of Engineers estimates that, of the total average annual gravel load transported by Cottonwood Creek, particles greater than 2.0 millimeters in diameter total approximately 19,000 tons per year. This amount is consistent with the average annual bedload of approximately 65,000 tons estimated by the U.S. Geological Survey. The California Department of Water Resources (1980) estimated that gravel mining reduced potential sand and gravel contributions to the Sacramento River by about 60%, resulting in a calculated bedload of 20,000 tons per year, with 3,000 tons of particles above one-half inch in diameter.

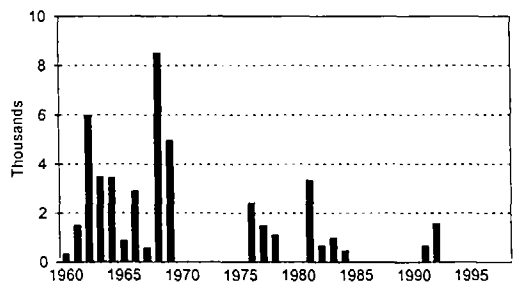
More is known about the hydrology and sediment transport process of Cottonwood Creek than about that of other streams in the northern Sacramento Valley because of studies conducted for the construction of several dams and environmental impact reports for gravel mining projects. Bankfull discharge (i.e., with the creek full to the tops of its banks) has been estimated at 20,000 cfs with a return interval of 1.8 years. The creek has a wide meander belt and a braided channel with perennial flow. The active channel width at low flow ranges from 50 to 150 feet but reaches more than 1,500 feet at bankfull discharge. The channel banks are mostly sand, gravel, and cobbles. The width of the floodplain varies, but it is generally wider and more poorly defined downstream. Sinuosity values (i.e., the ratio of creek length to the linear distance over which the creek travels) for Cottonwood Creek are low, ranging from 1.04 to 1.47. The low degree of sinuosity is attributable primarily to the high gravel and low silt and clay content of the bank material. The main channel tends to change course during large floods, resulting in a fairly wide belt of distributary channels and abandoned stream courses.

Some of the fish, wildlife, and plant resources dependent on the ecological health of Cottonwood Creek are fall-run, late-fall-run, and spring-run chinook salmon and steelhead trout. Although northern spotted owls, northwestern pond turtles, and foothill yellow-legged frogs in the South Fork will benefit from proposed restoration actions, these species are not a direct focus of actions in the Cottonwood Creek Ecological Management Zone.

The use of Cottonwood Creek by chinook salmon and steelhead trout is determined by the timing of rainfall. In years when storms arrive late in the season, the migration of salmon and steelhead is delayed. In some years, early rainfall allows salmon to enter the creek and spawn, but subsequent low winter and spring flows limit the production of young salmon.

The average annual return of fall-run salmon is approximately 1,000 to 1,500 adults but has ranged from a few hundred to more than 8,000 fish. The return of late-fall-run salmon is much smaller, consisting of fewer than 500 fish each year. The late-fall-run salmon enter Cottonwood Creek and spawn in the main stem and lower reaches of the North, Middle, and South Forks of the creek.

Salmon spawning gravel habitat in the lower reaches of Cottonwood Creek has been degraded. Some areas



Fall-run Chinook Salmon Returns to Cottonwood Creek, 1960-1999 (CDFG 1999).

are covered entirely with sand and silt, and others are compacted with sediments or have become armored. Silt in Cottonwood Creek is derived from many sources; some of these sources are natural, but most are a result of undesirable land use practices, including timber harvesting and road-building activities on private and public land in the upper watershed. Overgrazing, wildfires, extensive land clearing in the foothill and valley areas, and discharges of decomposed granite from Rainbow Dam are also sources of sediment.

Streamflow, coarse sediment supply, and stream meander are closely linked. Together, these processes support and promote the regeneration of healthy riparian and riverine plant communities. Important restoration components include protecting the floodplain and existing stream meander characteristics of Cottonwood Creek.

Important functions of the upper watershed of Cottonwood Creek are to moderate streamflows resulting from storm events and to provide high quality water to the Sacramento River and Delta. Erosion from timber harvest, road building, and the adverse affects of grazing practices diminish the watershed's ability to moderate flows and provide high quality water. The potential for catastrophic wildfire can be reduced by fuel management programs.

Cottonwood Creek has an extensive riparian and riverine aquatic plant community that can be enhanced by improved land management and maintenance of natural sediment supply. Denuded areas need an opportunity to regenerate, and existing riparian forest needs protection.

Water conveyance structures in the lower sections of Cottonwood Creek impair the upstream passage of adult chinook salmon and steelhead. Restoring natural sediment supply can alleviate these problems over time and permit unobstructed access to important aquatic habitats.

Extensive gravel mining in Cottonwood Creek has damaged spawning habitat and significantly reduced gravel recruitment to the Sacramento River. In addition, gravel mining creates passage and stranding problems for fish by allowing the creek to spread over the large extraction area.

During spring, low flows and high water temperatures may impede or prevent the upstream migration of adult spring-run chinook salmon to summer holding areas.

The Cottonwood Creek Ecological Management Zone includes two ecological management units: the Upper Cottonwood Creek Ecological Management Unit and the Lower Cottonwood Creek Fan Ecological Management Unit.

List of Species to Benefit from Restoration Actions in the Cottonwood Creek Ecological Management Zone

- chinook salmon
- steelhead trout
- lamprey
- native anuran amphibians
- native resident fishes
- neotropical migratory birds
- plants and plant communities.

Descriptions of Ecological Management Units

Upper Cottonwood Creek

The Upper Cottonwood Creek Ecological Management Unit provides the streamflow and coarse sediments needed to maintain the overall ecological health of lower Cottonwood Creek and the Sacramento River. Important stream reaches in the Upper Cottonwood Creek Ecological Management Unit include the South and North Forks of Cottonwood Creek, Beegum Creek, and the mainstem reach of Cottonwood Creek above the confluence with the

South Fork. The Upper Cottonwood Creek Ecological Management Unit can sustain important migration, holding, spawning, rearing, and emigration habitats for fish and wildlife species if streamflows are maintained and watersheds are rehabilitated.

The South Fork of Cottonwood Creek contains good to outstanding riparian vegetation in the foothills and lower stretches. Spring-run chinook salmon and steelhead trout can migrate to the headwaters of the South Fork, using Maple Gulch as their principal holding area. The length of the stream system below natural fish barriers is 130 linear miles, which includes the three main forks of the creek and Beegum Creek.

Spring-run chinook salmon enter Cottonwood Creek and migrate to the headwaters of the South and Middle Forks during April, May, and June. The two principal holding areas are the South Fork above Maple Gulch and Beegum Creek, a tributary to the Middle Fork. During spring of drier years, low flows and high water temperatures may impede or prevent the upstream migration of adult spring-run salmon to summer holding areas. There are no recent estimates of spring-run chinook populations; however, historic runs averaged approximately 500 salmon.

Steelhead trout enter Cottonwood Creek during late fall and early winter and spawn during winter and spring. The upper reaches of the Middle Fork, Beegum Creek, and the South Fork provide spawning and nursery areas. There are no recent estimates of steelhead populations for Cottonwood Creek. The creek also supports resident rainbow trout and brown trout in the upper tributaries.

Lower Cottonwood Creek

The Lower Cottonwood Creek Ecological Management Zone can provide important spawning areas for fall- and late-fall-run chinook salmon. Gravel transport through lower Cottonwood Creek is a significant ecological function and sufficient streamflows are needed to provide sediment transport and gravel cleansing. A long-term effort will be implemented to restore and maintain plant communities along the creek.

Salmon spawning areas in the lower reaches of Cottonwood Creek have been degraded. Some areas are entirely covered with sand and silt, and others are compacted with sediments or have become armored during floodflows. Sedimentation binds the gravel together, which prevents salmon from creating redds (salmon spawning nests); it also reduces intergravel oxygen transport, so eggs deposited in the gravel do not survive. Armoring results when gravel is washed away during floods, leaving rocks and boulders too large for salmon to move during spawning.

Gravel has been mined in the lower Cottonwood Creek fan for many years. Gravel extraction damages spawning areas in the creek and reduces the recruitment of spawning gravel to the Sacramento River. Two major instream gravel extraction projects operate in Cottonwood Creek below the Interstate 5 bridge.

Visions for the Ecological Management Zone and Units

The vision for the Cottonwood Creek Ecological Management Zone is to restore natural streamflow patterns, coarse sediment supply, natural floodplain and flood processes, and riparian forest and riverine aquatic habitats. In addition, the proposed restoration actions are designed to reduce or eliminate to the extent necessary stressors that impair ecological processes, including gravel mining operations, structures that inhibit chinook salmon and steelhead trout migrations, and land use activities (e.g., water diversions, logging, and grazing).

A restored Cottonwood Creek will provide incremental benefits to the overall objective of restoring and maintaining important aquatic species, such as chinook salmon and steelhead trout, in Cottonwood Creek and in the Sacramento River. With restoration, Cottonwood Creek Ecological Management Zone will support sustainable populations of fall-, late-fall-, and spring-run chinook salmon and steelhead trout after natural sediment supply and gravel recruitment, cleansing, and transport processes are reactivated; gravel spawning and riparian habitats are restored; and the adverse effects of upper watershed diversions, logging, and grazing are reduced.

Vision for Upper Cottonwood Creek

The vision for the Upper Cottonwood Creek Ecological Management Zone is to maintain coarse sediment recruitment, cleansing, and transport; improve habitat for chinook salmon, steelhead trout, and other native fishes; improve habitat corridors for wildlife populations; and restore riparian and riverine plant communities through improved land use and forest management practices.

The Cottonwood Creek watershed is a high-value area, both because it is a distinct Ecological Management Zone and because of its linkage with the Sacramento River Ecological Management Zone. Restoring and maintaining ecological processes and functions related to streamflow, sediment supply, gravel recruitment, cleansing, and transport, and the creation and maintenance of habitats can best be achieved by developing and implementing a local watershed management plan. The creation of a watershed management plan by the recently formed Cottonwood Creek Watershed Group is necessary. This planning effort would evaluate and develop recommendations for timber harvesting, land use, fire and fire suppression, and the management of oak woodland habitats to reduce erosion, maintain riparian zones, and provide for more sustained runoff patterns.

VISION FOR LOWER COTTONWOOD CREEK

The vision for the Lower Cottonwood Creek Ecological Management Zone is to restore, reactivate, and maintain coarse sediment supply, floodplain and flood processes, gravel recruitment, and stream meander. The vision also includes reducing stressors on these processes, including gravel mining activities in the Cottonwood Creek stream corridor.

Instream gravel extraction should be managed to protect salmon spawning and rearing habitat within Cottonwood Creek and to maintain and enhance sediment supply to the Sacramento River. Implementing such management would result in immediate benefits to salmon in Cottonwood Creek and the Sacramento River. Spawning gravel is a finite resource in the Sacramento River system, and Cottonwood Creek contains one of the most important reserves.

VISIONS FOR ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOWS: Streamflows shape the stream channels, support riparian vegetation, and transport nutrients and sediments. The vision for streamflows in Cottonwood Creek is to emulate the natural runoff pattern with a late-summer or early fall flow event.

COARSE SEDIMENT SUPPLY: Coarse sediments are abundant in Cottonwood Creek; however, gravel recruitment has diminished because of extensive mining activities. The vision is that restoring natural gravel recruitment and sediment transport processes will contribute to maintaining important habitat substrates and ecological processes in Cottonwood Creek and the Sacramento River.

STREAM MEANDER: In unimpaired systems, streams meander within their historic floodplains. This meander contributes sediments for transport and deposition, rejuvenates riparian succession, and creates new habitats for fish and other aquatic species. The vision is that a natural stream meander process will provide much of the habitat needed to support healthy riparian systems, wildlife, and aquatic species.

NATURAL FLOODPLAIN AND FLOOD PROCESSES: Coarse sediment supply, stream meander, and floodplain and flood processes are closely interrelated. The vision is that all three of these processes will moderate channel incision and scour by providing areas for bank overflow, contribute to species diversity by creating landforms that support different community structure, provide low-velocity refuge for fish and other aquatic organisms during floods.

VISIONS FOR HABITATS

RIPARIAN AND RIVERINE AQUATIC HABITATS: Health riparian habitat provides a migratory corridor for terrestrial species that connects low and higher elevation habitats. Shaded riverine aquatic habitat provides shade, contributes to moderating stream temperatures, and provides woody debris, which juvenile fish use as escape and resting cover. The vision is that Cottonwood Creek will support healthy riparian, shaded riverine aquatic and woody debris habitats, which in turn will support improved survival of aquatic and terrestrial species.

FRESHWATER FISH HABITAT: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native and anadromous fish species. Upper Cottonwood Creek is typical of a salmon-steelhead stream and lower Cottonwood Creek is typical of a fall chinook salmon spawning stream (Moyle and Ellison 1991). The vision is to maintain the quality of freshwater fish habitat in Cottonwood Creek through actions directed at streamflows, coarse sediment supply, stream meander, natural floodplain and flood processes, and maintaining and restoring riparian and riverine aquatic habitats.

ESSENTIAL FISH HABITAT: Cottonwood Creek has been identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). The vision is to maintain or restore EFH in Cottonwood Creek including substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

VISION FOR REDUCING OR ELIMINATING STRESSORS

GRAVEL MINING: Coarse sediment supply in Cottonwood Creek is adversely affected by gravel mining. This lack of instream sediments affects stream channel morphology, stream meander, and riparian systems. The vision for Cottonwood Creek is that gravel mining activities will be relocated to areas outside the active stream channel.

VISIONS FOR SPECIES

CHINOOK SALMON: The vision for Central Valley chinook salmon is to recover all stocks presently listed or proposed for listing under ESA and CESA, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that use fully existing and restored habitats. The fall-, spring-, and late-fall-runs of chinook salmon depend on Cottonwood Creek's streamflow, natural sediment supply, and riverine aquatic habitats. The vision is that Cottonwood Creek will provide for sustainable chinook salmon populations.

STEELHEAD: The vision for steelhead is to recover this species listed as threatened under ESA. Steelhead use Cottonwood Creek and will benefit from many of the actions that will improve conditions for chinook salmon. The vision is that Cottonwood Creek will support a sustainable steelhead population.

LAMPREY: The vision for lamprey is to maintain and restore population distribution and abundance to higher levels that at present. The vision is also to understand life history and factors in Cottonwood Creek better which influence abundance. Lamprey are a California species of special concern. Because of limited information regarding their status, distribution, and abundance, the vision is that additional monitoring or research will provide the data necessary to manage these species and their habitat better.

NATIVE ANURAN AMPHIBIANS: The vision for the native anuran species is to stop habitat loss and the introduction of other species that prey on the different life stages of these amphibians. Ongoing surveys to monitor known populations and find additional populations are essential to gauge the health of the species in this group. To stabilize and increase anuran populations, non-native predator species should be eliminated from historic habitat ranges. Increasing suitable habitat and maintaining clean water supplies that meet the needs of the various species in this group is essential.

NATIVE RESIDENT FISH: The vision for native resident fish species is to maintain and restore by distribution and abundance of species such as Sacramento blackfish, hardhead, tule perch, Sacramento sucker, and California roach.

NEOTROPICAL MIGRATORY BIRDS: The vision for neotropical migratory birds is to maintain and increase populations through restoring habitats on which they depend.

PLANT SPECIES AND COMMUNITIES: The vision for plan species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland and riparian and riverine aquatic habitats.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Maintaining and restoring the ecological health of the Cottonwood Creek Ecological Management Zone and its respective Ecological Management Zones will depend primarily on cooperative endeavors to locate alternative sources of water in the upper watershed and to eliminate gravel extraction operations in the lower creek.

WATERSHED MANAGEMENT PLANNING

Restoration of this Ecological Management Zone requires developing and implementing a comprehensive watershed management program for the upper and lower areas. Eliminating gravel extraction operations will increase the delivery of sediments to the Sacramento River, improve upstream fish passage, improve spawning habitat for chinook salmon using the lower reach, and allow for restoring a riparian corridor and a clearly defined stream channel. Improved watershed management in the upper watershed will protect streamflow, gravel sources, spawning and rearing habitat of salmon and steelhead, and wildlife habitats. The Cottonwood Creek Watershed Group is seeking to develop and implement a watershed management plan. This planning effort would assess current conditions in the watershed to provide a baseline from which to develop future projects. In addressing watershed stewardship, the Cottonwood Creek Watershed Group has recommended evaluating vegetation management, land use, fire and fuel suppression, managing oak woodlands, reducing erosion, maintaining riparian zones, and providing more sustained runoff patterns in the upper watershed area. Their proposed planning effort would seek to return to natural or near-natural ecosystem functioning, reactivate and maintain natural sediment transport processes, improve floodplain and flood processes, and protect salmon spawning and rearing habitat in the lower watershed area.

AGGREGATE RESOURCE MANAGEMENT PLAN

In attaining the vision for the Cottonwood Creek Ecological Management Zone, ERPP encourages gravel operators and the local counties cooperatively to develop and implement an aggregate resource management plan (ARMP). Potential measures in a county-wide ARMP would include recommendations or requirements for:

- limiting instream extraction to less than the sustained yield of the system while providing sediment input to the Sacramento River,
- implementing measures to prevent channel incision, such as installing stream grade control structures, and
- revegetating all permanently exposed lands that have been denuded by mining operations.

CENTRAL VALLEY PROJECT IMPROVEMENT ACT

The Central Valley Project Improvement Act (CVPIA) added "mitigation, protection and restoration of fish and wildlife" as a purpose of the Central Valley Project. It required the imple-mentation of a program that makes all reasonable efforts to increase the natural production of anadromous fish in Central Valley rivers and streams to not less that twice the average levels present from 1967 to 1991.

The U.S. Fish and Wildlife Service (USFWS) and the Bureau of Reclamation (Reclamation) are implementing the CVPIA, which provides for restoring habitats and species and eliminating many stressors. Key elements of the CVPIA program include the Anadromous Fish Restoration Program (USFWS 1995) and the Anadromous Fish Screening Program. Other elements are directed at spawning gravel replenishment on the Sacramento River below Keswick Dam, water acquisition, and other measures that will contribute to health of the Cottonwood Creek, Sacramento River and Sacramento-San Joaquin Delta Ecological Management Zones.

SALMON, STEELHEAD TROUT AND ANADROMOUS FISHERIES PROGRAM ACT

Established in 1988 by Senate Bill 2261, this Act directs the California Department of Fish and Game (DFG) to implement measures to double the numbers of salmon and steelhead present in the Central Valley (DFG 1993, 1996). The DFG's salmon and steelhead restoration program includes cooperative efforts with local governments and private landowners to identify problem areas and to assist in obtaining funding for feasibility studies, environmental permitting, and project construction.

CALFED BAY-DELTA PROGRAM

CALFED has funded two ecosystem restoration projects in Cottonwood Creek. One project funded the formation of a watershed group and another funded restoration of the creek channel.

LINKAGE TO OTHER ECOLOGICAL MANAGEMENT ZONES

Cottonwood Creek can support larger populations of fall-, late-fall-, and spring-run chinook salmon and steelhead trout, but there are many stressors outside the Cottonwood Creek Ecological Management Zone that impair or reduce the survival of adult and juvenile chinook and steelhead. Restoration efforts in the Sacramento River, Sacramento-San Joaquin Delta, and Suisun Marsh/San Francisco Bay Ecological Management Zones will all contribute to improved returns of adult fish.

In addition, the gravel recruitment, cleansing, and transport functions of Cottonwood Creek are critical to maintaining the long-term ecological health of the Sacramento River Ecological Management Zone and the fish, wildlife, and plant resources that it supports.

RESTORATION TARGETS AND PROGRAMMATIC ACTIONS

ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOWS

TARGET 1: During summer and fall, more closely emulate the seasonal streamflow pattern, so that flows are sufficient for chinook salmon holding and spawning in most year types by providing up to 20 to 50 cfs. These flows can mobilize and transport sediments, allow upstream and downstream fish passage, create point bars, and contribute to stream channel meander and riparian vegetation succession (◆).

PROGRAMMATIC ACTION 1A: Augment summer and fall flow in Cottonwood Creek by purchasing water from willing sellers and developing alternative supplies.

RATIONALE: *The streams in the Cottonwood Creek Ecological Management Zone provide extremely valuable habitat for spring-run chinook salmon and steelhead trout and for fall-run chinook salmon in some years. One of the key attributes of streamflow in this Ecological Management Zone is to provide for successful upstream passage of adult fish and fish spawning. In some years, flows are insufficient to provide fish passage or recede too quickly after fish spawn and expose or dewater redds containing incubating eggs or sac fry. In addition, flow in Cottonwood Creek is the power that drives many ecological functions and processes linked to stream channel morphology, sediment transport and gravel recruitment, riparian communities, and fish habitat.*

Instream flow needs on Cottonwood Creek should be subject to focused research to determine if the proposed flow increase of 20 to 50 cfs is appropriate.

COARSE SEDIMENT SUPPLY

TARGET 1: Maintain existing levels of erosion and gravel recruitment in streams in the Cottonwood Creek Ecological Management Zone, and provide for increasing the transport of these sediments to the Sacramento River by an average of 30,000 to 40,000 tons per year (◆◆◆).

PROGRAMMATIC ACTION 1A: Cooperatively develop and implement a gravel management program for Cottonwood Creek. The program would protect and maintain important ecological processes and functions related to sediment supply, gravel recruitment, and gravel cleansing and transport. This would involve working with state and local agencies and gravel operators to protect spawning gravel and enhance recruitment of spawning gravel to the Sacramento River in the valley sections of Cottonwood Creek.

PROGRAMMATIC ACTION 1B: Cooperate with the aggregate resource industry to relocate existing gravel operations on Cottonwood Creek to areas outside of the active stream channel.

TARGET 2: Repair and rehabilitate spawning gravels in 10 to 20 miles of the lower South Fork and mainstem of Cottonwood Creek (◆◆◆).

PROGRAMMATIC ACTION 2A: In the short term, develop a cooperative program to rip and clean or reconstruct important salmon spawning riffles on the South Fork Cottonwood Creek and on lower Cottonwood Creek below the South Fork.

RATIONALE: *Gravel deposits in the lower South Fork and in the mainstem below the South Fork are essential to maintaining spawning and rearing habitats* *of spring-run and fall-run chinook salmon, steelhead trout, and other native fishes. Historically, Cottonwood Creek was one of the most important sources of gravel to the Sacramento River. Since Shasta Dam was completed in the 1940s, Cottonwood Creek has become the single largest contributor of coarse sediments. Improving and maintaining sediment sources and transport capabilities of this stream are essential components necessary to restore and maintain the ecological health of the Sacramento River.*

Gravel transport is the process whereby flows carry away finer sediments that fill gravel interstices (i.e., spaces between cobbles). Gravel cleansing is the process whereby flows transport, grade, and scour gravel. Gravel transport and cleansing by flushing most of the fines and the movement of bedload (the load of material carried downstream in the streambed by flow) are important to maintaining the amount and distribution of spawning habitat in the Cottonwood Creek basin. Although these processes have been greatly reduced or altered as a result of human activities, they can be restored and maintained by changing water flow and sediment supplies, removing stressors, or directly manipulating channel features and stream vegetation. Gravel deposits in the lower South Fork and in the mainstem below the South Fork have been adversely affected by sedimentation from upstream sources in the watershed. Mechanical means will be used infrequently to free excessive quantities of fine sediments from the gravel substrates until upstream sources of sediment have been reduced or eliminated through watershed management and restoration.

STREAM MEANDER

TARGET 1: Preserve or restore the 50- to 100-year floodplain and existing channel meander characteristics of streams in the Cottonwood Creek Ecological Management Zone, particularly in low-gradient areas throughout the lower 20 miles where most deposition occurs and where stream channel meander is most pronounced (◆◆).

PROGRAMMATIC ACTION 1A: Cooperatively evaluate reestablishing the floodplain along the lower reach of Cottonwood Creek, and evaluate constructing setback levees to reactivate channel meander in areas presently confined by levees.

PROGRAMMATIC ACTION 1B: In the short term, develop a cooperative program to mechanically create a more defined stream channel in lower Cottonwood Creek. This would facilitate fish passage by minimizing water infiltration through the streambed and maintaining flow connectivity with the Sacramento River until natural meander returns.

RATIONALE: *Stream meander belts are the area in which natural bank erosion and floodplain and sediment bar accretions occur along stream courses. Natural stream meander in Cottonwood Creek functions dynamically to transport and deposit sediments and provide transient habitats important to algae, aquatic invertebrates, and fish. Meander also creates surfaces that are colonized by natural vegetation that support wildlife. Cottonwood Creek is a nondammed tributary and a significant source of sediment to the Sacramento River. To maintain the creek's natural stream channel and fluvial dynamic processes and to provide long-term resilience for its watershed and stream channel processes in the Sacramento River, Cottonwood Creek should be fully restored and protected.*

NATURAL FLOODPLAINS AND FLOOD PROCESSES

TARGET 1: Develop a cooperative program to identify opportunities to allow Cottonwood Creek seasonally to inundate its floodplain (◆◆).

PROGRAMMATIC ACTION 1A: Conduct a feasibility study to determine means by which to increase floodplain interactions on lower Cottonwood Creek.

PROGRAMMATIC ACTION 1B: Minimize adverse effects of permanent structures such as bridges on floodplain processes.

RATIONALE: *Natural functioning floodplain processes on Cottonwood Creek are equally important with stream meander and natural sediment supply. A conceptual model of these interactions needs to be developed further to understand the dynamic structure of Cottonwood Creek and to allow the design and implementation of future actions to protect and restore these important ecological functions.*

HABITATS

RIPARIAN AND RIVERINE AQUATIC HABITATS

TARGET 1: Develop a cooperative program to establish a continuous 130-mile riparian habitat zone along upper and lower Cottonwood Creek and its tributaries through conservation easements, fee acquisition, or voluntary landowner measures (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to establish, restore, and maintain riparian habitat on Cottonwood Creek through conservation easements, fee acquisition, or voluntary landowner cooperation.

PROGRAMMATIC ACTION 1B: Encourage the development of long-term measures in the comprehensive watershed management plan to improve water temperatures further. Develop a cooperative approach with counties and local agencies to implement land use management to protect riparian vegetation along the streams. Develop programs to restore lost riparian vegetation.

PROGRAMMATIC ACTION 1C: Cooperatively negotiate long-term agreements with local landowners to maintain and restore riparian communities along the lower reaches of Cottonwood Creek.

RATIONALE: *Many species of wildlife in the Cottonwood Creek watershed depend on or are closely associated with riparian habitats. Of all the habitat types in California, riparian habitats support the greatest diversity of wildlife species. Degradation and loss of riparian habitat have substantially reduced the habitat area available for associated wildlife species. Loss of this habitat has reduced water storage, nutrient cycling, and foodweb support functions.*

FRESHWATER FISH HABITAT AND ESSENTIAL FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination (◆◆).

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for Cottonwood Creek ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitats. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of Cottonwood Creek and its floodplain, and in maintaining and restoring riparian and riverine aquatic habitats.*

REDUCING OR ELIMINATING STRESSORS

DAMS AND OTHER STRUCTURES

TARGET 1: Facilitate passage of steelhead and spring-run chinook salmon to the holding, spawning, and rearing habitat in the higher elevation reaches and tributaries (◆◆).

PROGRAMMATIC ACTION 1A: Begin an evaluation of structures (such as culverts, bridge abutments, grade control structures, etc.) that may be impeding or hindering migration to the high quality upstream habitat and implement measures to facilitate upstream passage.

RATIONALE: *Because Cottonwood Creek and its tributaries have no major dams, this system represents one of the best opportunities to restore steelhead and spring-run chinook salmon to the mid- to high-elevation habitats on which they depend. However, even in the absence of large impassable dams, migration of adults can be impaired by smaller structures, such as culverts and road grade control structures, that may not be complete barriers to migration but can hinder migration at low flows. Also, the cumulative effect of numerous structures can cause significant delays in migration, which can reduce survival. Restoring viable populations of steelhead and spring-run chinook to this system would contribute significantly to the over-all recovery of these fish in the Central Valley.*

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◆ Colusa Basin Ecological Management Zone

Introduction

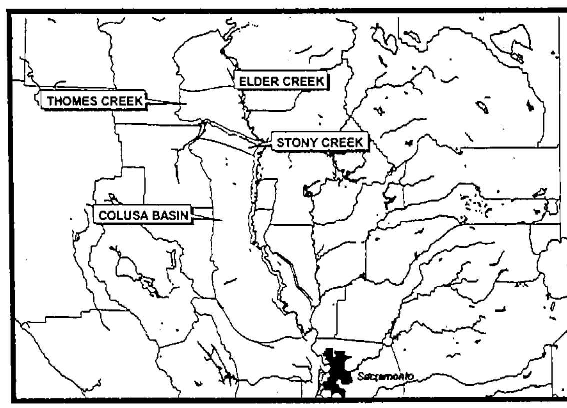
The long-term ecological health of the Delta depends on the health of its component parts. The Colusa Basin Ecological Management Zone contribution to the health of the Sacramento-San Joaquin Delta and Sacramento River Ecological Management Zones will increase after its ecological processes, habitats, and ability to support sustainable fish, wildlife, and plant communities are improved. The Colusa Basin Ecological Management Zone supports the Bay-Delta by contributing flow and sediment, and by providing riparian and riverine aquatic and wetland habitat that supports a wide variety of wildlife.

The streams in this Ecological Management Zone provide seasonally important rearing habitat for many fish species found in the Sacramento River.

The Colusa Basin Ecological Management Zone is one of the primary waterfowl and wetland migratory birds migration and wintering areas of the Pacific Flyway. The Zone contains three National Wildlife Refuges and some critical privately owned wetlands in the Sacramento Valley. The Colusa Basin Drainage area contains vital waterfowl and wetland habitats, contributes to the filtering of agricultural return flow, and has potential for riparian restoration. The wetlands along the drain provide important habitat for endangered and threatened species. The Colusa National Wildlife Refuge has some of the highest concentrations of giant garter snake in the Central Valley.

Description of the Management Zone

The Colusa Basin Ecological Management Zone is an extensive hydrologic and geographic area west of the Sacramento River between Cottonwood Creek to the north and Cache Creek to the south. This zone is divided into the Stony Creek, Elder Creek, Thomes Creek, and Colusa Basin Ecological Management Units.



Location Map of the Colusa Basin Ecological Management Zone and Units.

Protecting and improving important ecological processes and functions will help to maintain important attributes of the Colusa Basin Ecological Management Zone, and preserve its ability to serve as a source of sediment and nutrients to the Sacramento River Ecological Management Zone.

Important ecological processes needed to provide a healthy ecosystem in the Colusa Basin Ecological Management Zone and contribute to the health of the Sacramento River are the streamflow patterns of the basin and natural sediment supply.

The three largest tributary streams in this zone (Stony, Elder, and Thomes creeks) all discharge into the Sacramento River. The Colusa Basin maintains some of its historic capacity to retain and detain floodwater. It captures the seasonal inflow from small westside tributaries that flow into it.

The soils underlying the Stony, Elder, and Thomes Creek watersheds are important sediment sources to the Sacramento River.

The Colusa Basin is a particularly important area for waterfowl and shorebirds and can provide a substantial amount of seasonally flooded wintering habitat.

List of Species to Benefit from Restoration Actions in the Colusa Basin Ecological Management Zone

- lamprey
- giant garter snake
- native anuran amphibians
- native resident fishes
- neotropical migratory birds
- waterfowl
- plants and plant communities.

Descriptions of Ecological Management Units

Stony Creek Ecological Management Unit

Stony Creek is a westside stream originating in the Coast Ranges and draining into the Sacramento River south of Hamilton City. Three storage reservoirs are located in the watershed. The primary focus area on Stony Creek is the stream reach below Black Butte Dam. This includes Stony Creek from Black Butte Dam to Interstate Highway 5 (I-5), I-5 to Highway 45, and Highway 45 to the confluence with the Sacramento River.

Stony Creek has a seasonal run off pattern of high winter and very low summer and fall flows, typical of western Sacramento Valley foothill streams. Unimpaired summer and early fall flows are 0 cubic feet per second (cfs) for 8-9 months, except in high rainfall years.

Summer and fall flows are higher than unimpaired flows as water is delivered below Black Butte Dam for agricultural use. These flows generally exceed 100 cfs in summer except in the driest years, when flows of only 10 to 30 cfs are released. Fall flows are generally less than 100 cfs except in the wettest years. Essentially no surface flows reach the Sacramento River during the summer and fall.

Water is diverted from several locations along the Stony Creek system below Black Butte Dam. About 150 cfs is diverted for irrigation from Black Butte Reservoir into the North Diversion Canal. Additional water is diverted at the South Diversion Canal, into the Tehama-Colusa Canal (TCC) east of Orland, and into the Glenn-Colusa Canal before the creek enters the Sacramento River.

Historically, riparian vegetation along Stony Creek below the site of Black Butte Dam was virtually non-existent.

A recent soil and mineral classification study by Glenn County indicates that Black Butte Reservoir has captured about 41 million cubic yards of sediment (Glenn County 1996).

Elder Creek Ecological Management Unit

Elder Creek is a westside tributary that enters the Sacramento River 12 miles south of Red Bluff. It flows into the Sacramento Valley from the west, draining a watershed of approximately 142 square miles. The watershed contains mostly shale, mudstone, and fine sedimentary deposits that produce minimal amounts of gravel, most of which is deposited where the stream enters the valley. No large gravel deposits are present in the lower stream reaches. An flood-control levee system in the lower section has directed and concentrated flows, increasing sediment transport and degradation throughout the reach.

Several small water diversions, but no large dams, have been constructed on Elder Creek. The flow is generally intermittent, with a widely fluctuating flow regime. Flow records indicate peak flows of more than 11,000 cfs, but the stream is normally dry from July to November.

Elder Creek has a natural flow pattern of moderate winter and spring flows and very low summer and fall flows, typical of streams in the western Sacramento Valley foothills. Summer and early fall flows are near 0 cfs, except in the highest rainfall years. In the wettest years, winter flows average 600 to 1,600 cfs. In the driest years, average monthly winter flows are only 5 to 20 cfs.

The stream reach from Rancho Tehama to the mouth is a low-gradient, braided channel. Approximately 20 miles upstream of the valley floor, the stream gradient increases rapidly in a rugged canyon area that supports resident fish, but probably has limited value for steelhead.

Thomes Creek Ecological Management Unit

Thomes Creek is the largest gravel source in Tehama County. The stream has a watershed area of about 300 square miles. Thomes Creek enters the Sacramento River 4 miles north of Corning. No large dams have been constructed on the stream. The stream is usually dry or flowing intermittently below the U.S. Geological Survey (USGS) stream gage near Paskenta until the first heavy fall rains.

Thomes Creek has an unimpaired natural pattern of flashy winter and spring flows and very low summer and fall flows, typical of streams in the western Sacramento Valley foothills. The short-duration, high volume flows may impair riparian revegetation. Summer and early fall flows are near 0 cfs, except in the wettest years. Precipitation is seasonal, with more than 80 percent in December, January, and February. Precipitation in the drainage varies with elevation. The average annual rainfall is 15 to 45 inches

The lower reach of Thomes Creek has been significantly altered by the construction of flood-control levees and bank protection projects.

The lower Thomes Creek reaches contain large amounts of sediment and gravel. Thomes Creek has at least three year-round gravel mining operations and several seasonal ones. These gravel mining operations are conducted in compliance with the county gravel resource plan and permitted under terms of the Department of Fish and Game.

Thomes Creek is one of the most intact tributaries on the west side of the Sacramento Valley. Thomes Creek provides important spawning habitat for native Central Valley fish, such as Sacramento sucker, and Sacramento pikeminnow (squawfish). These native species may be a reason why the area is used by wintering bald eagles. Some experts believe that Thomes Creek ranks second in importance, behind Cottonwood Creek, in terms of conservation priorities on the west side of the valley. Thomes Creek is in remarkably good condition in the upper watershed and has a well-developed riparian forest along much of its upper reach.

Colusa Basin Ecological Management Unit

The Colusa Basin drainage area extends from the Coast Ranges on the west to the Sacramento River on the east. It received flow and sediment from small streams located between Stony Creek on the north and Cache Creek on the south. The drainage encompasses approximately 1,500 square miles in Glenn, Colusa, and Yolo counties; 570 square miles of this area consist of the respective watersheds of the westside tributaries, with the rest located in the relatively flat valley bottom. Numerous small streams, including forks and branches, constitute the watershed, about 11 of which flow directly into the Colusa Basin Drain. Access to the upper portions of most smaller westside tributary streams is blocked where the GCID canal intersects the streams.

The main conveyance system in the Colusa Basin is known as the Colusa Trough, the Reclamation District 2047 Drain, the Colusa Basin Drainage Canal, or, more commonly, the Colusa Basin Drain. Flows in the basin generally discharge into the Sacramento River heading southeast through various sloughs. Reclamation efforts that began in the 1850s have converted wetlands and sloughs into agricultural areas.

Agricultural drainwater from the basin also enters the Sacramento River near Knights Landing through the Knights Landing Ridge Cut. In past years, this return water contributed to elevated water temperatures in the lower Sacramento River below the town. Water temperatures during May and June often exceeded 70°F, which is detrimental to juvenile chinook salmon. Recent improvements in agricultural and water management practices, reduced flow volume and reduced temperature and chemical loading, have diminished the problems formerly related to drainwater.

The Colusa Basin Ecological Management Unit provides important seasonal and permanent habitats for many species of migratory waterfowl and shorebirds, and the federally listed giant garter snake.

Vision For The Ecological Management Zone

The vision for the Colusa Basin Ecological Management Zone is to maintain or rehabilitate important fishery, wildlife, and plant communities and ecological processes and functions that contribute to the health of the Delta. Attaining this vision will involve restoring or reactivating important ecological processes and functions that create and maintain habitats for fish, wildlife, and plant communities throughout the Ecological Management Zone and its component Ecological Management Units.

This vision focuses on restoring ecological processes and functions related to sediment transport and restoring seasonally flooded aquatic habitats that provide important wintering areas for waterfowl and shorebird guilds, and in providing wetland habitats that will contribute to the recovery of the giant garter snake. The vision also included a large cooperative program with landowners to improve the wildlife benefits related to agricultural practices in the area. In addition, it emphasizes maintenance or improvements to the ecological processes and improvements to fish habitats. Visions for these ecosystem elements follow.

VISIONS FOR ECOLOGICAL MANAGEMENT UNITS

STONY CREEK ECOLOGICAL MANAGEMENT UNIT

Many native fish species use the lowermost reach of Stony Creek, below Highway 45, at its confluence with the Sacramento River for rearing from fall through early summer when water is suitably cool. The vision is to maintain and improve valuable aquatic and terrestrial habitat types by restoring upstream areas to improve system integrity and increase habitat complexity at the confluence.

ELDER CREEK ECOLOGICAL MANAGEMENT UNIT

The vision for the Elder Creek Ecological Management Unit is to restore degraded habitat, the sediment balance (to reduce the quantity of fine sediments in the gravel substrate), and a more natural stream channel and riparian habitat in the lower section.

Because of levees and other structures, Elder Creek transports sediment through the lower sections instead of allowing deposition.

Elder Creek's lower reach and its confluence with the Sacramento River may occasionally provide an important seasonal, and sometimes extended, rearing habitat for juvenile anadromous and resident fish. Maintaining and improving the ecological processes related to streamflow; sediment supply; a and transport will also provide a clearly defined stream channel and riparian zone.

THOMES CREEK ECOLOGICAL MANAGEMENT UNIT

The vision for the Thomes Creek Ecological Management Unit is establishing a clearly defined stream channel consistent with flood control needs, effectively enhancing sediment transport in the lower stream reach, and improving sediment delivery to the Sacramento River.

COLUSA BASIN ECOLOGICAL MANAGEMENT UNIT

The vision for the Colusa Basin Drain Ecological Management Unit is to remedy ecological problems related to the Colusa Basin Drain and the mainstem Sacramento River and to maintain and improve the area's value in providing seasonally flooded wetland habitat.

The Colusa Basin Drain is sometimes a significant source of warmwater inflow to the Sacramento River, but is probably not a significant problem during May and June. In general, rice floodup and maintenance precludes significant drainwater during this period. There may be thermal impacts resulting from rice field dewatering prior to harvest in late August and September. The drain may also draw chinook salmon from their natural migratory corridor, resulting in their loss to the spawning population.

VISIONS FOR ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOW: The vision is that streamflows would be maintained to support many ecological processes and functions essential to the health of individual streams in the Colusa Basin Ecological Management Zone and contribute to the health of the mainstem Sacramento River.

COARSE SEDIMENT SUPPLY: The vision for sediment supply in streams of the Colusa Basin Ecological Management Zone is that natural stream sediments will contribute to stream channel formation and provide for native resident fish spawning and invertebrate production.

NATURAL FLOODPLAIN AND FLOOD PROCESSES: The Colusa Basin is one of the Sacramento Valley's natural overflow basins. The vision is to maintain the system's flood capacity, introduce nutrients to the system, and support natural regeneration and succession of riparian and riverine plant communities.

VISION FOR HABITATS

SEASONAL WETLAND HABITAT: The vision is that increased seasonal flooding of leveed lands, use of the Colusa Basin's natural flood detention capacity, protection and enhancement of existing wetlands, and development of cooperative programs with local landowners will contribute to increased habitats for waterfowl and other wetland dependent fish and wildlife resources such as shorebird, wading birds, and the giant garter snake.

RIPARIAN AND RIVERINE AQUATIC HABITAT: The vision is to maintain existing riparian and shaded riverine aquatic habitats and to restore these habitats where feasible that support terrestrial and aquatic species. Throughout much of this zone, riparian protection and restoration will be in conjunction with flood control and levee maintenance practices.

FRESH EMERGENT WETLAND HABITAT: The vision is to maintain and enhance existing permanent marshes in the Colusa Basin Ecological Management Zone.

FRESHWATER FISH HABITAT: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native and anadromous fish species. The lower sections of these creeks are typical of fall chinook salmon spawning streams (Moyle and Ellison 1991). The quality of freshwater fish habitat in these creeks will be maintained through actions directed at streamflows, coarse sediment supply, stream meander, natural floodplain and flood processes, and maintaining and restoring riparian and riverine aquatic habitats.

ESSENTIAL FISH HABITAT: The streams in the Colusa Basin Ecological Management Zone have been tentatively identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). Key features of EFH to maintain or restore in these creeks include substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

AGRICULTURAL LANDS: Improving habitats on and adjacent to agricultural lands in the Colusa Basin Ecological Management Zone will benefit native waterfowl and wildlife species. Emphasizing certain agricultural practices (e.g., winter flooding and harvesting methods that leave some grain in the fields) will also benefit many wildlife that seasonally use these important habitats.

VISIONS FOR REDUCING OR ELIMINATING STRESSORS

CONTAMINANTS: Pesticides and herbicides are applied extensively in this Ecological Management Zone and may adversely affect aquatic organisms. The vision is that contaminant input levels to the system will not impair restoration or maintenance of healthy fish, wildlife, and plant communities.

VISIONS FOR SPECIES

GIANT GARTER SNAKE: The vision for the giant garter snake is to contribute to the recovery of this State and federally listed threatened species in order to contribute to the overall species richness and diversity. Achieving this vision will reduce the conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. Protecting existing and restoring additional suitable wetland and upland habitats will be critical to achieving recovery of the giant garter snake. The proposed restoration of aquatic, wetland, riparian, and upland habitats in the Colusa Basin Ecological Management Zone will help in the recovery of these species by increasing habitat quality and area.

WATERFOWL: The vision for waterfowl is to maintain and restore healthy populations at levels that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses consistent with the goals and objectives of the Central Valley Habitat Joint Venture and North American Waterfowl Management Plan. Many species of resident and migratory waterfowl will benefit from improved aquatic, wetland, riparian, and agricultural habitats. Increase use of the Colusa Basin Ecological Management Zone and possibly increases in some populations would be expected.

PLANT SPECIES AND COMMUNITIES: The vision for plan species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland and riparian and riverine aquatic habitats.

Note on Chinook Salmon in the Colusa Basin Ecological Management Zone

Chinook salmon are not included in the vision for this Ecological Management Zone. Historically, Thomes, Elder, and Stony creeks sporadically supported spawning chinook salmon when rainfall and streamflow patterns allowed upstream migration. Under ideal flow conditions, these streams can still support fall-run chinook. These three creeks have been identified as "Essential Fish Habitat" by the National Marine Fisheries Service. In response to this, CALFED has reevaluated its approach and recommended actions and decided the proposed actions are appropriate for this Zone at this time.

The approach presented includes efforts to resolve uncertainties and problems arising from the ecological dysfunction of streamflow, coarse sediments, and floodplains. These processes need to be improved prior to developing or recommending actions to restore fall-run chinook salmon, which at this time is not warranted.

Future actions directed at fall-run chinook salmon, if appropriate, will depend on how well the system functions after issues related to streamflow and sediment transport and supply are reviewed and remedial projects are successfully implemented.

The role or value of fall-run chinook salmon in this Zone is uncertain at this time, and future recommendations will be based on credible science and projects implemented as adaptive interventions or experiments.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

The vision for the Colusa Basin Ecological Management Zone can be achieved by primarily relying on local resource conservation districts, landowner associations, watershed associations, watershed conservancies, water districts, and local landowners. In addition, the expertise of state, federal and local agencies can be used where appropriate to improve or assist in local planning efforts. Local groups presently include the Stony Creek Business and Landowners Coalition, the Thomes Creek Watershed Association, Tehama Colusa Canal Authority, and the Orland Unit Water Users Association. Key agencies in this effort are DFG, USFWS, the U.S. Natural Resources Conservation Service (NRCS), Reclamation, and local government agencies. The Colusa Basin Drainage District will play an important part in designing restoration efforts in the Colusa Basin Ecological Management Unit. The District recently completed major elements of a Basin Integrated Resource Management Plan and Watershed Priority Ranking Assessment Study. This planning process brought together representatives from agricultural, environmental, urban, and rural groups to identify, discuss, and resolve issues in a way that benefits all parties. In addition, local landowners, stakeholders, and private organizations will be important to restoration program success.

CENTRAL VALLEY HABITAT JOINT VENTURE

The Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan have developed objectives for wetlands in the Colusa Basin Ecological Management Zone. These objectives are consistent with the ERPP targets developed for this Ecological Management Zone.

CENTRAL VALLEY PROJECT IMPROVEMENT ACT

In addition to many provisions for the restoration of anadromous fish in the Central Valley, the Central Valley Project Improvement Act contains provisions related to "other" programs to protect, restore, and mitigate for past fish and wildlife impacts of the Central Valley Project including threatened and endangered plants and animals.

CALFED Bay-Delta Program

CALFED has funded one ecosystem restoration projects in Colusa Basin. This project reduces sediment inflow to Sand and Salt creeks.

Linkage to Other Ecological Management Zones

The Colusa Basin Ecological Management Zone is closely linked to the Sacramento River Ecological Management Zone and has a high degree of connectivity through the confluences of Stony, Elder, and Thomes Creeks. The Colusa Basin is directly linked to the Sacramento River through the Colusa Basin Drain. This Ecological Management Zone provides important habitats for a variety of migratory species including anadromous fish, waterfowl, and other species dependent on wetland and riparian habitats.

Restoration Targets and Programmatic Actions

Ecological Processes

Central Valley Streamflows

Target 1: Maintain the existing seasonal runoff patterns that mobilize and transport sediments, allow upstream and downstream resident fish passage, and contribute to riparian vegetation succession. (◆).

Programmatic Action 1A: Develop locally initiated programs to restore upper watershed health and functions.

Programmatic Action 1B: Reduce excessive fire fuel loads in the upper watersheds.

Programmatic Action 1C: Improve forestry management practices related to timber harvesting, road building and maintenance, and livestock grazing.

Programmatic Action 1D: Develop a watershed management plan for Thomes Creek.

Programmatic Action 1E: Develop a watershed management plan for Elder Creek.

Programmatic Action 1F: Develop a watershed management plan for Stony Creek.

Rationale: *Colusa Basin Ecological Management Zone streams provide several features that are important within the Ecological Management Zone and for adjacent zones. Major ecological processes and functions that are driven by flow include gravel recruitment, transport, deposition, and cleansing. Stony, Thomes, and Elder creeks can provide sediment for transport to the Sacramento River and habitat in the Sacramento River for chinook salmon and other aquatic species. Maintaining and improving the ecological health of streams in the Colusa Basin Ecological Management Zone will require maintaining existing runoff patterns and eliminating other stressors such as invasive exotic plants (Arundo and tamarisk) that constrain ecological processes. In addition, improvements in watershed health will contribute to maintaining seasonal runoff patterns, water yield, and water quality and reduce sediment loading to downstream storage reservoirs.*

Coarse Sediment Supply

Target 1: Maintain the sediment available for transport during storms and seasonal flow events in Thomes Creek (◆◆).

Programmatic Action 1A: Maintain sediment transport in Thomes Creek by continuing to monitor aggregate extraction activities to ensure sediment is available for delivery to the Sacramento River.

Target 2: Maintain the quantity of sediment transported from Elder Creek to the Sacramento River (◆◆).

Programmatic Action 2A: Maintain sediment transport in Elder Creek by continuing to monitor aggregate extraction activities to ensure sediment is available for delivery to the Sacramento River

Rationale: *Sand and gravel extraction activities on the streams in the Colusa Basin Ecological Management Zone are conducted in compliance with local and state regulations. The tributaries are important sediment sources for the Sacramento River. Sediments contribute to several important ecological functions and are required for specific habitats, particularly chinook salmon and steelhead habitats. Black Butte Dam on Stony Creek has eliminated natural gravel recruitment to the lower stream reach. The feasibility of protecting Stony Creek, its stream* *and riparian corridor, and its contribution of sediment to the Sacramento River should be evaluated.*

NATURAL FLOODPLAIN AND FLOOD PROCESSES

TARGET 1: Establish a desirable sediment deposition level in the Colusa Basin (◆).

PROGRAMMATIC ACTION 1A: Improve the Colusa Basin sediment deposition capacity by working with local landowners to develop an integrated plan consistent with flood-control requirements.

RATIONALE: *Floodplain processes include the natural floodwater and sediment detention and retention process whereby flows and sediment are retained within the floodplains. Retaining and detaining water and sediment in basin floodplains are controlled primarily by flow patterns and channel geomorphology, and secondarily by soils and plant communities.*

HABITATS

SEASONAL WETLANDS

TARGET 1: Protect and manage 2,000 acres of existing seasonal wetland habitat consistent with the goals of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan (◆◆).

PROGRAMMATIC ACTION 1A: Develop and implement a cooperative program to improve management of 2,000 acres of existing, degraded seasonal wetland habitat.

TARGET 2: Develop and implement a cooperative program to enhance 26,435 acres of existing public and private seasonal wetland habitat consistent with the goals of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan (◆◆).

PROGRAMMATIC ACTION 2A: Restore and manage seasonal wetland habitat throughout the Ecological Management Zone.

RATIONALE: *Restoring seasonal wetland habitats along with aquatic, permanent wetland, and riparian habitats is an essential element of the restoration strategy for the Colusa Basin Ecological Management Zone. Restoring these habitats will also reduce the amount and concentrations of contaminants that could interfere with restoring the ecological health of the aquatic ecosystem. Seasonal wetlands support a high production rate of primary and secondary food species and large blooms (dense populations) of aquatic invertebrates.*

Wetlands that are dry in summer are also efficient sinks for the transformation of nutrients and the breakdown of pesticides and other contaminants. The roughness of seasonal wetland vegetation filters and traps sediment and organic particulates. Water flowing out from seasonal wetlands is typically high in foodweb prey species concentrations and fine particulate organic matter that feed many Delta aquatic and semiaquatic fish and wildlife. To capitalize on these functions, most of the seasonal wetlands of the Colusa Basin Ecological Management Zone should be subject to periodic flooding and overland flow from river floodplains.

RIPARIAN AND SHADED RIVERINE AQUATIC HABITATS

TARGET 1: Protect and maintain riparian vegetation along Stony Creek, Elder Creek, Thomes Creek, and the Colusa Basin Ecological Management Unit channels and sloughs where possible. This will provide cover and other essential habitat requirements for native resident fish species and wildlife (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to protect or rehabilitate riparian vegetation, where possible.

RATIONALE: *Healthy riparian corridors along creeks, sloughs, and channels, including those in the Colusa Basin Ecological Management Unit, provide essential cover, shade, and food for spawning, rearing, and migrating native resident fishes, and a wide variety of wildlife, neotropical birds, and other terrestrial species.*

FRESHWATER FISH HABITAT AND ESSENTIAL FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination (◆◆).

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitat and essential fish habitat. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of Stony, Elder, and Thomes creeks and their floodplains, and in maintaining and restoring riparian and riverine aquatic habitats.*

AGRICULTURAL LANDS

TARGET 1: Cooperatively manage 111,285 acres of agricultural lands (◆◆).

PROGRAMMATIC ACTION 1A: Increase the area of rice fields and other crop lands flooded in winter and spring to provide high-quality foraging habitat for wintering and migrating waterfowl and shorebirds and associated wildlife.

PROGRAMMATIC ACTION 1B: Convert agricultural lands in the Colusa Basin Ecological Management Zone from crop types of low forage value for wintering waterfowl and other wildlife to crop types of greater forage value.

PROGRAMMATIC ACTION 1C: Defer fall tillage on rice fields in the Colusa Basin Ecological Management Zone ,to increase the forage for wintering waterfowl and associated wildlife.

RATIONALE: *Following the extensive loss of native wetland habitats in the Central Valley, some wetland wildlife species have adapted to the artificial wetlands of some agricultural practices and have become dependent on these wetlands to sustain their populations. Agriculturally created wetlands include rice lands; fields flooded for weed and pest control; stubble management; and tailwater circulation ponds.*

Managing agricultural lands to increase forage for waterfowl and other wildlife will increase the survival rates of overwintering wildlife and strengthen them for migration, thus improving breeding success (Madrone Associates 1980)

Creating small ponds on farms with nearby waterfowl nesting habitat but little brood habitat will increase production of resident waterfowl species when brood ponds are developed and managed properly. Researchers and wetland managers with the DFG, U.S. Fish and Wildlife Service and the California Waterfowl Association have found that well managed brood ponds produce the high levels of invertebrates needed to support brooding waterfowl. Other wildlife such as the giant garter snake will also benefit. Restoring suitable nesting habitat near brood ponds will increase the production of resident waterfowl species.

Restoring nesting habitat, especially when it is near brood ponds, will increase the production of resident waterfowl species. When the restored nesting habitat is properly managed, large, ground predators are less effective in preying on eggs and young of waterfowl and other ground nesting birds. Managing agricultural lands to increase forage for waterfowl and other wildlife will increase the overwinter survival rates of wildlife and strengthen them for migration, thus improving breeding success (Madrone and Assoc. 1980).

REDUCING OR ELIMINATING STRESSORS

CONTAMINANTS

TARGET 1: Reduce the adverse effects of herbicides, pesticides, fumigants, and other agents that are toxic to fish and wildlife in the Colusa Basin Ecological Management Zone (◆).

PROGRAMMATIC ACTION 1A: Work with local agricultural interests and water districts implement and evaluate a contaminant effects study.

RATIONALE: *Contaminants from point and nonpoint sources affect water quality and survival of fish, waterfowl, and the aquatic foodweb. Contaminants may cause severe toxicity and organism mortality or long-term, low-level toxicity that affects species' health and reproductive success.*

INVASIVE RIPARIAN AND MARSH PLANTS

TARGET 1: Eradicate Arundo and tamarisk in watersheds where they have only small population, then concentrate on eradicating satellite populations extending beyond major infestations, and finally, reduce and eventually eliminate the most extensive populations (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative pilot study to control Arundo (false bamboo) and tamarisk (salt cedar) in streams within the Colusa Basin Ecological Management Zone.

RATIONALE: *Invasive riparian and marsh plants have become sufficiently established in some locations to threaten the health of the Bay-Delta ecosystem. The riparian and salt marsh plants that pose the greatest threats to aquatic ecosystems are those that directly or indirectly affect rare native species, decrease foodweb productivity, and reduce populations of desired fish and wildlife species.*

Factors that relate to the degree of influence invasive riparian and salt marsh plants have on the Bay-Delta include additional introductions from gardens and other sources, and ground disturbances and hydrologic regimes that create favorable conditions for their establishment.

The effects of Arundo's ability to alter ecosystem processes may be profound. It is far more susceptible to fire than native riparian species. However, although it recovers from fires, most native vegetation does not, leading to increased postfire dominance by Arundo. By increasing sedimentation after establishing in stream channels, Arundo stabilizes islands, hinders braiding and shifting patterns in stream channel movement, and prevents native stream channel vegetation from establishing. An example of this can be seen at Stony Creek in northern California. Because Arundo has a vertical structure, it does not overhang water like native riparian vegetation. The result is less shade over water, providing less cover, increased water temperatures, and altered water chemistry, all conditions that can harm fish and other existing aquatic organisms and ultimately change the aquatic species composition.

Tamarisk is widespread in California rivers; however, an accurate assessment of the extent and rate of spread of the weed is unknown. Like Arundo, more survey mapping is needed to determine the extent of tamarisk, the levels of threat posed by the weed, the best time to control it safely, and a prioritized strategy for removing it.

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◆ Butte Basin Ecological Management Zone

Introduction

The ecological health of the Bay-Delta depends on ecological processes and functions, habitats, and fish and wildlife species present in Butte Basin Ecological Management Zone streams, wetlands, and floodplains. The status and abundance of spring-run chinook salmon and steelhead trout are important measures of the health, not only of the Sacramento-San Joaquin River Delta, but also of the Butte Basin. The Butte Basin Ecological Zone supports the Delta ecosystem through significant contributions of streamflow, sediments, and other attributes.

The Butte Basin Ecological Management Zone provides habitat for a wide variety of fish, wildlife, and plant communities and habitats. These include spring-run chinook salmon, steelhead trout, resident fish communities, waterfowl, riparian vegetation, and seasonally and permanently flooded wetlands. The Butte Sink contains important refuge areas including Gray Lodge Wildlife Area, Butte Basin Wildlife Area, Butte Sink National Wildlife Refuge, and the Butte Sink Wildlife Management Area.

Important ecological processes and functions in the Butte Basin Ecological Management Zone include the annual streamflow and storm runoff patterns, sediment supply and gravel recruitment, and stream meander in each stream's watershed. These important processes are in a reasonably healthy condition throughout the ecological management zone, but specific improvements are needed in certain watersheds. The greatest need is to maintain processes closely linked to the natural streamflow regime. Continued efforts toward improving low flows and reducing physical barriers to fish migration will improve the overall ecological health of the watersheds in the basin while contributing to species restoration.

Important fish and wildlife resources in the basin include spring-run chinook salmon, fall-run chinook salmon, steelhead trout, resident fish guilds, waterfowl guilds, shorebird and wading bird guilds, and riparian wildlife guilds. Generally, the wildlife populations are healthy. Spring-run chinook and steelhead, however, need to achieve higher sustainable annual population levels before they are considered healthy and no longer a problem in the Delta. Achieving healthy status for these fish populations is also dependent on implementing restoration actions downstream of this ecological management zone.

Photo © California Department of Water Resources

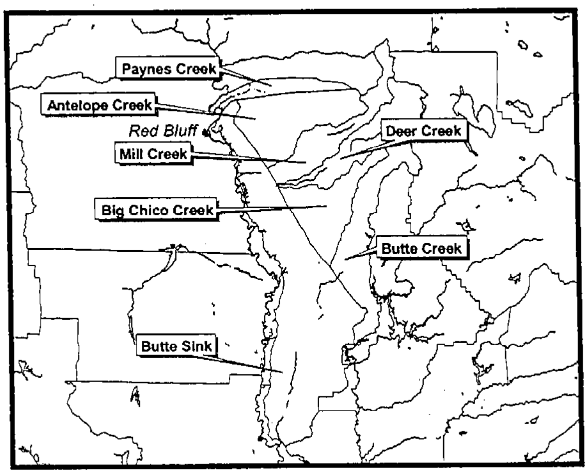
Important habitats in the Butte Basin Ecological Management Zone include anadromous fish migration, holding, spawning, and nursery habitats (freshwater and essential fish habitats), which are needed to maintain spring-run chinook and steelhead and other chinook populations. Seasonally flooded wetlands are prevalent through the lower portions of the basin and are extremely important habitat areas for waterfowl, shorebird, and wading bird guilds. Riparian and riverine aquatic habitat is important to aquatic and terrestrial species. Woody debris, such as tree branches and root wads, provide important cover for young fish. Healthy riparian vegetation provides a migration corridor that connects the mainstem Sacramento River with habitats in the upper watershed. This corridor is used by terrestrial species, such as birds and mammals.

Stressors to ecological processes, habitats, and species in the zone include diversion structures in the streams; unscreened diversions; insufficient flow in the lower portions of most of the streams, which may seasonally inhibit the upstream and downstream migration of anadromous fish; areas of inadequate riparian vegetation and woody debris; and the potential illegal harvest of spring-run chinook salmon that oversummer in isolated pools in many of the streams.

DESCRIPTION OF THE MANAGEMENT ZONE

The Butte Basin Ecological Management Zone encompasses a significant portion of the Sacramento Valley, east of the Sacramento River and north of the Colusa Basin Ecological Management Zone, and includes the following seven ecological units:

- Paynes Creek Ecological Unit,
- Antelope Creek Ecological Unit,
- Mill Creek Ecological Unit,
- Deer Creek Ecological Unit,
- Big Chico Creek Ecological Unit,



Location Map of the Butte Basin Ecological Management Zone and Units

- Butte Creek Ecological Unit, and
- Butte Sink Ecological Unit.

LIST OF SPECIES TO BENEFIT FROM RESTORATION ACTIONS IN THE BUTTE BASIN ECOLOGICAL MANAGEMENT ZONE

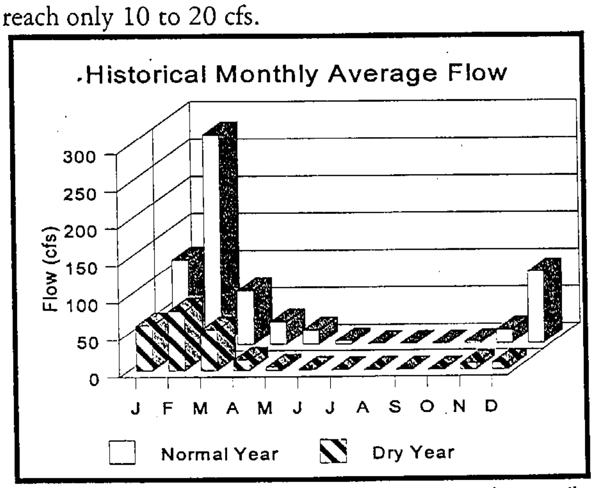
- fall-run chinook salmon
- spring-run chinook salmon
- steelhead trout
- lamprey
- native anuran amphibians
- native resident fishes
- neotropical migratory birds
- giant garter snake
- waterfowl
- plants and plant communities.

DESCRIPTIONS OF ECOLOGICAL MANAGEMENT UNITS

PAYNES CREEK ECOLOGICAL MANAGEMENT UNIT

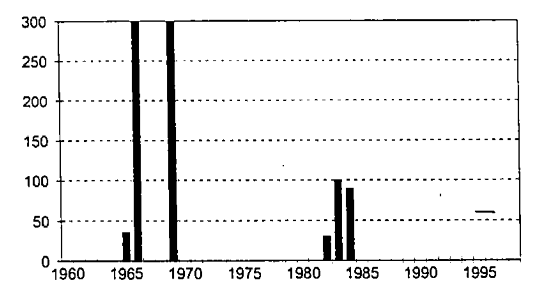
Paynes Creek enters the Sacramento River 5 miles north of Red Bluff. It flows into the Sacramento Valley from the east, draining a watershed of approximately 93 square miles. Paynes Creek originates in a series of small lava springs approximately 6 miles west of the town of Mineral. There are no significant dams on the stream; however, as many as 16 diversions seasonally divert water. Diverted water is used for irrigation, stock watering, and commercial aquaculture. Diversions are confined to the period between late spring and early fall. Significant losses of juveniles can occur in spring if the irrigation season begins when juvenile salmon are attempting to emigrate from the stream into the Sacramento River. Approximately 15 diversions in Paynes Creek need to be screened to protect juvenile fish.

Paynes Creek has a natural flow pattern of high winter and low summer-fall flows, typical of many Sacramento Valley streams that originate in foothills rather than the crests of the Sierra Nevada or Cascade ranges. Low summer and fall flows are further reduced by diversions. The stream is often dry during summer and fall. In wetter years, flows in winter average 200 to 600 cfs. In winter months of dry years, average monthly flows peak at only 50 to 80 cfs. In the driest years, winter monthly average flows reach only 10 to 20 cfs.



Paynes Creek Streamflow, 1956-1966 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Fall-run chinook salmon and steelhead trout use Paynes Creek when streamflow is sufficient to allow upstream passage. Surveys in the 1960s documented an average run size of 143 fall-run salmon; 300 fish was the maximum run observed in a single season. In most years, rainfall provides sufficient flow for the fall-run chinook salmon to move upstream by late fall.



Fall-run Chinook Salmon Returns to Paynes Creek, 1960-1999 (CDFG 1998).

Riparian and riverine aquatic habitat needs to be improved by providing adequate streamflows and by protecting shorelines from livestock. Vegetation planting may be required in certain areas to hasten and sustain a riparian corridor along the stream.

The size of the salmon run in Paynes Creek is closely linked to rainfall. Therefore, actions to restore and improve conditions for chinook salmon and steelhead are more likely to succeed during periods of normal to above normal rainfall. Limiting water diversions during critical migration periods would help to maintain and improve flows. Reduced diversions could be achieved through voluntary restrictions; direct water purchase; or development of alternative sources, such as wells or storage facilities. Adequate flows are needed in Paynes Creek to provide for the fall adult migration, winter season fry rearing, and spring juvenile outmigration in drier years. Minimum flows in upstream summer rearing areas are needed to sustain steelhead.

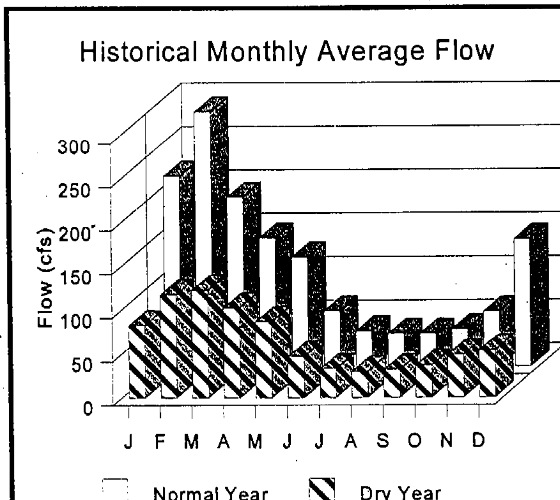
In addition to low flow, inadequate spawning gravel has been identified as a significant factor limiting salmon production. The California Department of Fish and Game (DFG) built five spawning riffles with 1,000 tons of spawning gravel in 1988. Improvement to the sediment supply, including gravel for fish spawning, needs further evaluation.

Restoration and maintenance of Paynes Creek could be improved by establishing a Paynes Creek watershed conservancy. Restoring and maintaining Paynes Creek could be facilitated by developing and implementing a comprehensive watershed management plan.

ANTELOPE CREEK ECOLOGICAL MANAGEMENT UNIT

Antelope Creek flows southwest from the Cascade Range foothills and enters the Sacramento River 9 miles southeast of Red Bluff. The drainage is approximately 123 square miles, and the average stream discharge is 107,200 acre-feet (af) per year. Antelope Creek is relatively unaltered above the valley floor, but the seasonal lack of flow to the Sacramento River reduces the creek's potential to produce anadromous fish.

Antelope Creek has a natural streamflow pattern like other nondammed streams in this ecological management zone. Peak flows occur in winter and spring. Lowest flows occur in summer and fall. In wettest years, average flows in winter months range from 200 to 1,200 cfs. In driest years, flows in winter months average below 50 cfs. In all but the wettest years, summer and early fall flows average from 20 to 50 cfs. The natural flow pattern is altered by diversions in the lower creek from spring through fall.



Antelope Creek Streamflow, 1942-1982 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

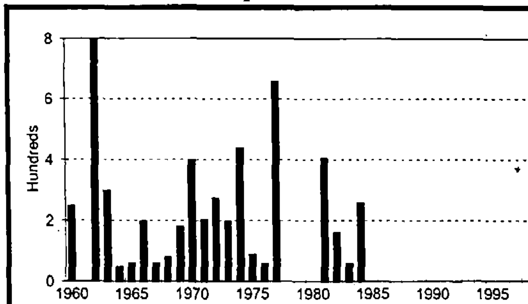
There are two water diversions at the canyon mouth on Antelope Creek. The Edwards Ranch uses water from both diversion points under riparian and pre-

1914 water rights. The Los Molinos Mutual Water Company (LMMWC) shares one diversion with a water right of 70 cfs. Antelope Creek flow is typically diverted from April 1 through October 31. Average flow during this period, measured from 1940 through 1980, was 92 cfs. With water diversion rights exceeding streamflow, the lower reach of the stream is often dry. The seasonal flow needs improvement to permit unobstructed fish passage. To reestablish and increase salmon and steelhead in Antelope Creek, priority must be given to providing and maintaining adequate passage flows from October 1 through June 30 below the Edwards and LMMWC diversion dam. Diversions on Antelope Creek have been screened to protect juvenile salmon and steelhead during their downstream passage.

Migration flows and temperatures adequate to attract salmon must be provided at Antelope Creek's confluence with the Sacramento River. Diversions during the chinook and steelhead migration season should be limited to maintain a flow of at least 25 cfs at the mouth of Antelope Creek. Instream flows should be maintained throughout the irrigation diversion season to provide aquatic habitat and riparian vegetation benefits.

The riparian and riverine aquatic habit along the Antelope Creek corridor needs several improvements. Some areas have been denuded and will require significant revegetation. Woody debris, such as branches and root wads originating from the riparian forest, provides valuable cover for young fish. The riparian zone provides an important migratory corridor for terrestrial species by connecting the mainstem Sacramento River with upper watershed habitats.

Fall- and spring-run chinook salmon and steelhead trout have used Antelope Creek. Population estimates for fall-run salmon on Antelope Creek from 1965 through 1984 ranged from 50 to 4,000, with an average annual run of approximately 467 fish. Historically, an estimated 500 spring-run chinook salmon and approximately 300 steelhead trout annually used Antelope Creek. Since 1986, the California Department of Fish and Game has conducted intensive snorkle surveys on Antelope Creek. Over a period of 12 years, a total of only 19 spring-run chinook salmon have been observed. During 1997, no adult spring-run chinook salmon were observed. This series of observations suggest that Antelope Creek no longer supports a self-sustaining population of chinook salmon. The status of steelhead in Antelope Creek is unknown.



Fall-run Chinook Salmon Returns to Antelope Creek, 1960-1999, (CDFG 1999).

The overall role of Antelope Creek in supporting viable populations of anadromous fish is strongly constrained by flow patterns, flow quantity, high water temperatures, geomorphology of the valley section of the stream, and the steep gradient in the upper reaches.

Insufficient fall flow patterns may delay the upstream migration and spawning of adult fall-run chinook and downstream migration of juvenile spring-run chinook. Likewise, inadequate late spring flows may limit part of the spring-run upstream migration and downstream juvenile fall-run chinook migration. In the lower stream section below the canyon mouth, Antelope Creek is subject to braiding and channel bifurcation, which also impair upstream fish passage.

The Antelope Creek Ecological Unit could be improved by establishing and supporting an Antelope Creek watershed conservancy. Restoring and maintaining Antelope Creek could be improved by developing and implementing a comprehensive watershed management plan. Forest management, including reducing fire fuel loads, would protect riparian habitats and streamflows and help to prevent excessive sediment from being washed into the creek.

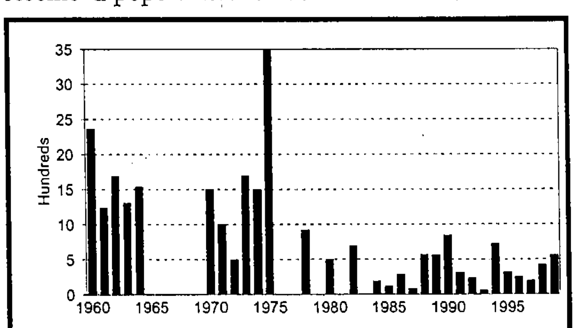
MILL CREEK ECOLOGICAL MANAGEMENT UNIT

Mill Creek is a major tributary of the Sacramento River, flowing from the southern slopes of Mt. Lassen and entering the Sacramento River at river mile (RM) 230, 1 mile north of the town of Tehama. The stream originates at an elevation of approximately 8,500 feet and descends to 200 feet at its confluence with the Sacramento River. The watershed drains 134 square miles, and the stream is approximately 65 miles long. The creek is confined within a steep-sided, relatively inaccessible canyon in the upper watershed. Mill Creek spring-run chinook salmon are unique, because they spawn at altitudes above 5,000 feet—the highest altitudes known for salmon spawning in California. The stream flows through the Ishi Wilderness Area and the Gray Davis Dry Creek Reserve, which is managed by The Nature Conservancy. Two dams on the lower 8 miles of the stream divert most of the natural flow for irrigation purposes, usually from May and until September.

Mill Creek has a somewhat atypical seasonal flow pattern. Flows remain relatively high through spring, even in dry years, because of snowmelt and springs on Mt. Lassen. In wettest years, average monthly flows in winter and spring range from 800 to 1,800 cfs. In driest years, flows range only from 60 to 120 cfs. With no storage reservoirs and minimal diversions on the river, streamflows are near natural and unimpeded, except in the valley lowland reach.

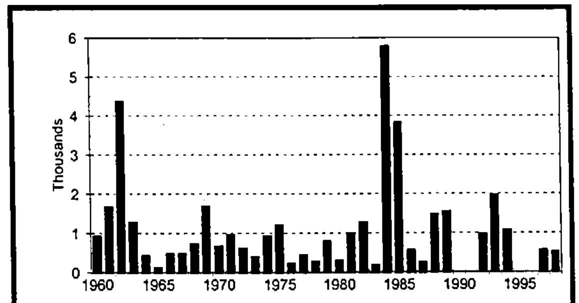
The ecological health of the Mill Creek ecological unit is rated above average due to unimpeded stream flow and the undisturbed quality throughout the holding and spawning habitat of spring-run chinook salmon and steelhead. Populations of spring-run chinook salmon and steelhead have declined sharply in recent years, in large part due to problems outside of the unit.

Spring-run chinook salmon populations in Mill Creek have ranged from a maximum of 3,500 fish to a low of no fish during the severe drought of 1977. During the past decade, annual spring-run chinook populations have averaged 390 fish. More than 2,000 steelhead have been counted at Clough Dam, and steelhead runs averaged 1,100 fish from 1953 to 1965. Anecdotal accounts place the present annual steelhead population at a few hundred fish.



Spring-run Chinook Salmon Returns to Mill Creek, 1960-1999 (CDFG 1999).

Fall-run chinook salmon population estimates have ranged from approximately 6,000 spawners in 1984 to 150 in 1965. The fall run has averaged 2,200 fish for the 38 years of record. Late-fall-run salmon have occasionally been observed spawning in the lower reaches of Mill Creek, but no estimates are available.



Fall-run Chinook Salmon Returns to Mill Creek, 1960-1998 (1999).

Mill Creek differs from other eastside streams because of its high silt load and turbidity during the spring snowmelt period. Recent water quality monitoring for Mill Creek indicates that lands within Lassen Volcanic National Park contribute the major source of silt from the steep barren slopes adjacent to the headwaters. There are insignificant land use activities that occur on the Lassen National Forest lands, however, most of the area is protected by its wilderness designation. The majority of the siltation sources in Mill Creek are the result of natural geologic processes that have existed for thousands of years and are not an impediment to the survival of the endemic anadromous fish populations.

Spawning areas in lower Mill Creek consist primarily of large cobbles and boulders, with very little spawning gravel. Spawning gravel naturally accumulates in the lower reaches of the stream but is flushed from the stream during higher flow events.

Three diversion structures were constructed on Mill Creek in the early 1900s, however, only two are operational. The upper and lower diversions are low structures and have been screened since the 1920s. The Department of Fish and Game has completed several improvements to these structures over the past 50 years including the addition of fish ladders and resloping and refacing the surface of the structures to improve fish passage. These diversion structures are owned and managed by the Los Molinos Mutual Water Company and are regularly inspected by the Department of Fish and Game to insure optimum fish passage conditions.

The middle diversion structure is known as the Clough Diversion which was constructed in the early 1920s and is privately owned. The structure was screened and has a functional fish ladder. The Clough Dam was breached during the January 1997 flood and presently is not a barrier to fish passage. Alternative designs for reconstructing the dam include options to provide water for irrigation without impairing fish passage.

All of the water diversions have screens, owned by the DFG, in place and in good operating condition.

Sufficient flows permit unobstructed fish passage and cleanse and distribute new spawning gravels. One of the key elements in restoring Mill Creek's salmon and steelhead populations is obtaining dependable flow in the lower stream reaches. A negotiated agreement with the water users is the preferable means of achieving this goal, because it would minimize conflicts between historical land uses and restoration of salmon and steelhead habitat. This has been partially achieved through a cooperative water exchange agreement which has been in place for seven years.

The riparian corridor needs improvement in several areas. Some locations have been denuded and will require significant revegetation.

Gravel spawning habitat in the valley floor section of the creek is not adequate for fall-run chinook salmon. Gravel recruitment is limited because of a relatively low natural supply attributable to the geologic features in the basin. Existing gravel sources may be enhanced to improve spawning areas for fall-run chinook salmon. An evaluation of the potential benefits of providing supplemental gravel into the channel should be completed.

Conservation, restoration, and preservation efforts on Mill Creek have been established by the Mill Creek Conservancy which supports the local approach to watershed management. The local residents, concerned citizens, and resource agencies worked together and prepared the Mill Creek Watershed Management Strategy which is a comprehensive document containing specific recommendation for resource protection.

Restoration activities are presently being implemented in accordance with the priorities stated in the Mill Creek Watershed Management Strategy. The Strategy Report addresses potential stressors including the potential adverse impacts from timber harvesting and additional recreational activities. However, the majority of the upper and middle watershed is protected from detrimental activity due to its Wilderness designation, PACFISH regulations, and private conservation easements.

The majority of the Mill Creek watershed remains undisturbed and is still capable of supporting historic runs of salmon and steelhead. Potential restoration work is concentrated in the lower watershed area on the valley floor that has been impacted by human activities. The major restoration efforts include replanting native riparian vegetation and securing additional instream flows.

Potential timber harvest in the upper watershed threatens loss of holding and spawning areas due to habitat degradation. Selective harvest and well-planned road construction would minimize this effect. Additional recreation areas must be carefully planned and implemented to preserve existing fish habitat. Forest management, including reducing fire fuel loads, will protect riparian habitats and streamflows and help to prevent excessive sediment from being washed into the creek.

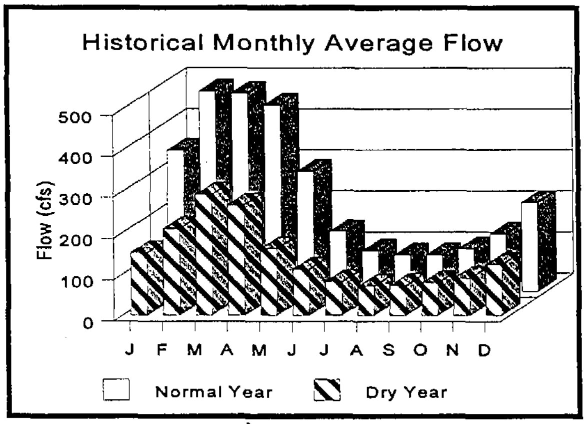
Adult spring-run chinook salmon oversummering in deep upstream pools are susceptible to illegal harvest. The remoteness of the spawning areas contributes to enforcement problems.

DEER CREEK ECOLOGICAL MANAGEMENT UNIT

Deer Creek is a major tributary to the Sacramento River, originating upstream of Deer Creek Meadows on the slopes of Butt Mountain. The creek enters the Sacramento River approximately 1.5 miles north of Woodson Bridge State Park. The watershed drains 200 square miles and is 60 miles long. Part of the upper stream is paralleled by State Highway 32. The lower 10 miles of the creek flow through the valley, where most of the flow is diverted. This lower section encompasses a relatively large flood plain bounded on either side by levees.

In many years prior to 1990, three diversion dams and four diversion ditches depleted all of the natural flow from mid-spring to fall. Since 1990, the local irrigation districts, with assistance from the Departments of Fish and Game and Water Resources, have voluntarily provided fish passage flows at critical times. All of the diversion structures have fish ladders and screens. Of all Sacramento Valley streams, Deer Creek has the greatest potential for restoring spring-run chinook salmon. Overall, the ecological health of the Deer Creek Ecological Management Unit is rated above average. Although spring-run chinook salmon and steelhead populations need to increase in size, the factors limiting these populations lie primarily outside of the unit.

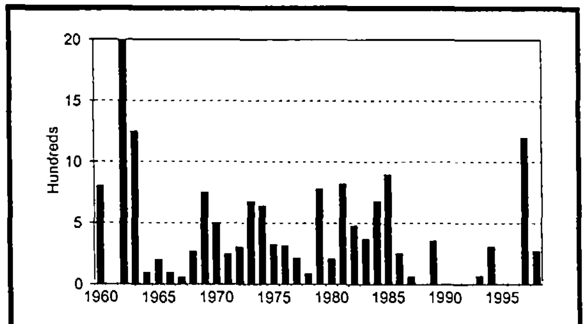
Deer Creek has a seasonal flow pattern similar to that of Mill Creek. Flows are highest in winter and spring, and summer and fall flows. Peak monthly flows in wet winters reach up to 2,600 cfs. In driest years, winter flows reach only 90 to 110 cfs. Minimum summer and fall base flows are 60 to 80 cfs.



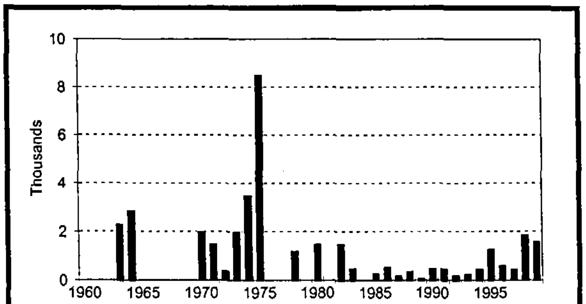
Deer Creek Streamflow, 1923-1993 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Fall- and spring-run chinook salmon and steelhead trout use Deer Creek. During the past decade, an average of approximately 550 spring-run and 1,000 fall-run chinook have spawned annually in Deer Creek. Habitat in the upper watershed is relatively intact, with numerous holding areas and an abundance of spawning gravel. Some spawning areas in lower Deer Creek are lightly armored and could limit production of fall-run chinook salmon.

Except for the lack of streamflows on the valley floor below the agricultural diversions, fish habitat throughout the drainage is generally of good quality.



Fall-run Chinook Salmon Returns to Deer Creek, 1960-1998 (CDFG 1999).



Spring-run Chinook Salmon Returns to Deer Creek, 1960-1999 (CDFG 1999).

Water right holders on Deer Creek have recently expressed interest in developing alternative water sources for fishery flows. Water users are concerned about the depleted status of the spring-run chinook salmon and have been working toward mutually acceptable solutions to restore the fishery.

Sufficient flows permit unobstructed fish passage and cleanse and distribute new spawning gravels. Inadequate flow for upstream passage is the most significant problem on Deer Creek. Flows necessary to provide unimpaired migration in the lower stream section, for adult salmon and steelhead are undetermined but have been estimated to be 50 cfs at a minimum.

Adequate spawning gravel is found in lower Deer Creek for present population levels of fall-run salmon and existing gravel sources should be protected. Prior to any effort to supplement existing gravel supplies, a comprehensive analysis of stream channel dynamics is required. This study should include elements that address geomorphology, sediment transport flows, stream channel meander, sediment sources, and flood control needs or requirements.

Restoration efforts on Deer Creek will involves the ongoing participation and support of local landowners through the Deer Creek Conservancy, a local landowners organization. One role of the Deer Creek Conservancy has been the successful development of a cooperative watershed management plan including a watershed management strategy (Deer Creek Watershed Conservancy 1998). Plan formulation is in process and will help to preserve and restore spring-run chinook salmon and steelhead trout and other important attributes of the watershed. The ecological health of Deer Creek could be maintained by developing and implementing a comprehensive watershed management plan.

Additional recreation areas must be carefully planned and implemented to preserve existing fish habitat. Forest management, including reducing fire fuel loads, will protect riparian habitats and streamflows and help to prevent excessive sediment from being washed into the creek.

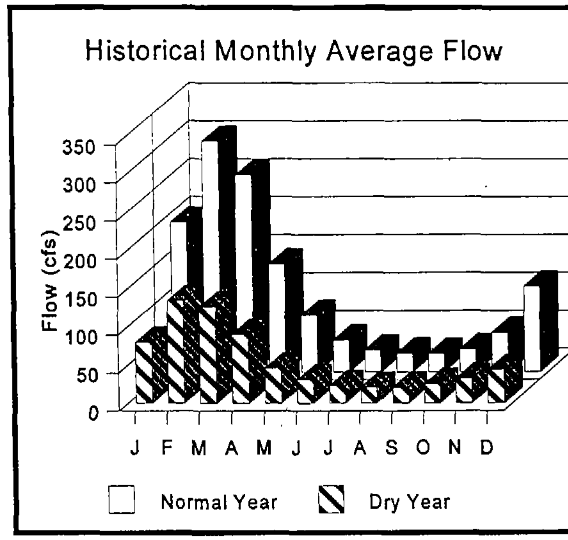
The riparian corridor needs protection and improvement in the lower and upper river. In the lower river, riparian habitat improvements will be coordinated with flood control management activities.

Adult spring-run chinook salmon oversummering in deep upstream pools are susceptible to poaching. The remoteness of the spawning area contributes to enforcement problems.

Big Chico Creek Ecological Management Unit

Big Chico Creek enters the Sacramento River 5 miles west of the City of Chico. It flows into the Sacramento Valley from the Sierra Nevada foothills, draining a watershed of approximately 72 square miles. There are no significant impoundments on the stream, and the only major water diversion has been relocated to the mainstem Sacramento River. The stream is the focal point of the local Chico community. The creek flows through Bidwell Park, downtown Chico, and the Chico State University campus. (Bidwell Park is the third largest city park in the nation.) Lindo Channel is an element of the local flood control system and originates at the Five Mile Recreation Area. The channel returns water to the creek near its mouth below the City of Chico.

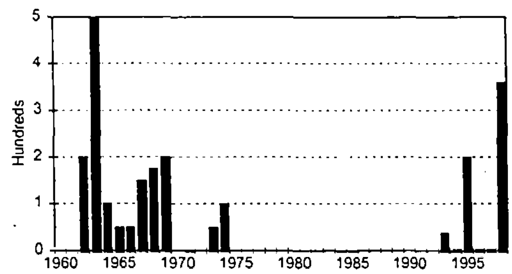
Big Chico Creek has a seasonal flow pattern similar to that of Antelope Creek with moderate winter flows and lower late spring to early fall flow than Mill and Deer Creeks. Peak winter month average flows reach 600-1,500 cfs. In driest years, winter flows reach only 20-40 cfs. Minimum summer and fall base flows are 15-20 cfs in all but the wettest years.



Big Chico Creek Streamflow, 1936-1986 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Important resources in Big Chico Creek include spring- and fall-run chinook salmon and steelhead trout and resident native fishes. Although spring-run chinook salmon and steelhead populations are very low, factors limiting these population lie primarily outside of the unit. Some improvements in the steelhead trout and spring-run chinook salmon populations can be made if habitat and flows can be restored.

In 1958, the spring-run chinook salmon population was estimated at 1,000 adults, although the average annual run was probably less than one-half this amount during the 1950s and 1960s. In 1995, an estimated 200 spring-run returned to Big Chico Creek, followed in 1998 by 359 spring-run. The 1998 return was likely the progeny of the 1995 return and was assisted by a series of wet years and the relocation of the M&T Pumping Station to the mainstem Sacramento River. Steelhead populations are thought to have averaged approximately 150 returning adults during this same period. Recent estimates indicate a potential to rebuild the spring-run chinook population, a low steelhead population, and a highly variable spawning population of fall-run chinook salmon.



Spring-run Chinook Salmon Returns to Big Chico Creek, 1980-1998 (CDFG 1999).

In addition, adult spring-run chinook are deterred by intermittent flow in Lindo Channel and inadequate fish passage at the One and Five Mile Recreation Areas and at Iron Canyon in upper Bidwell Park. Marginal spawning and rearing habitat in Big Chico Creek and Lindo Channel below the Five Mile Recreation Area is used by fall-run chinook salmon. Big Chico Creek and Lindo Channel are used by many interests for a variety of purposes, including wildlife habitat, anadromous fisheries reproduction and rearing, urban storm drainage, flood control, and recreation.

Functioning in the flood control and recreational pool system, the ecological system supports three salmonid runs. Without careful coordination, successful management of one use may conflict with successful management of another. Even though excellent spawning gravel exists in Lindo Channel, in most years, intermittent flows preclude successful spawning. Big Chico Creek flows for nearly 11 miles through the City of Chico, much of it through Bidwell Park. Vegetation along Big Chico Creek in Bidwell Park is an excellent example of a mature riparian community. Lindo Channel functions as a flood relief channel for Big Chico Creek and supports riparian habitat. Both are surrounded by urban and agricultural uses that could degrade their environmental quality.

Inadequate flow for upstream passage is the most significant problem on Big Chico Creek. During all but the wetter years, flows in fall remain at summer lows. This inhibits and delays the upstream fall-run chinook salmon migration. Water management operations, such as the flow split at Five Mile Diversion Dam, that can improve flows for passage should be evaluated.

Gravel recruitment is limited by existing diversion dams, or gravel is in poor supply from past floods or flood control practices. Existing gravel sources should be protected and supplemental gravel placed into the creek channel as needed.

Restoration efforts on Big Chico Creek will involve the participation and support of local landowners through the Big Chico Creek Task Force, a local organization of stakeholders. The Big Chico Creek Task Force will be instrumental in developing a comprehensive watershed management plan and will assist or sponsor some of the needed restoration elements in the basin. One role of the Big Chico Creek Task Force will be to sponsor the development of a cooperative watershed management plan that will assist in the effort to preserve and restore spring-run chinook salmon and steelhead trout.

The ecological health of the creek could be improved by developing and implementing a comprehensive watershed management plan. Timber harvest in the upper watershed could threaten loss of holding and spawning areas because of habitat degradation. Selective harvest and well-planned road construction may minimize this effect. Additional recreation areas must be carefully planned and implemented to preserve existing fish habitat. Forest management, including reducing fire fuel loads, will protect riparian habitats and streamflows and help to prevent excessive sediment from being washed into the creek.

The riparian corridor needs to be protected and improved in the lower and upper river. In the lower river, riparian habitat improvements will be coordinated with flood control management activities in cooperation with local landowners.

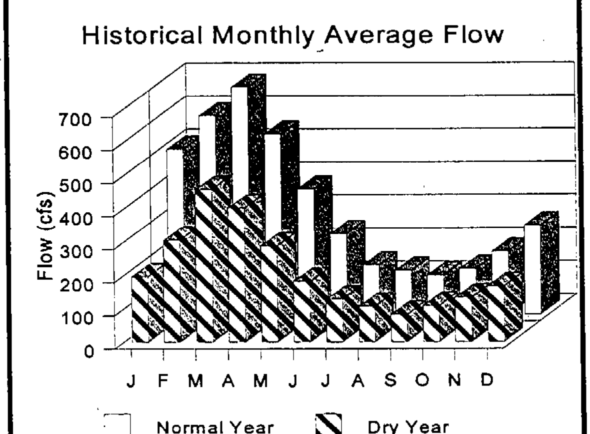
Salmon and steelhead passage problems at Iron Canyon, One-Mile Pool, and Five-Mile Diversion will be improved by repairing weirs and fishways.

Adult spring-run chinook salmon oversummering in deep upstream pools are susceptible to poaching. The remoteness of the spawning areas contributes to enforcement problems. Protect holding pools by obtaining willing seller titles or conservation easements on lands adjoining pools.

Butte Creek Ecological Management Unit

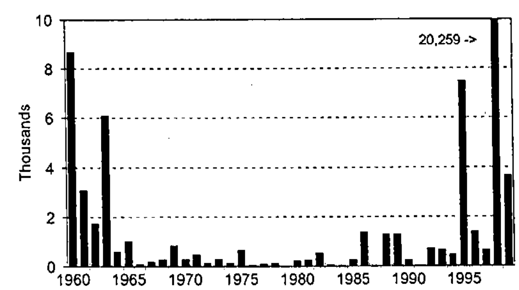
Butte Creek originates in the Jonesville Basin, Lassen National Forest, on the western slope of the Sierra Nevada. It drains the northeastern portion of Butte County. The creek enters the Sacramento Valley southeast of Chico and meanders in a southwesterly direction to the initial point of entry into the Sacramento River at Butte Slough. A second point of entry into the Sacramento River (at lower flows) is through the Sutter Bypass and Sacramento Slough. Butte Creek drains the foothills just south of the Big Chico Creek watershed and North Fork of the Feather River drainage. The upper Butte Creek watershed (northeast of Chico) has an area of approximately 150 square miles. Lower Butte Creek flows parallel to the Sacramento River for almost 50 miles to the Butte Slough outfall. It then continues through the Sutter Bypass and Sacramento Slough channels to join the Feather River near the confluence with the Sacramento River, almost 100 miles downstream of Chico. Butte Slough connects with the Sacramento River through flap gates in the Sacramento River levee. These gates may not be open during the salmon and steelhead migration periods.

Streamflow on Butte Creek is similar to that on Deer Creek, with water from snowmelt and springs to maintain summer and fall flow even in drier years. Peak flow in winter of wet years reaches 1,000 to 3,000 cfs. In driest years, winter flows average only 90 to 120 cfs. Summer and fall minimum flows generally average 120 to 160 cfs but may reach only 50 cfs in driest years.

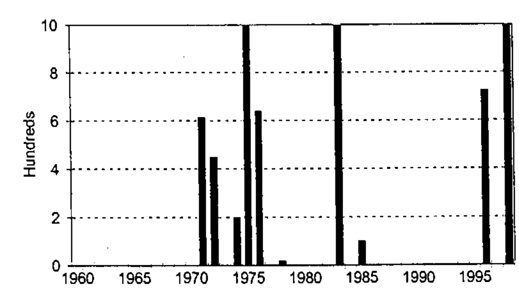


Butte Creek Streamflow, 1963-1993 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Fall- and spring-run chinook salmon and steelhead trout exist in Butte Creek. As late as the 1960s, Butte Creek supported more than 4,000 adult spring-run chinook salmon, a lesser number of fall-run chinook salmon, and a small number of steelhead trout. More recently, the spring-run chinook populations have ranged from fewer than 200 adults to more than 1,000. Spring-run chinook salmon estimates reached a record of more than 8,000 in 1995, and Butte Creek demonstrated its ability to attract a large spring-run chinook salmon population with adequate streamflows. The fall-run chinook salmon population varies between a few fish to as many as 1,000. The number of steelhead is unknown.



Spring-run Chinook Salmon Returns to Butte Creek, 1960-1999 (CDFG 1999).



Fall-run Chinook Salmon Returns to Butte Creek, 1960-1998 (CDFG 1999).

The decline of Butte Creek's chinook salmon and steelhead populations is attributed to:

- inadequate flows,
- unscreened diversions,
- inadequate passage over diversion dams,
- unblocked agricultural return drains that attract and strand adult fish,
- poor water quality, and
- poaching.

Nine diversion dams on Butte Creek above Butte Slough supply water for power generation, irrigation, gun clubs, and domestic use. All are known to impair and delay migrating fish. One, the Point Four Ranch Dam, was removed in July 1993. Passage at seven of the dams could be improved by either removing the dam or upgrading the ladders. All of the diversions from these dams are unscreened, except the diversion at the Parrott-Phelan Dam, which was recently screened. Presently, three of the seven dams are being removed as part of the Western Canal siphon project, and three others (Durham Mutual, Adams, and Gorrill) have defined projects to build or rebuild ladders and fish screens.

The Centerville Head Dam, immediately below the DeSabla powerhouse, is the upper limit of anadromous fish migration. Water diverted from three adjacent watersheds commingles with the natural flows of Butte Creek and often is the major portion of the flow. Feather River water enters Butte Creek at two locations: via the West Branch into DeSabla Reservoir and through the Thermalito Afterbay and the Western Canal. Flows from both Big and Little Chico Creeks enter Butte Creek from agricultural diversions that empty into Little Butte Creek. Flows from the Sacramento River reach Butte Creek from various diversion points, from as far north as the mouth of Big Chico Creek to the Reclamation District 1004 pumps located near Princeton.

Adult spring-run chinook salmon migrate into Butte Creek during February through June. They oversummer primarily in pools from the confluence of Little Butte Creek to the Centerville Head Dam and begin spawning in late September. Spring-run chinook fry emigrate as early as December, whereas smolts emigrate the following spring. Generally, adequate migration flow exists from Centerville Head Dam downstream to the Western Canal Dam; however, during dry years, several areas above Western Canal may hinder upstream passage. In these dry years, adult spring-run chinook salmon encounter low, warm flows above Western Canal and may become stranded.

Adult fall-run chinook salmon enter lower Butte Creek during late September and early October. Their upstream passage is often blocked by dewatered stream reaches caused by diversions for flooding State and federal refuges and private duck clubs. Below the Western Canal, adult fall-run chinook often encounter impassable barriers, dewatered areas, silt deposition areas, lack of suitable gravel, and inadequate cover and shade. Several barriers exist above the Western Canal that impede the adult migration until high flows occur. Most fall-run chinook salmon spawn in the area from Durham to the Parrott-Phelan Dam, although some are known to spawn above these dams. Spawning generally occurs from October through December. Fall-run fry begin to emigrate during January and February, and smolts emigrate during April and May. However, many juveniles are entrained at the diversions or perish because of poor water quality.

Although little is known about steelhead in Butte Creek, adults probably ascend in the late fall and winter. They probably spawn during winter and spring in tributaries, such as Dry Creek, and the mainstem creek above Parrott-Phelan diversion.

The water allocation problems in the lower Butte Creek system need to be reduced. The diversion of water for agriculture, waterfowl refuges, and seasonally flooded wetlands should not impair efforts to rebuild salmon and steelhead stocks. Butte Creek water management is extremely complex. Maintaining adequate fishery flows will require close coordination among all water users in the basin. Extension of State Watermaster Service into the lower reach of Butte Creek should be considered to fulfill these management goals. This extension, however, requires the State Water Resources Control Board to adjudicate water below the Western Canal siphon. The area above is adjudicated. State Watermaster Service presently exists down to Western Canal. Extension of this service below Western Canal would require adjudication of the remaining water rights. Wildlife refuges and hunting clubs dependent on Butte Creek water provide some of the most valuable wildlife and waterfowl habitat in the Sacramento Valley. The timing of water needs conflicts among duck clubs, agriculture, and the anadromous fisheries .

Seasonal flooding of refuges and duck clubs conflicts with flows needed for spawning fall-run chinook salmon. Rice field irrigation overlaps with the need for transportation flows for both spring-run adults and juvenile salmon in April and May. Evaluating and determining water rights, water use, and instream flow needs will be a long-term effort requiring the involvement of irrigation districts, private landowners, and agency personnel. Rebuilding salmon runs in Butte Creek will require a negotiated balance among wildlife, agriculture, and fishery needs. Flow improvements can be gained by providing minimum flow requirements below diversions and acquiring existing water rights from willing sellers.

It is generally believed that gravel recruitment in the upper sections is not affected by existing diversion dam since they are either seasonal agricultural dams or relatively low-head hydropower dams which have not had major impacts on gravel recruitment of sediment supply. Existing gravel sources should be protected and supplemental gravel placed into the creek channel as needed.

The Butte Creek Watershed Conservancy is an important organization in developing, evaluating, and implementing measures to improve the ecological health of Butte Creek. This conservancy comprises local stakeholders who work closely with federal and State resource agencies to maintain and restore habitats along the creek. The Butte Creek Watershed Conservancy will be instrumental in developing a comprehensive watershed management plan. It will assist or sponsor some of the needed restoration elements in the basin, including improving streamflows for gravel recruitment and fish passage. The management plan will help to preserve and restore spring-run chinook salmon and steelhead trout. The ecological health of the creek also could be improved by developing and implementing a comprehensive watershed management plan. Current timber harvest in the upper watershed is generally not a threat to chinook salmon or steelhead holding and spawning areas. Maintaining the existing harvest and well-planned road construction will minimize any future effects. Additional recreation areas must be carefully planned and implemented to preserve existing fish habitat. Forest management, including reducing fire fuel loads, will protect riparian habitats and streamflows and help to prevent excessive sediment from being washed into the creek.

The riparian corridor needs to be protected and improved in the lower and upper river. In the lower river, riparian habitat improvements will be coordinated with flood control management activities in cooperation with local landowners.

Salmon and steelhead passage will be provided at diversion dams, including Western Canal, Durham Mutual, Adams, Gorrill, McGowan, and McPherrin. In some cases, dams will be removed. In others, fish ladders will be constructed or upgraded. Migration into lower Butte Creek via Butte Slough and the Sutter Bypass is the present means for salmon and steelhead passage to and from Butte Creek. Gates on the Sacramento River at the head of Butte Slough could be modified and operated to allow year-round passage of both juveniles and adult fish. There may also be improvements in the operation of weirs and diversions in the Sutter Bypass channels that will improve the survival of salmon and steelhead.

BUTTE SINK ECOLOGICAL MANAGEMENT UNIT

The Central Valley is one of the most important waterfowl wintering areas in the Pacific Flyway. In recognition of the value of waterfowl throughout North America, the Central Valley Habitat Joint Venture was formed to protect and restore wetlands in the Central Valley. The Butte Sink is one of the important elements of this venture. There are 11,363 acres of publicly owned and managed waterfowl habitat in the area, including the Butte Sink National Wildlife Refuge (733 acres), Gray Lodge Wildlife Area (8,375 acres), Upper Butte Sink unit of Gray Lodge (3,750 acres). The Gray Lodge WA is natural habitat in complex of wetlands and associated uplands whereas the Upper Butte Sink Unit and Butte Sink NWR are mostly agricultural land that will be restored to natural habitat. Hunting clubs maintain more than 30,000 acres of habitat in a normal year. Of this total, about 18,000 acres are natural wetlands and 12,000 acres are harvested rice fields flooded for hunting. Currently, 5,350 acres of private duck clubs are permanently protected by USFWS Conservation Easements in the Butte Basin. The National Audubon Society owns and manages another 500 acres of wetlands at the Paul L. Wattis Audubon Sanctuary west of Butte Creek (Central Valley Habitat Joint Venture 1990).

The area is also seasonally important for salmon and steelhead passage between the Sacramento River and holding, spawning, and rearing areas of the creeks. The sink is predominately wetlands interspersed with riparian vegetation all of which is subject to frequent natural seasonal flooding, which are major reasons for its importance to fish and wildlife, particularly waterfowl.

VISION FOR THE ECOLOGICAL MANAGEMENT ZONE

The vision for the Butte Basin Ecological Management Zone includes restoring important fishery, wildlife, and plant communities to health. Generally, health will be attained when the status of specific biological resources is no longer a problem in the Delta. To attain this vision, this program will seek to improve streamflow and riparian corridors, screen diversions, remove barriers to fish migration, and restore watershed health through improved forest and rangeland management.

The vision for the Butte Basin Ecological Management Zone focuses on restoring physical processes and habitats and reducing stressors to meet spring-run chinook salmon and steelhead population levels of the late 1960s and early 1970s. In addition, improvements in the riparian corridors will provide improved habitat for waterfowl and other wildlife. The program proposes targets and actions that will increase protection for naturally produced chinook salmon and steelhead as they rear and migrate to the mainstem Sacramento River. Important actions to improve survival include maintaining and restoring a healthy riparian zone, which includes ample shaded riverine aquatic (SRA) habitat, woody debris, and biologically productive gravel beds for fish spawning and invertebrate production. The vision also anticipates screening many small water diversions and providing sufficient flows during important periods of adult migration and juvenile emigration.

The Ecosystem Restoration Program (ERP) recommends the following approaches for restoring the Butte Basin Ecological Management Zone.

VISIONS FOR ECOLOGICAL MANAGEMENT UNITS

PAYNES CREEK ECOLOGICAL MANAGEMENT UNIT

The vision for the Paynes Creek Ecological Unit is to improve steelhead trout and fall-run chinook salmon populations by improving streamflows and gravel spawning habitat. Paynes Creek can make minor but important contributions to the upper Sacramento River runs of these fish if adequate holding, spawning, rearing, and migration habitat are provided. Adequate streamflows are important for maintaining and restoring the connectivity of upstream spawning and nursery areas with the mainstem Sacramento River. Sufficient flows must be provided to cleanse and distribute new spawning gravels. The riparian corridor needs significant improvement in several areas; some have been denuded and will require significant revegetation.

ANTELOPE CREEK ECOLOGICAL MANAGEMENT UNIT

The vision for the Antelope Creek Ecological Unit is to increase its ability to make small contributions to chinook salmon and steelhead populations by improving fall and spring flows, increasing spawning gravels and restoring riparian corridors. The health of Antelope Creek will be maintained so that it can provide seasonal inflow, sediments, and nutrients to the Sacramento River. Antelope Creek will provide important migratory corridors for aquatic and terrestrial species. Antelope Creek could be important in some years for salmon and steelhead with adequate flows and improved spawning and rearing habitat.

MILL CREEK ECOLOGICAL MANAGEMENT UNIT

Mill Creek is an important ecological unit in the Butte Basin Ecological Management Zone. It provides valuable habitat for anadromous and native resident fish. The vision for the Mill Creek Ecological Unit is to increase spring- and fall-run chinook salmon and steelhead by maintaining adequate streamflows, restoring riparian corridors, and maintaining upper watershed health. This could be accomplished by implementing a locally sponsored comprehensive watershed management and restoration program, and by implementing actions recommended for the Sacramento River, Delta, and Suisun Mash ecological management zones. It is important to note that Mill Creek's undisturbed condition offers holding and spawning habitat which is essentially unchanged from historic times. Restoration of the creek's anadromous fish populations may depend on the success of downstream restoration actions.

DEER CREEK ECOLOGICAL MANAGEMENT UNIT

The Deer Creek Ecological Unit is one of the more important ecological units in the Butte Basin Ecological Management Zone. It provides for highly valued populations of spring-run chinook salmon and steelhead, and populations of other chinook salmon and resident native fish. The vision for Deer Creek is to increase chinook salmon and steelhead runs by maintaining adequate streamflows, spawning gravels, fish passage, protecting and restoring riparian corridors, and maintaining upper watershed health. This is being accomplished by a locally sponsored comprehensive watershed management and restoration program which is supported by many state and federal agencies.

DEER CREEK WATERSHED DEMONSTRATION PROGRAM: Deer Creek has been tentatively selected as a demonstration watershed for the CALFED Stage 1 (first seven years) Implementation Program. During Stage 1, CALFED will support ongoing management and restoration efforts in the watershed. Success in Stage 1 will set the stage for subsequent implementation phases as information derived in the Deer Creek watershed will have broad application in designing and implementing similar programs in other watersheds throughout the Sacramento Valley.

Cumulatively, an investment in Deer Creek during Stage 1 will provide direct benefits to the creek and provide the types of restoration information needed to successfully move the Ecosystem Restoration Program into subsequent implementation phases. A few of the lessons to be learned in the Deer Creek watershed include how to improve overall watershed health; how to integrate local, state, federal, and private efforts in a large-scale restoration program; how to design and implement actions to benefit spring-run chinook salmon and steelhead; and how to best manage ecological processes such as sediment transport and stream meander in a partially modified stream system.

One of the cornerstones to the probable success of this effort is the Deer Creek Watershed Conservancy. The Conservancy is an active organization comprised of landowners within the watershed who have joined together with state and federal resource management agencies to protect and restore the unique ecological attributes of the watershed. Though a stakeholder planning process, the Conservancy has completed a watershed management plan including and existing conditions report and an important watershed management strategy which outlines actions to protect the future of Deer Creek.

BIG CHICO CREEK ECOLOGICAL MANAGEMENT UNIT

The vision for the Big Chico Creek Ecological Management Unit is to increase runs of chinook salmon and steelhead by providing adequate streamflows, providing unobstructed fish passage, protecting and restoring riparian corridors, and maintaining upper watershed health. This could be accomplished by implementing a locally sponsored comprehensive watershed management and restoration program.

BUTTE CREEK ECOLOGICAL MANAGEMENT UNIT

The vision for the Butte Creek Ecological Management Unit is restoring spring-run chinook salmon and steelhead populations by improving fish passage, increasing and improving streamflow, consolidating and screening diversions, and protecting and restoring the riparian corridor. These improvements will help to restore and maintain habitats needed to support a large population of spring-run chinook salmon and modest populations of fall-run chinook salmon and steelhead trout. Screening will allow continued water diversion for agricultural purposes and for the seasonal flooding of private wetlands and adjacent wildlife refuges. Restoring habitat in Butte Creek would allow the spring-run and fall-run chinook population to achieve increased annual spawning populations.

BUTTE SINK ECOLOGICAL MANAGEMENT UNIT

The vision for the Butte Sink Ecological Management Unit includes restoring stream channels, streamflow, and riparian SRA habitat, as well as adjacent wetland habitat. ERPP also envisions restoring or maintaining stream channels, streamflows, and SRA habitat to improve rearing and migrating conditions for salmon and steelhead and to improve habitats for resident native fishes, such as the Sacramento splittail.

VISIONS FOR ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOW: Healthy streamflows are required to sustain sediment transport, stream meander, riparian plant communities and aquatic organisms. The vision is that streamflows will emulate (imitate) the natural seasonal runoff pattern. This would include a late-summer or early fall flow event to sustain ecological processes related to channel maintenance. Such flows would attract and improve the upstream migration of adult chinook salmon.

COARSE SEDIMENT SUPPLY: Natural sediment supplies and gravel recruitment below major dams have been eliminated. Supplementing gravel and other sediments at those sites and reactivating sediment transport in lower creek sections would assist in maintaining ecological processes and important habitat substrates used for invertebrate production and fish spawning. The vision is that existing natural sediment supplies will be protected to maintain stream channel gradients, provide gravel for spawning and invertebrate production, and contribute to maintaining riparian vegetation.

STREAM MEANDER: A natural stream meander process will provide much of the habitat needed to support healthy riparian systems, wildlife, and aquatic species. The vision is that streams will be allowed to naturally migrate consistent with flood control requirements.

VISIONS FOR HABITATS

SEASONAL WETLAND HABITAT: The vision is that increased seasonal flooding of leveed lands, use of the Butte Sinks's natural flood detention capacity, protection and enhancement of existing wetlands, and development of cooperative programs with local landowners will contribute to increased habitats for waterfowl and other wetland dependent fish and wildlife resources such as shorebird, wading birds, and the giant garter snake.

RIPARIAN AND RIVERINE AQUATIC HABITATS: Habitats important to anadromous fish production in this ecological zone are impaired by land use activities, including developments along the stream corridors. Improvements are needed to restore riparian, shaded riverine (of rivers) aquatic (SRA), and woody debris habitats. These, in turn, will support improved aquatic species survival. The vision is that the riparian system will provide shading to moderate water temperatures, provide habitat for aquatic species, and provide a migration corridor for birds and other terrestrial species.

FRESH EMERGENT WETLAND HABITAT: The vision is to maintain and enhance existing permanent marshes in the Colusa Basin Ecological Management Zone.

FRESHWATER FISH HABITAT: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native and anadromous fish species. The upper reaches of creeks in Butte Basin Ecological Management Zone are typical of salmon-steelhead streams and the lower section are typical of fall chinook salmon spawning stream (Moyle and Ellison 1991). The quality of freshwater fish habitat in these creeks will be maintained through actions directed at streamflows, coarse sediment supply, stream meander, natural floodplain and flood processes, and maintaining and restoring riparian and riverine aquatic habitats.

ESSENTIAL FISH HABITAT: The streams in this ecological management zone have been identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). Key features of EFH to maintain or restore in these creeks include substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

AGRICULTURAL LANDS: Improving habitats on and adjacent to agricultural lands in the Butte Basin Ecological Management Zone will benefit native waterfowl and wildlife species. Emphasizing certain agricultural practices (e.g., winter flooding and harvesting methods that leave some grain in the fields) will also benefit many wildlife that seasonally use these important habitats.

VISIONS FOR REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS: Removing water through unscreened diversions is a direct source of young fish mortality. Reducing these losses would contribute to overall ecosystem health by promoting sustainable fisheries and higher population levels. The vision is that alternative water sources will reduce reliance on instream diversions and that water will be diverted in a manner that does not impair efforts to restore aquatic species and riparian habitat.

DAMS AND OTHER STRUCTURES: Improve the opportunity for the successful upstream and downstream migration of anadromous fish species. The vision is that instream structures will not impair the up- and downstream migration of aquatic species.

HARVEST OF FISH AND WILDLIFE: The legal and illegal harvest of chinook salmon and steelhead in the streams, Bay-Delta, and ocean constrain the recovery of wild populations. Harvest rate reductions will be necessary to allow recovery of populations. The vision is that harvest will not impair efforts to rebuild chinook salmon and steelhead populations.

ARTIFICIAL PROPAGATION OF FISH: The artificial production of chinook salmon and steelhead supports important sport and commercial fisheries and mitigates loss of salmon and steelhead habitat that resulted from dam construction. Due to release practices, fish from several Central Valley hatcheries supplement the naturally spawning salmon and steelhead in the Sacramento River and its tributaries. Hatchery salmon and steelhead may impede the recovery of wild populations by competing with wild stocks for resources. Hatchery-raised stocks, because of interbreeding, may not be genetically equivalent to wild stocks or may not have the instincts to survive in the wild. If these stocks breed with wild populations, overall genetic integrity suffers. Improvements in hatchery practices are necessary to ensure recovery of wild salmon and steelhead populations. The vision is that hatchery practices throughout the Sacramento Valley will not impair the genetic integrity or identity of chinook salmon and steelhead in the Butte Basin Ecological Management Zone.

VISIONS FOR SPECIES

FALL-RUN CHINOOK SALMON: The vision for fall-run chinook salmon is to recover all stocks presently proposed for listing under the ESA, achieve naturally spawning populations levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and the use fully existing and restored habitat. Fall-run chinook will directly benefit from restoration actions to improve ecological processes and habitat, and by reducing stressors that reduce juvenile and adult fish survival. The vision is that fall-run chinook salmon will be sustained at levels that fully use existing and restored habitat.

SPRING-RUN CHINOOK SALMON: The vision for spring-run chinook salmon is to recover this State and federally listed threatened species, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that fully use existing and restored habitats. Spring-run chinook will directly benefit from restoration actions to improve ecological processes and habitats, and by reducing stressors that reduce juvenile and adult fish survival. The vision is that adult and juvenile spring-run chinook salmon will fully use existing and restored habitat.

STEELHEAD: The vision for steelhead it to recover this federally listed threatened species and achieve naturally spawning populations of sufficient size to support inland recreational fishing and that use fully existing and restored habitats. Steelhead will directly benefit from restoration actions to improve ecological processes and habitats, and by reducing stressors that reduce juvenile and adult fish survival. The vision is that steelhead will fully use existing and restored habitat.

LAMPREY: The vision for anadromous lamprey is to maintain and restore population distribution and abundance to higher levels than at present. The vision is also to better understand life history and identify factors which influence abundance. Lamprey are a California species of special concern. Because of limited information regarding their status, distribution, and abundance, the vision is that additional monitoring or research will provide the data necessary to better manage these species and their habitat.

NATIVE ANURAN AMPHIBIANS: The vision for the native anuran amphibian species is to stop habitat loss and the introduction of other species that prey on the different life stages of these amphibians. Ongoing surveys to monitor known populations and find additional populations is essential to gauge the health of the species in this group. To stabilize and increase anuran populations, non-native predator species should be eliminated from historic habitat ranges.

Increasing suitable habitat and maintaining clean water supplies that meet the needs of the various species in this group is essential.

NATIVE RESIDENT FISH: The vision for native resident fish species is to maintain and restore by distribution and abundance of species such as hardhead, Sacramento sucker, and California roach.

NEOTROPICAL MIGRATORY BIRDS: The vision for neotropical migratory birds is to maintain and increase populations through restoring habitats on which they depend.

GIANT GARTER SNAKE: The vision for the giant garter snake is to contribute to the recovery of this State and federally listed threatened species in order to contribute to the overall species richness and diversity. Achieving this vision will reduce the conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. Protecting existing and restoring additional suitable wetland and upland habitats will be critical to achieving recovery of the giant garter snake. The proposed restoration of aquatic, wetland, riparian, and upland habitats in the Butte Basin Ecological Management Zone will help in the recovery of this species by increasing habitat quality and area.

WATERFOWL: The vision for waterfowl is to maintain and restore healthy populations at levels that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses consistent with the goals and objectives of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan. Many species of resident and migratory waterfowl will benefit from improved aquatic, wetland, riparian, and agricultural habitats. Increase use of the Butte Basin Ecological Management Zone, particularly in the Butte Sink Ecological Management Unit, and possibly increases in some populations would be expected.

GREATER SANDHILL CRANE: The vision for the greater sandhill crane is to contribute to the recovery of this State-listed threatened species. Improvements in pasture lands and seasonally flooded agricultural habitats, such as flooded corn fields, should help toward recovery of the greater sandhill crane population.

PLANT SPECIES AND COMMUNITIES: The vision for plan species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland and riparian and riverine aquatic habitats.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

WATERSHED ORGANIZATIONS MILL CREEK CONSERVANCY

The Mill Creek Conservancy is spearheading a cooperative approach to watershed management with special emphasis on protecting and enhancing chinook salmon and steelhead habitat. In December 1994, the Conservancy developed a Memorandum of Understanding (MOU) to create a Mill Creek Watershed Management Strategy. There are 17 partners to the MOU, including the U.S. Forest Service, California Department of Fish and Game (DFG), Bureau of Land Management, California Department of Water Resources (DWR), The Nature Conservancy, Natural Resource Conservation Service, Los Molinos School District, and others. In 1995, the Conservancy secured funding and developed a work program for a cooperative, local resource management approach. In 1996, a wide range of stakeholders participated in eight Scoping Study sessions to discuss goals and project priorities. The result was the *Mill Creek Watershed Management Strategy Report,* which contained 13 recommendations from the Watershed Advisory Committee. The USFWS, through the CVPIA, has provided funding for riparian restoration projects along lower Mill Creek. Planting and monitoring will be done over a three-year period.

DEER CREEK WATERSHED CONSERVANCY

The Deer Creek Watershed Conservancy was created by the property owners within the drainage to protect Deer Creek's unique ecological values. The Conservancy provides a forum for all stakeholders to become involved in the watershed and to share ideas regarding land use decisions. The processes used by the Conservancy helps build a common information base, keeps communication channels open, and establishes trust and credibility among those wishing to protect and enhance the watershed. The first act of this conservancy was to author and initiate legislation to prevent the construction of any new dams within the watershed.

Butte Creek Watershed Conservancy

The Butte Creek Watershed Conservancy was formed to provide a forum for communication among stakeholders and property owners in the watershed and to develop a watershed planning and management program.

Big Chico Creek Watershed Alliance

The Big Chico Creek Watershed Alliance was sponsored by the City of Chico to address specific problems in the watershed. Still active, it has the potential to serve as the public forum to bring together stakeholders, landowners, and technical experts to develop a watershed management program for Big Chico Creek.

Four Pumps Agreement

(Agreement Between the Department of Water Resources and the Department of Fish and Game to Offset Direct Fish Losses in Relation to the Harvey O. Banks Delta Pumping Plant.) This agreement between the Departments of Water Resources and Fish and Game is a mutually beneficial program to protect and restore habitat for anadromous fish, particularly for chinook salmon. Project-by-project funding is available through this agreement. Projects that provide quantifiable benefits to spring- and fall-run chinook salmon, within specified cost-benefit parameters, are generally approved for funding.

Maintaining and restoring the ecological health of the Butte Basin Ecological Management Zone units will heavily depend on local watershed groups. The ERPP encourages similar watershed groups on Paynes and Antelope Creeks. Efforts in the Butte Basin will be linked to the California Waterfowl Association, Ducks Unlimited, The Nature Conservancy, and the California rice industry. Overall efforts will require cooperation from resource agencies, such as DFG, DWR, U.S. Fish and Wildlife Service (USFWS), and the National Marine Fisheries Service (NMFS), as well as participation and support from the U.S. Bureau of Reclamation (Reclamation), the Natural Resources Conservation Service, and other private organizations, water districts, and individual landowners. These groups are expected to work together to maintain and restore streamflows and fish and wildlife habitat, reduce impacts of diversions, and minimize poaching and habitat and water quality degradation in basin streams. ERPP may provide supporting funding for enhancing streamflows, reducing fish passage problems, screening diversions, restoring habitats, and increasing Fish and Game Code enforcement to protect recovering populations of salmon and steelhead.

Central Valley Project Improvement Act

The U.S. Fish and Wildlife Service (USFWS) and the Bureau of Reclamation (Reclamation) are implementing the Central Valley Project Improvement Act (CVPIA), which provides for restoration of habitats and species and elimination of many stressors. Key elements of the CVPIA program include the Anadromous Fish Restoration Program (USFWS 1997) and the Anadromous Fish Screening Program. The CVPIA calls for doubling the salmon and steelhead populations in the Butte Basin by 2002.

Salmon, Steelhead and Anadromous Fisheries Program Act

Established in 1988 by Senate Bill 2261, this Act directs the DFG to implement measures to double the numbers of salmon and steelhead present in the Central Valley (CDFG 1993). The DFG's salmon and steelhead restoration program includes cooperative efforts with local governments and private landowners to identify problem areas and assist in obtaining funding for feasibility studies, environmental permitting, and project construction.

Other efforts to improve habitat and reduce stressors will be coordinated with existing state and federal programs and with stakeholder organizations. Their objectives include restoring Central Valley habitat and fish and wildlife populations.

Central Valley Habitat Joint Venture

The Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan have developed objectives for wetlands in the Butte Basin Ecological Management Zone. These objectives are consistent with the ERPP targets developed for this Ecological Management Zone.

CALFED Bay-Delta Program

CALFED has funded approximately 20 ecosystem restoration projects in Butte Basin. Many of these projects address improving fish passage and restoring riparian habitat. One of the more significant projects constructed a siphon to pass an irrigation canal under Butte Creek, removed five diversion dams, and eliminated 12 unscreened diversion for the Western Canal Irrigation District.

Other Programs

- Lassen National Forest Land and Resource Management Plan.
- National Water Quality assessment Program-the Sacramento River Basin.
- Redding Resource Management Plan.
- Deer Creek Water Exchange Project.
- The Watershed Management Initiative.
- California Rivers Assessment (CARA).
- Rangeland Water Quality Management Plan.
- Sierra Nevada Ecosystem Project.
- Sacramento Coordinated Water Quality Monitoring Program.
- Sacramento River Toxic Pollutant Control Program.
- Sacramento River Watershed Program.
- Tehama County General Plan.
- Tehama County Groundwater Management Plan.

Linkage to Other Ecological Management Zones

Many of the resource elements in the Butte Basin Ecological Management Zone depend heavily on conditions or elements in other zones. Anadromous fish, for example, are highly migratory and depend on conditions in the mainstem Sacramento River, Delta, San Francisco Bay, and nearshore Pacific Ocean. Because these fish are affected by stressors throughout their range, such as unscreened diversions, contaminants, water quality, harvest, and a variety of other factors, restoring anadromous fish populations in the Butte Creek Ecological Management Zone will require efforts in other zones.

Reducing or eliminating stressors in the downstream Ecological Management Zones and improving or restoring downstream habitat are important to restoring healthy fish, wildlife, and plant communities in the Butte Basin Ecological Management Zone.

Restoration Targets and Programmatic Actions

Ecological Processes

Central Valley Streamflow

Target 1: Increase spring and fall flow in Paynes Creek (◆).

Programmatic Action 1A: Develop a cooperative approach to increase flow in Paynes Creek by acquiring water from willing sellers or by developing alternative supplies.

Target 2: Increase flow in Antelope Creek during October 1 through June 30 (◆).

Programmatic Action 2A: Develop a cooperative approach to evaluate opportunities to increase flow in Antelope Creek. This involves acquiring water from willing sellers or providing alternative water supplies to diverters during the upstream and downstream migration of adult and juvenile spring- and fall-run chinook salmon and steelhead trout.

Target 3: Increase the flow in Mill Creek (◆).

Programmatic Action 3A: Develop a cooperative approach to increase flow in the lower 8 miles of Mill Creek. This involves acquiring water from willing sellers or by providing alterative water supplies to diverters during the upstream migration of adult salmon and steelhead.

Target 4: Increase flow in the lower 10 miles of Deer Creek (◆).

Programmatic Action 4A: Develop a cooperative approach to increase flow in the lower section of Deer Creek. This involves innovative means to provide alternative supplies during the upstream migration of adult spring-run and fall-run chinook salmon and steelhead trout.

TARGET 5: Increase flow in Butte Creek (◆◆).

PROGRAMMATIC ACTION 5A: Develop a cooperative approach to increase flow in Butte Creek by acquiring water from willing sellers.

TARGET 6: Maintain a minimum year-round flow of 40 cfs in Butte Creek between the Centerville Diversion Dam and the Centerville Powerhouse (◆◆◆).

PROGRAMMATIC ACTION 6A: Develop a cooperative program with PG&E to maintain a minimum flow in Butte Creek below the Centerville Diversion Dam.

TARGET 7: Develop and implement comprehensive watershed management programs to protect water quality, increase summer base flows, and protect and restore other resources such as riparian vegetation (◆).

PROGRAMMATIC ACTION 7A: Support local groups in funding and developing watershed management plans including support for watershed coordinators.

RATIONALE: *The streams in the Butte Basin Ecological Management Zone provide extremely valuable habitat for spring-run chinook salmon and steelhead trout. One of the key attributes of streamflow in this Ecological Management Zone is providing for successful upstream passage of adult fish. In addition, flow is the power that drives many ecological functions and processes linked to stream channel morphology, riparian communities, and fish habitat. Many of the diversions on these streams are for agricultural purposes, and alternative water supplies during important periods could permit flow to remain in the creek while alternative sources are provided. The lower watersheds of many of these streams are being subdivided, and additional demands are being placed on the limited water supplies and instream flows. Two important periods are during the upstream migration of adult spring-run chinook salmon and the downstream migration of yearling spring-run chinook salmon and steelhead, which typically occurs in late winter and early spring. Water diversions often shorten the migration season, when streamflows naturally decline. This is the period when supplemental or alternative water supplies could be used best.*

COARSE SEDIMENT SUPPLY

TARGET 1: Develop a cooperative program to replenish spawning gravel in Big Chico Creek. Especially target stream reaches that have been modified for flood control so that there is no net loss of sediments transported through the Sycamore, Lindo Channel, and Big Chico Creek split (◆◆).

PROGRAMMATIC ACTION 1A: Assist in the redesign and reconstruct the flood control box culvert structures on Big Chico Creek near the Five-Mile Recreation Area to allow natural downstream sediment transport.

TARGET 2: Develop a cooperative program to improve fall-run chinook salmon spawning habitat in the lower 8 miles of Mill Creek (◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to improve chinook salmon spawning habitats in lower Mill Creek by reactivating and maintaining natural sediment transport processes.

TARGET 3: Improve spawning gravel and gravel availability in Butte Creek (◆◆).

PROGRAMMATIC ACTION 3A: Develop a cooperative program to improve spawning habitat in Butte Creek by maintaining natural sediment transport processes.

RATIONALE: *Gravel transport and deposition processes in Butte Basin Ecological Management Zone streams are essential. These processes maintain spawning and rearing habitats of spring-run and fall-run chinook salmon, steelhead trout, and other native fishes. Opportunities to maintain and restore gravel recruitment are possible by manipulating natural processes and controlling or managing environmental stressors that adversely affect gravel recruitment.*

STREAM MEANDER AND FLOODPLAIN

TARGET 1: Preserve or restore the 50- to 100-year floodplains along the lower reaches of streams in the Butte Basin Ecological Management Zone, and construct setback levees to reactivate channel meander in areas presently confined by levees (◆◆).

PROGRAMMATIC ACTION 1A: Cooperatively evaluate whether a more defined stream channel in the lower 10 miles of Antelope Creek would facilitate fish passage by minimizing water infiltration through the streambed and maintaining flow connection with the Sacramento River.

PROGRAMMATIC ACTION 1B: Cooperatively evaluate whether a more defined stream channel in the lower 10 miles of Deer Creek would facilitate stream meander, channel-floodplain interactions, gravel recruitment and transport, and riparian regeneration.

RATIONALE: *Stream meander belts are the areas in which natural bank erosion and floodplain and sediment bar accretions occur along streams. Natural stream meander belts in alluvial areas of the Butte Basin Ecological Management Zone function dynamically. They transport and deposit sediments and provide transient habitats important to aquatic invertebrates and fish. They also provide and maintain surfaces that are colonized by natural vegetation that supports wildlife. The lower valley stream reaches in this Ecological Management Zone serve as important migratory corridors to the upper watersheds for spring-run chinook salmon and steelhead and provide spawning substrate for fall-run chinook salmon.*

HABITATS

SEASONAL WETLANDS

TARGET 1: Assist in protecting 10,000 acres of existing seasonal wetland habitat through fee acquisition or perpetual easements consistent with the goals of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan (◆◆).

PROGRAMMATIC ACTION 1A: Develop and implement a cooperative program to improve management of 10,000 acres of existing, degraded seasonal wetland habitat.

TARGET 2: Develop and implement a cooperative program to enhance 26,150 acres of existing public and private seasonal wetland habitat consistent with the goals of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan (◆◆).

PROGRAMMATIC ACTION 2A: Restore and manage seasonal wetland habitat throughout the Ecological Management Zone.

RATIONALE: *Restoring seasonal wetland habitats along with aquatic, permanent wetland, and riparian habitats is an essential element of the restoration strategy for the Butte Basin Ecological Management Zone. Restoring these habitats will also reduce the amount and concentrations of contaminants that could interfere with restoring the ecological health of the aquatic ecosystem. Seasonal wetlands support a high production rate of primary and secondary food species and large blooms (dense populations) of aquatic invertebrates.*

Wetlands that are dry in summer are also efficient sinks for the transformation of nutrients and the breakdown of pesticides and other contaminants. The roughness of seasonal wetland vegetation filters and traps sediment and organic particulates. Water flowing out from seasonal wetlands is typically high in foodweb prey species concentrations and fine particulate organic matter that feed many Delta aquatic and semiaquatic fish and wildlife. To capitalize on these functions, most of the seasonal wetlands of the Butte Basin Ecological Management Zone should be subject to periodic flooding and overland flow from river floodplains.

RIPARIAN AND RIVERINE AQUATIC HABITATS

TARGET 1: Develop a cooperative program to restore and maintain riparian habitat along the lower 10 miles of Mill Creek (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to restore and maintain riparian habitat along Mill Creek by acquiring conservation easements or by voluntary landowner participation.

TARGET 2: Develop a cooperative program to restore and maintain riparian habitat along the lower 10 miles of Deer Creek (◆◆◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to restore and maintain riparian habitat along Deer Creek by acquiring conservation easements or by voluntary landowner participation.

TARGET 3: Develop a cooperative program to restore and maintain riparian habitat along Big Chico Creek (◆◆◆).

PROGRAMMATIC ACTION 3A: Cooperate with local landowners to encourage revegetation of denuded stream reaches and to establish, restore, and maintain riparian habitat on Big Chico Creek.

TARGET 4: Develop a cooperative program to restore and maintain riparian habitat along Butte Creek (◆◆◆).

PROGRAMMATIC ACTION 4A: Cooperate with local landowners to encourage revegetation of denuded stream reaches and to establish, restore, and maintain riparian habitat on Butte Creek.

RATIONALE: *Many wildlife species, including several listed as threatened or endangered under the State and federal Endangered Species Acts (ESAs), and several special-status plant species in the Central Valley, depend on or are closely associated with riparian habitats. Riparian habitats support a greater diversity of wildlife species than all other habitat types in California. Riparian habitat degradation and loss have substantially reduced the habitat area available for associated wildlife species. This habitat loss has reduced water storage, nutrient cycling, and foodweb support functions.*

FRESHWATER FISH HABITAT AND ESSENTIAL FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination (◆◆).

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitat and essential fish habitat.. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of creeks in this ecological management zone and their floodplains, and in maintaining and restoring riparian and riverine aquatic habitats.*

AGRICULTURAL LANDS

TARGET 1: Cooperatively manage 108,832 acres of agricultural lands (◆◆).

PROGRAMMATIC ACTION 1A: Increase the area of rice fields and other crop lands flooded in winter and spring to provide high-quality foraging habitat for wintering and migrating waterfowl and shorebirds and associated wildlife.

PROGRAMMATIC ACTION 1B: Convert agricultural lands in the Butte Basin Ecological Management Zone from crop types of low forage value for wintering waterfowl and other wildlife to crop types of greater forage value.

PROGRAMMATIC ACTION 1C: Defer fall tillage on rice fields in the Butte Basin Ecological Management Zone to increase the forage for wintering waterfowl and associated wildlife.

RATIONALE: *Following the extensive loss of native wetland habitats in the Central Valley, some wetland wildlife species have adapted to the artificial wetlands of some agricultural practices and have become dependent on these wetlands to sustain their populations. Agriculturally created wetlands include rice lands; fields flooded for weed and pest control; stubble management; and tailwater circulation ponds.*

Managing agricultural lands to increase forage for waterfowl and other wildlife will increase the survival rates of overwintering wildlife and strengthen them for migration, thus improving breeding success (Madrone Associates 1980)

Creating small ponds on farms with nearby waterfowl nesting habitat but little brood habitat will increase production of resident waterfowl species when brood ponds are developed and managed properly. Researchers and wetland managers with the DFG, U.S. Fish and Wildlife Service and the California Waterfowl Association have found that well managed brood ponds produce the high levels of invertebrates needed to support brooding waterfowl. Other wildlife such as the giant garter snake will also benefit. Restoring suitable nesting habitat near brood ponds *will increase the production of resident waterfowl species.*

Restoring nesting habitat, especially when it is near brood ponds, will increase the production of resident waterfowl species. When the restored nesting habitat is properly managed, large, ground predators are less effective in preying on eggs and young of waterfowl and other ground nesting birds. Managing agricultural lands to increase forage for waterfowl and other wildlife will increase the overwinter survival rates of wildlife and strengthen them for migration, thus improving breeding success (Madrone and Assoc. 1980)

REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS

TARGET 1: Improve the survival of chinook salmon and steelhead in Butte Creek by helping to install positive-barrier fish screens (◆◆◆).

PROGRAMMATIC ACTION 1A: Improve the survival of juvenile chinook salmon and steelhead in Butte Creek by helping to the install screened portable pumps as an alternative to the Little Dry Creek diversion.

PROGRAMMATIC ACTION 1B: Increase the survival of juvenile chinook salmon and steelhead in Butte Creek by helping local interests to install positive-barrier fish screens at the Durham-Mutual Diversion Dam.

PROGRAMMATIC ACTION 1C: Increase the survival of juvenile chinook salmon and steelhead in Butte Creek by helping local interests to install positive-barrier fish screens at Adams Dam.

PROGRAMMATIC ACTION 1D: Increase the survival of juvenile salmon and steelhead in Butte Creek by helping local interests to install positive-barrier fish screens at Gorrill Dam.

PROGRAMMATIC ACTION 1E: Increase the survival of juvenile salmon and steelhead in Butte Creek by evaluating the need to install a positive-barrier fish screen at White Mallard Dam.

PROGRAMMATIC ACTION 1F. Increase the survival of juvenile salmon and steelhead in the Sutter Bypass by evaluating the need to install positive barrier fish screens on diversions.

RATIONALE: *Diverting, storing, and releasing water in the watershed directly affects fish, aquatic organisms, and nutrient levels in the system and indirectly affects habitat, foodweb production, and species abundance and distribution. Diversions cause water, nutrient, sediment, and organism losses. Seasonal and daily water release patterns from storage may affect habitat, water quality, and aquatic organism survival. Flood control releases into bypasses also cause adult and juvenile fish stranding.*

DAMS AND OTHER STRUCTURES

TARGET 1: Improve chinook salmon and steelhead survival in Antelope Creek by developing a cooperative program to reduce the use of seasonal diversion dams by 50% during the late spring, early fall, and winter (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate the reduced use of seasonal diversion dams that may be barriers to migrating chinook salmon and steelhead in Antelope Creek by acquiring water rights or providing alternative sources of water.

TARGET 2: Develop a cooperative program to improve the upstream passage of adult chinook salmon and steelhead in Big Chico Creek by providing access to 100% of habitat located below natural barriers (◆◆).

PROGRAMMATIC ACTION 2A: Repair or reconstruct the fish ladders in Big Chico Creek to improve the upstream passage of adult spring-run chinook salmon and steelhead trout.

PROGRAMMATIC ACTION 2B: Repair the Lindo Channel weir and fishway at the Lindo Channel box culvert at the Five Mile Diversion to improve upstream fish passage.

TARGET 3: Develop a cooperative approach to ensure unimpeded upstream passage of adult spring-run chinook salmon and steelhead in Mill Creek (◆◆◆).

PROGRAMMATIC ACTION 3A: Cooperatively develop and implement an interim fish passage corrective program at Clough Dam on Mill Creek until a permanent solution is developed cooperatively with the landowners.

TARGET 4: Develop a cooperative program to improve the upstream passage of adult spring-run chinook salmon and steelhead in Butte Creek to allow access to 100% of the habitat below the Centerville Head Dam (◆◆◆).

PROGRAMMATIC ACTION 4A: Increase the opportunity for the successful upstream passage of adult spring-run chinook salmon and steelhead on Butte Creek by developing a cooperative program to evaluate the feasibility of removing diversion dams, providing alternative sources of water, or constructing new high-water-volume fish ladders.

PROGRAMMATIC ACTION 4B: Improve chinook salmon and steelhead survival and passage in Butte Creek by cooperatively developing and evaluating operational criteria and potential modifications to the Butte Slough outfall.

PROGRAMMATIC ACTION 4C: Increase chinook salmon survival in Butte Creek by cooperatively helping local interests to eliminate stranding at the drainage outfalls in the lower reach.

RATIONALE: *Dams and their associated reservoirs block fish movement, alter water quality, remove fish and wildlife habitat, and alter hydrological and sediment processes. Other human-made structures may block fish movement or provide habitat or opportunities for predatory fish and wildlife, which could be detrimental to fish species of special concern.*

HARVEST OF FISH AND WILDLIFE

TARGET 1: Develop harvest management strategies that allow the wild, naturally produced fish spawning population to attain a level that fully uses existing and restored habitat. Focus the harvest on hatchery-produced fish (◆◆◆).

PROGRAMMATIC ACTION 1A: Control illegal harvest by providing increased enforcement efforts.

PROGRAMMATIC ACTION 1B: Develop harvest management plans with commercial and recreational fishery organizations, resource management agencies, and other stakeholders to meet the target.

PROGRAMMATIC ACTION 1C: Reduce the harvest of wild, naturally produced steelhead populations where necessary by marking hatchery-reared fish and instituting a selective fishery.

PROGRAMMATIC ACTION 1D: Evaluate a marking and selective fishery program for chinook salmon.

RATIONALE: *Restoring and maintaining chinook salmon and steelhead populations to levels that fully take advantage of habitat may require restrictions on harvest during, and even after, the recovery period. Stakeholder organizations should help to ensure a balanced and fair allocation of available harvest. Target population levels may preclude existing harvest levels of wild, naturally produced fish. For populations supplemented with hatchery fish, selective fisheries may be necessary to limit the wild fish harvest, while hatchery fish harvest levels reduce their potential to disrupt the genetic integrity of wild populations.*

ARTIFICIAL PROPAGATION OF FISH

TARGET 1: Minimize the likelihood that hatchery-reared salmon and steelhead produced in Central Valley salmon and steelhead hatcheries will stray into non-natal streams to protect naturally produced salmon and steelhead (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate the benefits of stocking hatchery-reared salmon and steelhead in the Sacramento River and Battle Creek. Stocking may be reduced in years when natural production is high.

TARGET 2: Limit hatchery stocking if salmon or steelhead populations can be sustained by natural production (◆◆◆).

PROGRAMMATIC ACTION 2A: Augment fall chinook salmon and steelhead populations only when alternative measures are deemed insufficient for populations recovery.

TARGET 3: Minimize further threats of hatchery fish contaminating naturally produced chinook salmon and steelhead stocks (◆◆◆).

PROGRAMMATIC ACTION 3A: Adopt methods for selecting adult spawners for the hatchery from an appropriate cross-section of the available adult population.

RATIONALE: *Hatchery augmentation should be limited to protect recovery and maintenance of wild populations. Hatchery-reared salmon and steelhead may directly compete with and prey on wild salmon and steelhead. Hatchery fish may also threaten the genetic integrity of wild stocks by interbreeding with the wild fish. Although irreversible contamination of the genetics of wild stocks has occurred, additional protective measures are necessary to minimize further degradation of genetic integrity. Because of the extent of development on the Sacramento River and Battle Creek, stocking chinook salmon and steelhead may be necessary to rebuild and maintain stocks to sustain sport and commercial fisheries.*

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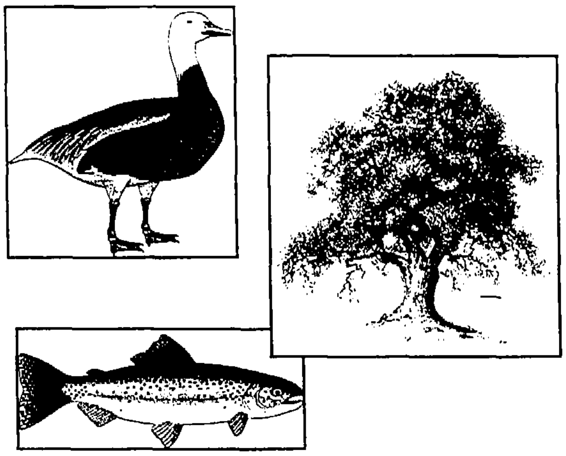
◆ Feather River/Sutter Basin Ecological Management Zone



Introduction

The Feather River/Sutter Basin Ecological Management Zone contributes to the health of the Sacramento-San Joaquin River Delta by sustaining ecological processes that support anadromous fish and other aquatic and terrestrial wildlife and plant habitats in this zone and in the Delta. Streamflow, sediment, and nutrients, including nitrogen, phosphorous, and organic detritus coming from this Ecological Management Zone, are all important to the Delta.

Chinook salmon, white sturgeon, green sturgeon, steelhead and lamprey are important anadromous fish species and striped bass and American shad are harvestable (sport) species that depend on healthy conditions in the Sacramento-San Joaquin Delta and Feather River/Sutter Basin Ecological Management Zones. The Feather River is important for spawning and rearing fall-run and spring-run chinook salmon, steelhead, white and green sturgeon, striped bass, and American shad. The Yuba River is important for fall-run chinook salmon, steelhead, and American shad, and potentially for spring-run chinook salmon. Bear River and Honcut Creek support small runs of fall-run chinook salmon. Sutter Bypass is an important migration route for spring-run and fall-run chinook salmon from Butte Creek. In most years, almost all populations of upper Sacramento River migratory fish are potentially affected by the Sutter Bypass. The bypass system (Tisdale, Colusa, and Moulton weirs) are configured such that at river flows exceeding approximately 22,000 cfs, flows begin to begin to be diverted into the bypass. During periods of high runoff, all flows above 30,000 cfs are diverted into the bypass. The Sutter Bypass also is an important spawning and rearing area for splittail, which migrate from the Bay-Delta each winter to spawn in flooded portions of the lower rivers, such as the Sutter Bypass. Under certain hydrologic conditions, bypass flooding may cause stranding and loss of juvenile fish and other aquatic resources.

Important ecological processes that would maintain or increase Feather River/Sutter Basin Ecological Management Zone health are:

- streamflow,
- coarse sediment supplies
- stream meander
- floodplain processes, and
- water temperature.

Important habitats include riparian wetlands, shaded riverine aquatic (SRA), freshwater fish habitat, and essential fish habitat. Seasonally flooded wetlands are common through the lower basin portions and are extremely important habitat areas for waterfowl, shorebird, and wading bird guilds. Important species include all runs of chinook salmon, steelhead trout, sturgeon, American shad, resident native fish guilds, waterfowl guilds, shorebird and wading bird guilds, and riparian wildlife guilds. Stressors, including flood control improvements, urbanization (floodplain encroachment), dams, legal and illegal fish harvest, insufficient flow in the lower portions of most streams, high water temperature during salmon spawning and egg incubation, poor water quality, stranding in flood bypasses and flood plains, hatchery stocking of salmon and steelhead, and unscreened or poorly screened water diversions, have affected the health of anadromous fish populations.

Description of the Management Zone

The Feather River/Sutter Basin Ecological Management Zone includes the following Ecological Management Units:

- Feather River Ecological Management Unit
- Yuba River Ecological Management Unit
- Bear River and Honcut Creek Ecological Management Unit, and
- Sutter Bypass Ecological Management Unit.

These units provide habitat for a wide variety of fish, wildlife, and plant species.

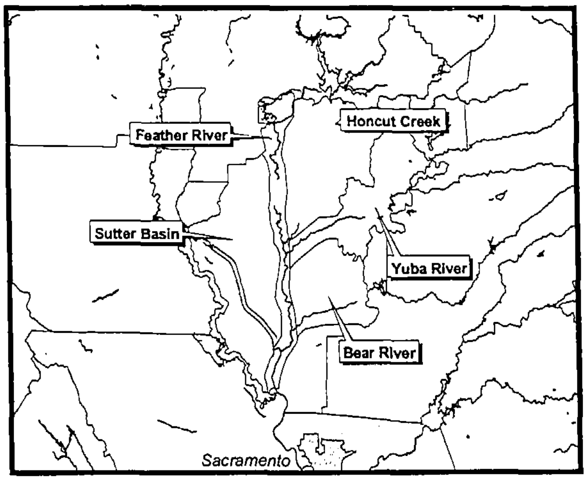
List of Species to Benefit from Restoration Actions in the Feather River/Sutter Basin Ecological Management Zone

- green sturgeon
- white sturgeon
- chinook salmon
- steelhead trout
- striped bass
- American shad
- lamprey
- splittail
- waterfowl
- neotropical migratory birds
- plants and plant communities.

Descriptions of Ecological Management Units

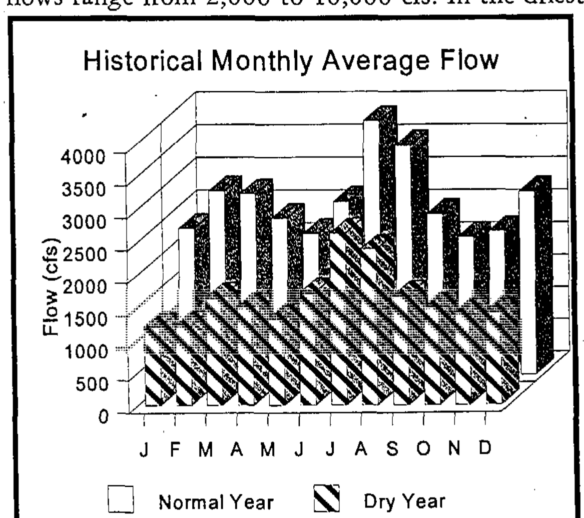
Feather River Ecological Management Unit

The Feather River, with a drainage area of 3,607 square miles, is the largest Sacramento River tributary downstream of Shasta Dam. Watersheds of the various forks drain high-elevation ranges of the Cascade Range and Sierra Nevada. Numerous storage reservoirs are located on the river, including Lake Almanor and Butt Valley Reservoir on the North Fork, Lake Davis and Bucks Lake on the Middle Fork, and Little Grass Valley Reservoir on the South Fork. Oroville and Thermalito Reservoirs are on the mainstem below the forks, and major water diversion take place at both reservoirs. The lower Feather River downstream of Oroville picks up the flow of major tributaries, including Honcut Creek, the Yuba River, and the Bear River.



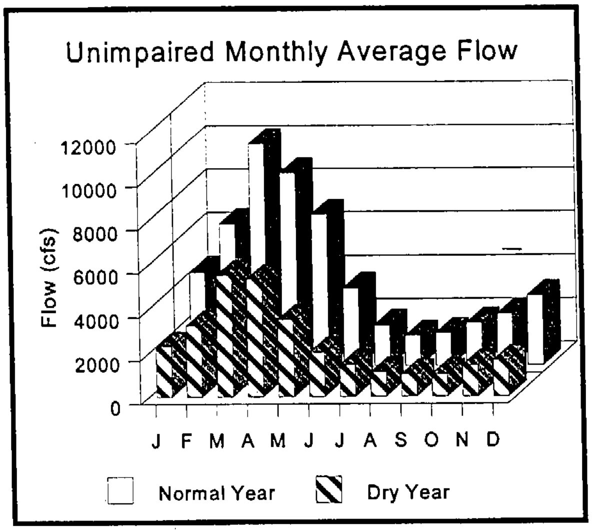
Location Map of the Feather River/Sutter Basin Ecological Management Zone and Units.

The Feather River has a natural (unimpaired) streamflow pattern typical of streams that drain the higher Cascade Range and Sierra Nevada elevations on the east side of the Sacramento Valley. Flows peak in winter and spring. Lower flows in summer and fall are sustained by snowmelt and foothill and mountain springs. In the wettest years, unimpaired monthly average flows in winter months average 24,000 to 48,000 cubic feet per second (cfs), whereas spring inflows are slightly lower at 18,000 to 28,000 cfs. In dry and normal years, winter and spring unimpaired flows range from 2,000 to 10,000 cfs. In the driest



Historical Streamflow on the Feather River below Oroville, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

years, unimpaired flows in winter months average 1,100 to 1,500 cfs and spring flows average slightly higher at 1,500 to 2,000 cfs. The lowest unimpaired flows are 800 to 1,000 cfs in August through October of the driest years. Summer and early-fall flows are normally 1,000 to 2,000 cfs, except in years of high rainfall, when they range from 2,000 to 6,000 cfs.



Unimpaired Streamflow on the Feather River at Oroville, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

The natural flow pattern has been altered by storage reservoirs in the middle and upper watersheds and diversions in the lower river. Comparing recent historical flows (1972 through 1992) and unimpaired flows for the same period near Oroville indicates impaired flow extent. With winter and spring inflows stored in reservoirs for summer and fall irrigation releases, there has been a shift in the river's flow pattern. In dry years, winter and spring flows have been reduced from 2,000 to 6,000 cfs to 1200 to 1,600 cfs. In normal years, the shift has been from 4,000 to 10,000 cfs to 2,000 to 3,000 cfs. In the driest years, winter and spring flows average about 800 to 900 cfs, compared to 1,100 to 1,500 cfs for unimpaired flow.

The opposite pattern is seen in summer and fall, when storage releases for irrigation increase base flows. Summer and fall flows in dry and normal years are approximately 50% to 60% higher than unimpaired flows. Highest flows are similar to unimpaired flows. In late summer and fall of driest years, unimpaired and historical flows are both in the 800 to 1,000 cfs range.

Oroville Reservoir, the lowermost reservoir on the Feather River, is the keystone of the State Water Project (SWP) operated by the California Department of Water Resources (DWR). Water is released from Oroville Dam through a multilevel outlet to provide appropriate water temperatures for the Feather River Hatchery and to protect downstream fisheries. Approximately 5 miles downstream from Oroville Dam, water is diverted at the Thermalito Diversion Dam into the Thermalito Power Canal, from there into the Thermalito Forebay and another powerhouse, and finally into Thermalito Afterbay. Water can be pumped from the Thermalito Diversion Pool back into Oroville Reservoir to generate peaking power. The Fish Barrier Dam, located approximately 1 mile below the Thermalito Power Canal intake, is the upstream limit of anadromous fish migration. The Oroville-Thermalito complex, completed in 1968, provides benefits to water conservation, hydroelectric power, recreation, flood control, and fisheries.

Feather River flows between the Thermalito Diversion Dam and the Thermalito Afterbay outlet are a constant 600 cfs. This river section is often referred to as the low-flow section. Water is released through a powerhouse, then through the fish barrier dam to the Feather River Hatchery, and finally into the low-flow section. Thermalito Afterbay serves both as an afterbay for upstream peaking-power releases to ensure constant river and irrigation canal flows, and as a warming basin for irrigation water being diverted to the rice fields. Because of warm water releases into the Feather River from Thermalito Afterbay, water temperatures in the approximately 14-mile section of salmon spawning area from the Thermalito Afterbay outlet to the mouth of Honcut Creek (referred to as the high-flow section) are higher than in the 8 miles

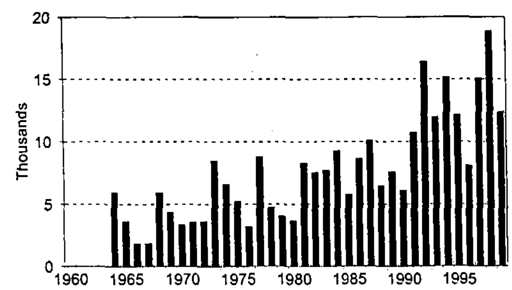
Oroville Dam on the Feather River (DWR Photo).

of the low-flow section. In recent years, the low flow section has been heavily used by fall-run chinook salmon spawners to the extent that overuse is a problem due to redd superimpostion (a situation in which fresh spawners dig up existing salmon nests in order to deposit their eggs).

Juvenile chinook salmon and other species of fish may become stranded on flood plain depressions, shallow ponds, and toe drains or borrow pits along the base of levees. In April 1998, thousands of young chinook salmon were found stranded in broad, shallow ponds on the flood plain near Nelson Slough. Stranding, under certain flow condition, may be a source of mortality to naturally produced chinook salmon in the Feather Basin. The losses probably occur from two sources, entrapment by which young fish are prevented from migrating downstream and through predation by resident warmwater gamefish such as largemouth black bass and other members of the sunfish family and predation by wading birds in the broad, shallow ponds. This flood plain stranding needs further evaluation, but limited engineering/technical evaluations indicate that many of the levee borrow pits could be hydrologically reconnected to the river to allow juvenile chinook to resume their seaward migration.

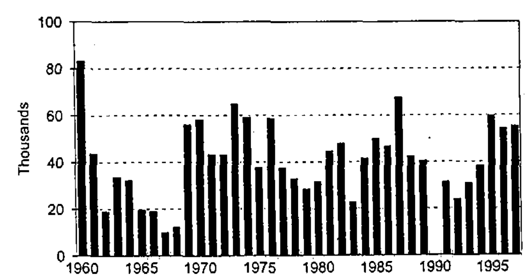
Important resources in the Feather River Ecological Management Unit include fall- and spring-run chinook salmon, steelhead, white and green sturgeon, striped bass, American shad, and lamprey. The Feather River Hatchery is the only Central Valley egg source for spring-run chinook salmon. Spring-run chinook salmon adults ascend the river in spring, hold over during summer in deep pools in the low-flow section, and are allowed into the hatchery in September. These fish are artificially spawned in the hatchery and also spawn naturally on the riffles in the low-flow section from late September to late October. Introgression (hybridization) of fall- and spring-run chinook salmon is a problem in the Feather River. About 20% of the tagged juvenile chinook salmon from females identified as spring run when returned were misidentified as fall-run. Similarly, about 29% of tagged juveniles from spring-run parents were misidentified as fall run when they returned as adults (Brown and Green 1997). A more recent analysis shows that in some years misidentification may be as high as 74%. Requirements for adult spring-run chinook salmon holding and early spawning influence the California Department of Fish and Game's (DFG's) water temperature and flow recommendations for the low-flow section.

Feather River spring-run chinook salmon population estimates during 1982 to 1991 averaged 2,800 fish. This is greater than the pre-project (i.e., SWP) average of 1,700 fish, primarily because of consistent cold-water deliveries to the hatchery and the low-flow section of the river. The Feather River spring-run chinook salmon's genetic status is uncertain. This stock may have hybridized with fall-run chinook salmon, but the extent of hybridization and the potential effect on spring chinook genetics in the Central Valley is unknown.



Fall-run Chinook Salmon Returns to Feather River Hatchery, 1964-1998 (CDFG 1999).

Most Feather River chinook salmon are fall-run fish that spawn in the low-flow section and below from October through December. As with spring-run fish, the present average run of fish returning to the hatchery and spawning in the river exceeds the pre-project population. In addition to spawning escapement, about 10,000 salmon (fall and spring runs combined) are harvested by anglers each year. During 1968-1993, Feather River Hatchery producéd about 7.4 million fall-run and 1.2 million juvenile spring-run chinook salmon and about 750,000 juvenile steelhead annually.



Fall-run Chinook Salmon Returns to the Feather River (excluding hatchery returns), 1960-1998 (CDFG 1999).

Feather River steelhead are primarily hatchery stock, natural production of juveniles in the low-flow section appears to be limited, possibly due to elevated water temperatures in summer or scouring of redds. The 2,000 steelhead hatchery mitigation goal is comparable to the present 10-year (1982 to 1983 through 1991 to 1992) average return to the hatchery of 1,454 steelhead and an angler catch in the Feather River estimated as high as 7,785 fish. Steelhead juveniles must remain in the river or be held in the hatchery for at least one year until they are large enough to begin their anadromous journey. Appropriate water temperature and flow in the low-flow section are vital to continued Feather River steelhead program success.

American shad ascend the Feather River to spawn from April through June. The number of shad in the river, and thus the success of anglers, depends on the relative flow magnitude at the mouth of the Feather and Sacramento Rivers. In the 1987 to 1992 drought, Feather River flows in April through June were relatively low and the number of shad returning to the river was lower than average.

Striped bass spawn in the lower Feather River downstream of the Yuba River's mouth from April through June. Striped bass are found in the river during much of the year with a peak occurrence in July and August. Lamprey enter in the spring and early summer to spawn and their young remain for up to several years before migration to the ocean.

YUBA RIVER ECOLOGICAL MANAGEMENT UNIT

The Yuba River watershed drains 1,339 square miles of the western Sierra Nevada slope and includes portions of Sierra, Placer, Yuba, and Nevada Counties. The Yuba River is tributary to the Feather River, which, in turn, feeds into the Sacramento River.

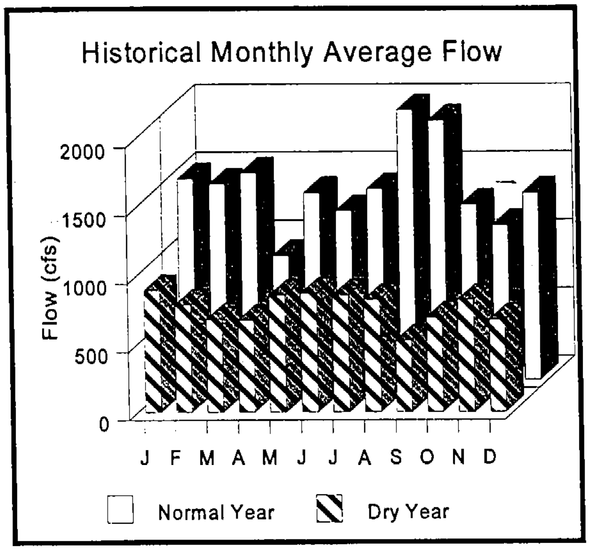
Three dams on the river have altered river flows and fish passage. Englebright Dam was built by the U.S. Army Corps of Engineers (Corps) in 1941 to collect placer mining debris that contributed to flooding in the Central Valley. Englebright Reservoir contributes storage capacity, hydropower, and cool, bottom-released water to the lower Yuba River. Most Englebright Reservoir water, the lowermost storage reservoir on the river and the upstream anadromous fish limit, is released through the Narrows 1 and 2 Englebright Dam powerhouses to generate hydroelectric power. The 0.2 mile of river between the dam and the two powerhouses has no flowing water unless the reservoir is spilling. The 0.7 mile of river from the Narrows 1 and 2 powerhouses to the Deer Creek mouth has steep rock walls; long, deep pools; and short stretches of rapids. Below this area, the river cuts through 1.3 miles of sheer rock gorge called the Narrows, forming a single large, deep, boulder-strewn pool.

The river canyon opens into a wide floodplain several miles beyond the downstream end of the Narrows, where large quantities of hydraulic mining debris remain from past gold-mining operations. This 18.5-mile section is typified as open-valley plain. Daguerre Point Dam, 12.5 miles downstream from Englebright Dam, is the major lower-river diversion point. The open plain continues 7.8 miles below Daguerre Point Dam to beyond the downstream Yuba Goldfields terminus. This section is primarily alternating pools, runs, and riffles, with a gravel and cobble substrate and contains most of the suitable lower Yuba River chinook salmon spawning habitat.

The remaining section of the lower Yuba River extends approximately 3.5 miles to its confluence with the Feather River. This river section is bordered by levees and is subject to Feather River backwater influence.

In the upper Yuba River watershed above Englebright Reservoir, storage reservoirs affect the natural flow pattern. The major storage reservoir is New Bullards Bar on the North Fork, with a storage capacity of about 1 million acre-feet (af) and a watershed area of 490 square miles. Fifteen other reservoirs have been constructed in the upper basin, with a combined storage capacity of 400,000 af. Power-generation diversions of about 100 cfs are made into the Feather River basin (from Slate Creek to Sly Creek), and about 600 cfs is diverted to the Bear River and Deer Creek watersheds for power and irrigation (from Lake Spaulding to Drum Canal and the South Yuba Canal). A major portion of the watershed is unregulated, however, and very high flows pass through Englebright Reservoir to the lower watershed during major storms.

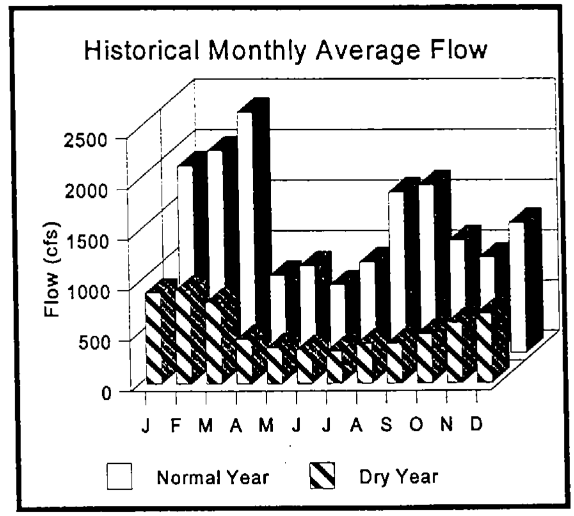
The natural, unimpaired flow pattern in the Yuba River is typical of Sacramento Valley tributaries with headwaters in the Sierra Nevada. Flows are highest in winter and spring, decreasing quickly in late spring. Annual inflow is highly variable. Basin inflows in winter months of years with the highest rainfall average 15,000 to 25,000 cfs, whereas inflow in the driest years averages 300 to 600 cfs. In the driest years, inflow in summer and early fall averages only 0 to 100 cfs. In dry and normal water years, average monthly inflows in summer and early fall are 200 to 600 cfs.



Historical Streamflows on the Yuba River below Englebright Dam, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

New Bullards Bar and Englebright Reservoirs store winter and spring flows and distribute water more evenly throughout the year and from year to year. Summer and early-fall irrigation releases are substantially higher than unimpaired flows. In the driest years, reservoir releases increase base flows in summer and early fall by 0 to 100 cfs to 70 to 260 cfs. In dry years, summer flows are 500 to 900 cfs compared to unimpaired flows of 190 to 230 cfs. Spring flows in dry and normal years are 300 to 900 cfs, as compared to unimpaired flows of 700 to 1,200 cfs. In years with the highest rainfall, flows are similar to unimpaired flows, averaging 10,000 to 20,000 cfs in winter months.

Diversions in the lower river, primarily from just above Daguerre Point Dam, reduce lower river flows during the irrigation season. Flows from August through October at Marysville are generally higher than unimpaired flows, whereas flows from March through June are substantially lower. In the driest years, summer flows are 70 to 90 cfs and winter flows are 190 to 230 cfs. Spring flows in dry years are 340 to 440 cfs compared to unimpaired flows of 800 to 3,700 cfs.

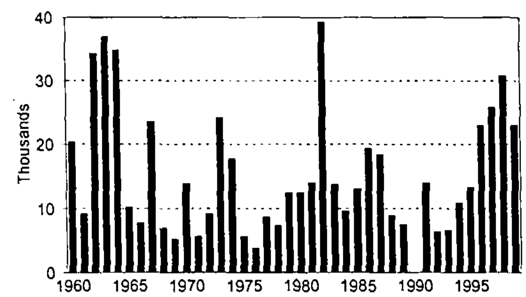


Historical Streamflow on the Yuba River at Marysville, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

The Yuba River is one of the most important Ecological Management Units in the Feather River/Sutter Basin Ecological Management Zone. The river supports highly valued populations of steelhead trout, resident rainbow trout, and fall-run chinook salmon, as well as populations of other anadromous and resident fish communities. The Yuba River is the only remaining wild steelhead fishery in the Central Valley. All other streams that have wild population, have population that are either so low that they do not support a fishery or are closed to angling. Spring-run chinook salmon abundance and status in the Yuba River is not known. Directed efforts are required to determine if it is a component of the fishery and whether additional management and restoration measures are required.

Fall-run chinook salmon is the most abundant anadromous fish species in the lower Yuba River. Historically, the Yuba River supported as much as 15% of the annual fall-run chinook salmon run in the Sacramento River system. Run sizes in the Yuba River have varied over the period of record (1953 to 1989), ranging from 1,000 fish in 1957 to 39,000 fish in 1982. Approximately 60% of those salmon spawned between Daguerre Point Dam and the Highway 20 bridge, with most of the remaining fish spawning above Highway 20 or below the dam.

Presently, fall-run chinook salmon spawning runs average 13,050 fish annually.



Fall-run Chinook Salmon Returns to the Yuba River, 1960-1998 (CDFG 1999).

Historically, there has been a small spring-run chinook salmon spawning population in the Yuba River. The run had almost disappeared by 1959, presumably because of diversions and hydraulic development projects. A remnant of the spring-run chinook salmon population persists in the lower Yuba River. It is maintained by fish produced in the river, salmon straying from the Feather River, and infrequent stocking of hatchery-reared fish by DFG (a practice that has been discontinued).

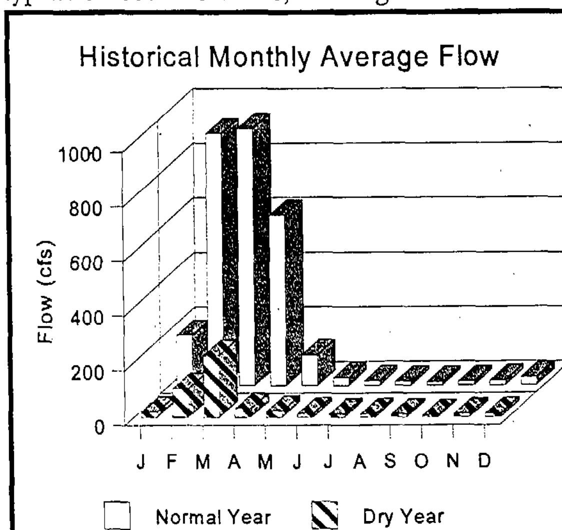
The lower Yuba River supports a seasonal American shad sport fishery from late April to July. The fishery is confined to the area between Daguerre Point Dam and its confluence with the Feather River. Studies have shown that the shad fishery on the Yuba River has declined significantly in the past two decades. The run was estimated at 30,000 to 40,000 spawning adults in 1968 and 40,000 adults in 1969. In recent years, however, the shad run has been only a fraction of that level. Daguerre Point Dam limits the upstream migration of American shad. The dam is equipped with two conventional pool-and-weir-type fishways. Shad do not generally enter fish ladders; therefore, most of the population is restricted to the river sections below the dam. Reduced flows below Daguerre Point Dam, particularly in spring and early summer, are a primary factor in the decline of the American shad run.

The three most significant diversions along the lower Yuba River are at or just upstream of Daguerre Point Dam. Water is generally extracted from late March through October. Hallwood Irrigation Company, Cordua Irrigation District, and Ramirez Water District share one diversion; the Brophy and South Yuba Water Districts share another; and Browns Valley Irrigation District operates a third. The combined diversions can reach a maximum of 1,085 cfs (see table below). Juvenile chinook salmon, and likely juvenile steelhead, are lost at all diversion intake structures because of impingement on screens, entrainment into unscreened diversions, or predation in the river adjacent to the intakes. Although losses at individual diversions may not be significant, the cumulative impact of all diversion-related losses may be substantial. DFG estimated that before 1970, approximately 200 steelhead trout spawned in the river annually, and the potential existed for about 2,000 spawning adults after completing New Bullards Bar Reservoir.

BEAR RIVER AND HONCUT CREEK ECOLOGICAL MANAGEMENT UNIT

The Bear River is the second largest tributary to the Feather River, with a watershed area of 300 square miles. It enters the Feather River at river mile (RM) 12, immediately upstream from the town of Nicolaus. Honcut Creek flows into the Feather River from a small foothill watershed approximately 15 miles below Thermalito. In highest rainfall years, winter flows average 3,400 to 5,600 cfs. In normal years, winter inflows are 600 to 800 cfs. In the driest years, watershed inflows average only 20 to 65 cfs in winter months and 0 cfs in all other months.

The natural or unimpaired Bear River flow pattern is typical of foothill streams, with high winter and



Historical Streamflow on the Bear River near Wheatland, 1962-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year)

Table 8. Diversion Rates in Acre-Feet per Month for the Major Water Districts Supplied by the Yuba County Water Agency on the Lower Yuba River

	Hallwood Irrigation Company	Corda Irrigation District		Ramirez Water District	Browns Valley Irrigation District		Brophy Water District	South Yuba Water District
Month	WR	WR	P	WR	WR	P	P	P
March	0	0	0	0	0	0	520	300
April	10,000	4,500	900	2,010	2,269	1,667	4,795	3,000
May	14,500	10,600	2,120	3,270	2,345	1,666	6,460	4,000
June	14,100	10,400	2,080	2,745	2,269	1,667	6,670	4,200
July	13,600	11,100	2,620	1,920	2,345	2,500	6,985	4,400
August	12,900	11,000	2,600	1,755	2,345	2,000	5,525	3,400
September	8,000	5,900	1,180	1,500	2,269	0	3,750	2,400
October	4,900	6,500	500	700	2,345	0	625	400
Total	78,000	60,000	12,000	13,900	16,187	9,500	35,330	22,100
Maximum cfs	275	--	275	75	38.2	42	230	150

Notes: WR = basic water right of water district.
P = purchase water through contract with Yuba County Water Agency.

spring flows and very low summer and fall flows in wet years. Summer and early-fall inflows remain near 0 cfs in dry and normal years. Honcut Creek has a similar unimpaired flow pattern that includes low annual flow in dry years and very low summer and fall flows in most years.

Bear River flows are almost entirely regulated by several storage reservoirs and numerous diversions. Camp Far West is the largest storage reservoir, followed by Rollins Reservoir in the upper watershed near Grass Valley and Auburn. The South Sutter Irrigation District (SSID) Diversion Dam is the largest diversion. Minimum flow releases below the diversion into the Bear River are 25 cfs in spring and 10 cfs during the rest of the year. Flows from June through December are generally 0 to 40 cfs except in the wettest years. Flows in years of high rainfall are similar to unimpaired flows from fall to spring, averaging 3,500 to 5,200 cfs in winter; summer flows are 30 to 50 cfs, compared to unimpaired flows of 70 to 150 cfs.

The upstream anadromous fish limit is the SSID Diversion Dam, approximately 15 miles above the Feather River confluence. The Bear River once supported substantial salmon and steelhead runs, but because of low flows in the lower river below the SSID Diversion Dam, no self-sustaining salmon runs presently exist, and the status of steelhead is unknown. Occasionally, when heavy fall rains and sufficient spillage take place at the SSID Diversion Dam, hundreds of fall-run chinook salmon and steelhead may ascend and spawn in the lower Bear River. In addition to the effects of Camp Far West Reservoir and the SSID diversion, other factors have contributed to streamflow problems in Bear River. These include numerous small water diversions and hydroelectric projects in the lower and upper watersheds. Agencies involved in these projects are the Nevada Irrigation District, Pacific Gas and Electric Company, Placer County Water Agency, and SSID. Portions of the water supply go to Auburn and Grass Valley. The proposed Garden Bar project, which would capture more of the winter streamflow for water supply, is currently inactive.

The major attribute of the Honcut Creek is its linkage to the District 10 area immediately north of Marysville. This area encompasses thousands of acres of private wetlands and flooded rice fields which provide important wintering and foraging habitat for waterfowl.

The Bear River and Honcut Creek Ecological Management Units are presently less ecologically important for anadromous fish species than the other units in this Ecological Management Zone because of the extensive water development and inadequate natural summer and fall base flows. In some years, these streams provide habitat for fall-run chinook salmon, steelhead, and resident native fish populations. The overall ecological health of the Bear River and Honcut Creek Ecological Management Units, however, is poor.

Sutter Basin Ecological Management Unit

The Sutter Bypass section of the Sutter Basin provides important waterfowl habitat and serves as a migratory route for salmon and steelhead in the upper Sacramento River and its tributaries, particularly Butte Creek. Salmon and steelhead migrating to Butte Creek use Butte Slough, which originates at the Butte Slough Outfall Gates and ends at the north end of the Sutter Bypass. The reach within the Sutter Bypass is generally referred to as the East and West Barrows and the connection with the Sacramento River is the Sacramento Slough. In wet years, when Sacramento River overflows into the bypass, both upstream-migrating adults and downstream-migrating juvenile salmon and steelhead use Butte Slough, the East and West Barrows, and Sacramento Slough. Native resident fish, including splittail, also use the bypass as spawning and rearing habitat. In wet years, some salmon, steelhead, and native resident fish may become stranded in isolated pockets and die when floodwaters recede from the bypass and respective overflow weirs (Tisdale, Colusa, and Moulton).

Sutter Bypass is also an important area for waterfowl and wildlife. The bypass has remnant riparian woodlands and wetlands and is part of the Sutter National Wildlife Refuge. Sutter Refuge is the only publicly owned waterfowl habitat in the Sutter basin. It consists of 2,590 acres of seasonally and permanently flood marsh and scattered uplands. Private duck clubs provide an 1,500 acres of habitat of which about 500 acres are natural wetland. Most of the private duck clubs and nearly all of the natural wetlands in this area are located in the Sutter Bypass (Central Valley Habitat Joint Venture 1990). The northern end of the bypass is connected to the extensive marshlands of Butte Sink. Large areas of the bypass are used to grow irrigated crops, such as rice.

Vision For The Ecological Management Zone

The vision for the Feather River/Sutter Basin Ecological Management Zone includes restoring and enhancing important fishery, wildlife, and plant communities by restoring ecological processes and habitats and reducing stressors. Attaining this vision requires restoring or reactivating important ecological processes that create and maintain fish, wildlife, and plant community habitats throughout the Ecological Management Zone.

The vision for this Ecological Management Zone focuses on maintaining and improving floodplain and flood processes, streamflow, coarse sediment recruitment and transport, and seasonally flooded aquatic habitats that provide important wintering areas for waterfowl and shorebird guilds. Actions to reduce stressors include the installation of screen on diversions, upgrading or installing fish passage facilities at diversion dams or other obstacles to fish migration, providing suitable water temperatures for summer rearing, reducing the extent of stranding loss of juvenile fish, and limiting the adverse effects of introducing hatchery fish on endemic aquatic species.

Hatcheries in this and adjacent Ecological Management Zones will be operated to preserve the genetic identity of endemic, naturally spawning chinook salmon and steelhead trout stocks. Hatchery-produced fish will be used to support sustainable ocean recreational and commercial fisheries and directed fisheries in the natal streams. Marking techniques will enable sport and commercial anglers to distinguish between hatchery-produced and naturally produced fish. Additional genetic analyses of the Feather River and Yuba River spring-run chinook populations are necessary to determine the value and role of these stocks in efforts to rebuild Feather River and other basin populations. In addition, the hatcheries may play an extremely important role in the propagation of genetically pure, wild spring-run chinook salmon and steelhead. These fish would be used to reestablish populations in areas that formerly supported the species.

Green sturgeon and white sturgeon use the Feather River for spawning, but additional studies are needed to identify and describe the species' habitat requirements and status in this basin. The Feather River could contribute more substantially to the overall sturgeon health and abundance if the species' life history and habitat requirements were known and habitat conditions maintained to benefit sturgeon along with other important species. Splittail would benefit from improvements in riparian and stream meander corridors, wetlands with connection to the rivers, and floodplain overflow basins and flood bypasses.

VISIONS FOR ECOLOGICAL MANAGEMENT UNITS

FEATHER RIVER ECOLOGICAL MANAGEMENT UNIT

The vision for the Feather River Ecological Management Unit is to improve natural spawning populations of spring- and fall-run chinook salmon and steelhead. This involves improving spring (March) flows below Oroville in dry and normal water-years, improving spring through fall base flows, providing suitable water temperatures for summer rearing, and improving spawning and rearing habitat in the lower river below Oroville. The vision also includes implementation of adaptive management components of monitoring and research to collect the scientific information required to best judge the merits of additional flows and the timing for additional flows that would provide the highest benefit for aquatic species and habitat maintenance.

The vision for the Feather River includes reactivating or maintaining important ecological processes that create and sustain habitats for anadromous fish. The Feather River must not only contribute substantially to the growth of many fish populations, but provide better support for naturally spawning steelhead, fall- and spring-run chinook salmon, American shad, white sturgeon and green sturgeon, lamprey, and striped bass. The most important processes include floodplain and flood processes and a natural streamflow pattern in the river, to which most of the anadromous and resident native fishes are adapted.

Higher, more natural spring flow events may encourage spring-run chinook salmon, steelhead, sturgeon, American shad, and striped bass move upstream into the Feather River during their traditional migrations in spring. Higher flows may also benefit juvenile fall-run chinook salmon migrating downstream and juvenile salmon migrating out of lower Feather River tributaries. These flows will also benefit stream-channel and riparian vegetation in the lower river and, consequently, will benefit fish. Improved riparian habitat will also benefit riparian-associated wildlife, such as those in the neotropical migratory bird guild. The added flows coming from the Feather River will also benefit juvenile salmon and steelhead from other Feather and Sacramento River tributaries in their journey through the lower Sacramento River below the Feather River and through the Delta and Bay.

Improving habitat in the lower Feather River will encourage natural production of these anadromous fish. Improving spawning habitat will increase young salmon and steelhead production. Restoring or maintaining stream-channel and riparian vegetation and reducing the extent of juvenile fish stranding will increase the survival and production of juvenile salmon and steelhead. Providing suitable water temperatures for summer rearing by managing cold water releases from Lake Oroville will significantly improve natural steelhead production.

YUBA RIVER ECOLOGICAL MANAGEMENT UNIT

The vision for the Yuba River is to improve spring streamflows for spawning runs of spring-run chinook salmon (potentially), steelhead, sturgeon, and American shad. These flows will also benefit downstream migration of juvenile fall-run chinook salmon, steelhead, and sturgeon. Improving streamflows will also benefit stream-channel and riparian habitat; native resident species, including splittail, that spawn farther downstream in the Feather River; and other species that reside further downstream in the Bay-Delta estuary. The vision also includes evaluation of gravel recruitment and sediment transport processes, stream-channel configuration, and riparian habitats in the lower Yuba River floodplain to improve anadromous and resident fish production and survival.

At present, sufficient stored water remains in the Yuba River system (in New Bullards Bar Reservoir) to help restore and maintain the river's anadromous fish runs. Providing the needed streamflow, temperature, and screens for the lower Yuba River will affect storage in the reservoir and require operation changes at diversions in the lower river. An early spring flow event in the lower river during dry and normal water years will improve upstream passage for spring-run chinook salmon, and improve spawning conditions for steelhead, sturgeon, and American shad. Such a flow event would also improve downstream migration conditions for juvenile fall-run chinook salmon, steelhead, and sturgeon. The higher flows will also improve natural stream-channel and riparian habitat conditions in the lower river, consequently benefitting fish as well as a variety of other aquatic and terrestrial wildlife species. Reducing mortality at diversions and improving stream-channel and riparian habitat will also improve fish production. Restoring or maintaining riparian habitat will provide substantial benefits to riparian-associated wildlife species in the neotropical migratory bird guild.

High water temperatures in late spring, summer, and fall in the lower river can be improved by constructing a multiple-level outlet on Englebright Dam. Water temperature control will also be improved by maintaining the stream channel configuration and riparian vegetation of the lower river. A channel with more diversity, including islands, backwaters, and shaded riverine aquatic habitat, will reduce river heating and provide cool-water refuges for juvenile fish. Reducing the number of ponds linked to the lower river (e.g., in the Yuba Goldfields) will reduce the input of warmer water. Encouraging the flow of cool groundwater from the Goldfields through small stream channels lined with riparian vegetation may not only reduce heating, but also provide cool-water refuges for juvenile steelhead. The potential benefits of constructing exclusionary devices to prevent adult chinook salmon and steelhead from entering the Goldfields should be evaluated.

Gravel sources will be protected and the natural supply supplemented where and when necessary. Existing and past gravel mining operations in the stream channel, which affect the natural fluvial sorting and cleansing of gravel and inhibit gravel recruitment downstream, will be changed to limit their effects.

Stream-channel and riparian habitat will be improved by promoting conservation of the lower river meander zone and active floodplain, rapidly phasing out gravel mining in the floodplain, and protecting shorelines and levee riparian vegetation from any damaging activities. Vegetation may need to be planted or the disturbed channel and floodplain regraded in certain areas to hasten and sustain recovery. Major efforts will be required to control or eradicate tamarisk and giant reed infestations, which prevent natural vegetation succession by native tree species. Improving the stream-channel configuration, such as shaded side channels and backwater areas that are heavily influenced by cool groundwater, will increase available spawning and rearing habitat and improve juvenile salmon and steelhead production in the lower river. Improving woody and other cover types in and along the stream margin will also increase juvenile salmon and steelhead production.

Steelhead and spring-run chinook salmon may greatly benefit from actions to restore access to historical holding, spawning and rearing areas upstream of Englebright Dam. Evaluations are needed on the extent and quality of habitat above Englebright Dam, the nature and quantity of sediments in the reservoir, the presence of any chemical contaminants in the sediments, and short- and long-term economic impacts. These evaluations are required so that decisions can be formulated regarding the efficacy of restoring fish access to stream reaches above Englebright Dam and are an integral element of the CALFED adaptive management approach to ecosystem restoration.

Stressors, such as unscreened diversions, fish passage problems, and illegal and legal harvest, should be reduced to improve health of salmon and steelhead populations. A cooperative will be developed program to evaluate the feasibility of screening irrigation diversions along the lower Yuba River. Upstream and downstream fish passage at Daguerre Point Dam should be improved and entrainment of juvenile steelhead into the diversion should be eliminate.

Measures being considered to reduce harvest of naturally produced chinook salmon in sport and commercial fisheries include restricting harvest and marking all hatchery-produced fish to permit selective harvesting of hatchery fish. Enforcement and public education measures will be undertaken to ensure that harvest rates for salmon and steelhead are minimal. The current practice of stocking spring- and fall-run chinook salmon and steelhead using fish reared in the Feather River Hatchery should be reconsidered. The ramifications of this practice for wild stocks in the Feather River and adjacent Central Valley watersheds require careful consideration. Efforts to evaluate the genetic integrity of spring-run chinook salmon stocks in the Feather River will be expanded to include fall-run chinook salmon and steelhead. Criteria used to select genetic types of adult salmon and steelhead for the hatchery will be carefully evaluated to minimize possibly damaging effects on the genetic integrity of wild populations in the Central Valley.

BEAR RIVER AND HONCUT CREEK ECOLOGICAL MANAGEMENT UNITS

The vision for the Bear River and Honcut Creek Ecological Management Units is to improve conditions for fall-run chinook salmon and steelhead by maintaining and improving stream-channel, riparian, and floodplain habitat; ensuring adequate spawning gravels; and, where possible, improving late-fall flows for adult salmon spawning migrations and late-winter flows to support young salmon emigrating from the river. In addition, improving gravel recruitment and riparian habitat would provide adequate habitat for salmon and steelhead in years when they use these streams. In addition to improving floodplain habitats, upper watershed health should be improved by reducing forest fuels and implementing other practices to protect streamflows, stream channels, and riparian habitat and minimize sediment input to the streams.

SUTTER BYPASS ECOLOGICAL MANAGEMENT UNIT

The vision for the Sutter Bypass Ecological Management Unit is to restore adequate streamflows, as well as stream channel, riparian, and wetland habitats in the floodplain, and to ensure passage of adult salmon migrating upstream through the Sutter Bypass and accessibility to floodplain spawning and rearing areas for splittail. In addition to improving conditions for migrating salmon and steelhead in the Sutter Bypass and eliminating stranding, actions taken to benefit salmon and steelhead will improve waterfowl and wildlife habitat in the bypass. Fish passage and unscreened diversion problems should be resolved where possible.

VISIONS FOR ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOWS: Streamflows shape stream channels. Riparian vegetation, provides habitat for fish, moderates water temperature in rivers, attracts anadromous fish to spawning streams, and transports young anadromous fish to downstream nursery areas in the Sacramento River, Bay-Delta estuary, and ocean. Streamflow in each of these rivers is impaired by upstream storage reservoirs and diversions, particularly in dry and normal rainfall years. A healthy streamflow pattern in the rivers and in the Sutter Bypass would emulate (imitate) the natural runoff pattern, with a late-winter/early-spring flow event and summer-fall base flows that maintain important ecological processes, functions, habitats, and important species. The vision for streamflows is to evaluate the ecological benefits of a short-term (10-day) flow event in late winter or early spring that typically occurred at least once in dry and normal years prior to water supply development on the rivers.

COARSE SEDIMENT SUPPLY: Gravel recruitment from basin watersheds is important to provide a natural stream channel configuration and stream substrate, as well as essential spawning gravels for salmon and steelhead. A natural sediment supply is also important to natural stream meander and to riparian habitat regeneration. Sediment transport and gravel recruitment has been eliminated below major dams in zone rivers. The vision is to supplement the gravel supply below major dams on the three rivers where needed for salmon and steelhead spawning habitat, riparian habitat, and natural stream channel and meander development.

STREAM MEANDER: In their floodplains, Central Valley rivers naturally meander through floodplain sediments, progressively eroding the next bank while adding to the previous bank. This process, called a stream meander, occurred in the stream corridors of the Feather, Yuba, and Bear Rivers. A natural stream meander process in the lower Feather, Yuba, and Bear River floodplains provides much of the habitat needed to support healthy riparian systems, wildlife, and aquatic species. Today, the natural meander process in each stream is inhibited by dams, bank protection, bridge abutments, flood control levees, and the reduction or elimination of natural coarse sediments now trapped behind the large dams. In some places, bank erosion occurs, but lack of sediment precludes adding to the previous banks. The vision is to restore a portion of the natural meander to the rivers by setting back levees where they are necessary and by removing structures from the floodplain where possible.

NATURAL FLOODPLAIN AND FLOOD PROCESSES: The Sacramento Valley formerly had many natural overflow basins that retained floodwaters, permitted sediment deposition, and provided fish and waterfowl habitat. Partially reactivating these important ecological functions will contribute to system health and provide for prolonged periods of natural streamflow and sediment input. Natural overflow basins would also supply important habitat for fish, including chinook salmon and splittail, as well as nesting and foraging habitat for many waterfowl. The vision is to restore natural overflow basins within the lower floodplains of the four rivers and Sutter Basin. This would provide additional flood control protection for other areas in this zone and downstream, as well as valuable natural wetland, riparian, and aquatic habitats for fish and wildlife.

CENTRAL VALLEY STREAM TEMPERATURES: Salmon and steelhead depend on cool water for their survival. In the Feather, Yuba, and Bear Rivers, salmon and steelhead are confined to the floodplains below the dams. Maintaining cool water below the dams is essential to maintaining salmon and steelhead in these rivers. Summer and early fall water temperatures in floodplains of these rivers are naturally warm, but are kept cool by cold-water releases from deeper bottom waters of the major reservoirs. The extent of cool water habitat below the dams depends on the amount of cold water released from the dams, the extent of shade along the river channels provided by riparian vegetation, and the amount of warm water discharge into the rivers from urban and agricultural drainage. Improving water temperatures below the major impoundments in this zone can contribute to ecological system health and promote sustainable fisheries. Steelhead and spring chinook particularly depend on cool summer water temperatures as they remain in the rivers through the summer. High fall water temperatures in the lower rivers hinder upstream migrations of fall-run chinook salmon and steelhead. The vision for water temperatures in these rivers is to provide sufficient summer and early-fall base flows from the dams and restore the riparian corridors and natural stream channel characteristics that limit river heating. Maintaining sufficient cool water storage in the reservoirs in droughts will also be important to maintain a minimum of cool-water habitat in the rivers.

VISIONS FOR HABITATS

SEASONAL WETLAND HABITAT: Seasonal flooding of leveed lands and flood bypasses provide important habitat for waterfowl, native fish, native plants, and wildlife. Flooding and draining seasonal wetlands also contributes to the aquatic foodweb. The vision is to increase the frequency and extent of over-bank flooding in the river floodplains and Sutter Basin.

RIPARIAN AND RIVERINE AQUATIC HABITATS: Riparian and shaded riverine aquatic habitats are important to the health of the rivers by providing shade, insects and organic debris important to the aquatic foodweb, and soil and bank protection. The riparian corridors and related riparian and shaded riverine aquatic habitats are impaired by lack of natural stream meander; river channel confinement by levees; and streamside vegetation loss to animal grazing, levee construction, and agricultural clearing. The vision is to improve and restore riparian habitat along the rivers and Sutter Bypass, where possible and needed.

FRESHWATER FISH HABITAT: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native and anadromous fish species. The lower reaches of the Feather, Yuba, and Bear rivers are typical of fall chinook salmon spawning streams (Moyle and Ellison 1991). The quality of freshwater fish habitat in these streams will be maintained through actions directed at streamflows, coarse sediment supply, stream meander, natural floodplain and flood processes, and maintaining and restoring riparian and riverine aquatic habitats.

ESSENTIAL FISH HABITAT: The Feather, Yuba, and Bear rivers have been identified as Essential Fish

Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). Key features of EFH to maintain or restore in these rivers include substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

AGRICULTURAL LANDS: Improving habitats on and adjacent to agricultural lands in the Feather River/Sutter Basin Ecological Management Zone will benefit native waterfowl and wildlife species. Emphasizing certain agricultural practices (e.g., winter flooding and harvesting methods that leave some grain in the fields) will also benefit many wildlife that seasonally use these important habitats.

VISIONS FOR REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS: Water diversions along the rivers and Sutter Bypass divert not only water but small fish. Many diversions are screened to reduce young fish losses. Reducing losses to screened and unscreened diversions will contribute to overall ecosystem health by promoting sustainable fisheries and higher population levels. The vision is to screen those diversions presently with no screens or with inadequate screens that where there is a potential to screen young fish in significant numbers, and for diversions where the fish screens are not operated continually throughout the irrigation season, to extend the operation throughout the period of diversion.

DAMS AND OTHER STRUCTURES: Instream structures can impair up- and downstream adult and juvenile fish passage. The vision for the Feather River/Sutter Basin Ecological Management Zone is that the connections between upstream fish holding, spawning, and rearing areas and the Sacramento River are improved and maintained to permit unobstructed or unimpaired fish passage. Fish passage at Daguerre Point Dam on the Yuba River needs to be improved to permit easier up and downstream passage for steelhead and chinook salmon. The vision also includes evaluating the potential of restoring access to historical habitats presently blocked by impassable dams.

HARVEST OF FISH AND WILDLIFE: The legal and illegal anadromous fish harvest in the river, estuary, and ocean constrains recovery of wild anadromous fish populations. Reducing the harvest would likely be necessary to allow recovery of wild populations to a healthy condition. The vision is to continue to take actions that will reduce the wild anadromous fish harvest and focus legal harvest on hatchery stocks of salmon and steelhead.

ARTIFICIAL PROPAGATION OF FISH: Stocking hatchery-reared salmon and steelhead in the Feather River supports important sport and commercial fisheries and helps to mitigate salmon and steelhead losses caused by large dams and reservoirs. Hatchery fish also supplement naturally spawning salmon and steelhead in the river. However, hatchery salmon and steelhead may impede the recovery of wild populations by competing with and preying on young wild fish and reducing the genetic integrity of the wild populations. The vision is to improve hatchery practices of adult fish selection, spawning, rearing, and release to minimize potential conflicts with naturally-spawning salmon and steelhead populations.

STRANDING: Biological and technical evaluations will be completed to fully assess the potential adverse effects of stranding and the resultant loss of juvenile chinook salmon. The vision is that stranding losses will be minimized such that stranding will not impair efforts to maintain self-sustaining populations of anadromous fish in the rivers and streams of this ecological management zone.

VISIONS FOR SPECIES

GREEN STURGEON: The vision for green sturgeon is to recovery the California species of special concern by maintaining and restoring population distribution and abundance to historical levels. Green sturgeon are known to inhabit and possibly spawn in the Feather River. Improved flows and stream channel and floodplain processes will benefit sturgeon populations through improved habitat and food supply. Higher peak late winter and spring flows will provide attraction for adult sturgeon moving upstream from the lower rivers, Delta, Bay, and ocean. Stream channel improvements will provide greater amounts and improved quality of spawning and early rearing habitat. Screening unscreened diversions will reduce young sturgeon losses to water diversions. Limiting the adult sturgeon harvest will also protect the populations.

WHITE STURGEON: The vision for white sturgeon is to maintain and restore population distribution and abundance to historical levels and support a sport fishery. White sturgeon are known to inhabit and possibly spawn in the lower Feather River. Improved flows and stream channel and floodplain processes will benefit sturgeon populations through improved habitat and food supply. Higher peak late winter and spring flows will provide attraction for adult sturgeon moving upstream from the lower rivers, Delta, Bay, and ocean. Stream channel improvements will provide greater amounts and improved quality of spawning and early rearing habitat. Screening unscreened diversions will reduce young sturgeon losses to water diversions. Limiting the adult sturgeon harvest will also protect the populations.

CHINOOK SALMON: The vision for chinook salmon is to recover all stocks presently listed or proposed for listing under ESA and CESA, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries. Spring- and fall-run chinook salmon will benefit from improved flows. Late-winter and spring flows will provide attraction for upstream migrating adult spring chinook and downstream migrating spring- and fall-run chinook. Summer and fall base flow improvements will benefit over-summering adult and juvenile spring-run chinook salmon, as well as upstream migrating fall-run chinook salmon. Improvements in wetland and riparian habitats; stream channel and meander; and coarse sediment recruitment will also improve spring- and fall-run chinook salmon spawning and rearing habitat. Screening unscreened and poorly screened diversions will improve young salmon production. Limiting harvest will help ensure adequate numbers of spawners.

STEELHEAD: The vision for steelhead trout is to recover this species listed as threatened under the ESA, and achieve naturally spawning populations of sufficient size to support inland recreational fishing and that use fully existing and restored habitat. Steelhead will benefit from improved peak flow events, especially in dry and normal years. Summer-fall base flows are needed to maintain over-summering juveniles and will also provide water temperatures low enough to allow juvenile steelhead to survive. Steelhead will also benefit from improved gravel spawning habitat, and stream rearing habitat, especially if summer river heating is reduced in the process. Screening unscreened and poorly screened diversions will improve young steelhead production. Limiting harvest to hatchery steelhead will help to protect wild steelhead.

Steelhead in the Feather River are supported by a hatchery propagation program at Feather River Hatchery. The hatchery program will continue, but improved environmental conditions in the river, the Sacramento River, and Delta will allow for more reliance on the wild, naturally spawning population.

GIANT GARTER SNAKE: The vision for the giant garter snake is to contribute to the recovery of this State and federally listed threatened species in order to contribute to the overall species richness and diversity. Protecting existing and restoring additional suitable wetland and upland habitats will be critical to achieving recovery of the giant garter snake. The proposed restoration of aquatic, wetland, riparian, and upland habitats in the Feather River/Sutter Basin Ecological Management Zone will help in the recovery of this species by increasing habitat quality and area.

STRIPED BASS: The vision for striped bass is to maintain healthy populations, consistent with restoring native species, to their 1980s level of abundance to support a sport fishery in the Bay, Delta, and tributary rivers. Striped bass will indirectly benefit from larger late winter, early spring flow events provided in the lower Feather River to benefit chinook salmon and steelhead. The higher flow will provide upstream attraction flows and improve transport of eggs from spawning areas in the lower Feather and Sacramento Rivers.

AMERICAN SHAD: The vision for American shad is to maintain a naturally spawning population, consistent with restoring native species, that supports a sport fishery similar to the fishery that existed in the 1960s and 1970s. Improved spring flows should benefit American shad runs in the lower Feather and Yuba Rivers. Greater magnitude flow events in spring will provide attraction flows for adults to lower river spawning areas. Higher spring through fall base flows should improve spawning and early rearing, post-spawning adult survival, and juvenile shad survival and downstream migration. Although

American shad require warmer temper tures for spawning, stream temperatures will be driven by the requirements of native chinook salmon and steelhead.

SPLITTAIL: The vision for splittail is to recover this federally listed threatened species. Improvements in the riparian and stream meander corridors, wetlands, and floodplain overflow basins will improve spawning and early rearing habitat of splittail and other native resident fish species. Improved late winter and early spring flows will provide attraction flows for upstream migrating adult splittail from the Delta, and improve transport of larvae splittail downstream to the lower rivers and Bay-Delta.

WATERFOWL: The vision for waterfowl is to maintain and restore healthy populations at levels that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses, through protection and improvement of habitats and reduction in stressors. Waterfowl will benefit from improved riparian corridors, floodplain overflow basins, and more wetlands.

PLANT SPECIES AND COMMUNITIES: The vision for plan species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland and riparian and riverine aquatic habitats.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Maintaining and restoring the health of the Ecological Management Units in the Feather River/Sutter Basin Ecological Management Zone will depend on the efforts of local and State water management agencies. Efforts in the Sutter Basin will be linked to activities of the California Waterfowl Association, Ducks Unlimited, The Nature Conservancy, and the California Rice Industry. Overall, these efforts will require cooperation from resource agencies, such as DFG, the California Department of Water Resources (DWR), the U.S. Fish and Wildlife Service (USFWS), and the National Marine Fisheries Service, as well as participation and support from the U.S. Bureau of Reclamation (Reclamation), the U.S. Natural Resources Conservation Service (NRCS), and other private organizations, water districts, and landowners. These groups will work together to maintain and restore streamflows and fish and wildlife habitat, reduce impacts of diversions, minimize poaching, and minimize habitat and water quality degradation in basin streams. Funding may be provided to enhance streamflows, reduce fish-passage problems, screen diversions, restore habitats, and increase California Fish and Game Code enforcement to protect recovering salmon and steelhead populations. The U.S. Army Corps of Engineers owns and operates the Daguerre Point Dam on the Yuba River and is undertaking evaluations to improve fish passage and fish screening opportunities.

CENTRAL VALLEY PROJECT IMPROVEMENT ACT

Restoring and maintaining ecological processes and functions in the Feather/Sutter Ecological Management Zone will augment other important ongoing and future restoration efforts for the zone. The program proposed by the Central Valley Project Improvement Act (CVPIA) will complement efforts of the USFWS's Anadromous Fish Restoration Program (USFWS 1997). The goal of the program is to double the average anadromous fish population that was produced naturally in the system from 1967 through 1991.

SALMON, STEELHEAD TROUT AND ANADROMOUS FISHERIES PROGRAM ACT (SB 2261)

The vision will also help the DFG to reach its goal, under this program, of doubling the number of anadromous fish that were produced in 1988.

CENTRAL VALLEY HABITAT JOINT VENTURE

The Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan have developed objectives for wetlands in the Butte Basin Ecological Management Zone. These objectives are consistent with the ERPP targets developed for this Ecological Management Zone.

UPPER YUBA RIVER STUDIES PROGRAM

The Upper Yuba River Studies Program is a stakeholder driven process directed by the Upper Yuba River Workgroup. The agreed upon purpose of the Program is to determine if the introduction of wild chinook salmon and steelhead to the Upper

Yuba river watershed is biologically, environmentally, and socio-economically feasible over the long term.

CALFED BAY-DELTA PROGRAM

CALFED has funded four ecosystem restoration projects in Feather River and Sutter Basin. One project screened the Browns Valley Irrigation District diversion. Another project developed a watershed plan for the Yuba River.

LINKAGE TO OTHER ECOLOGICAL MANAGEMENT ZONES

Many of the resource elements in the Feather River/Sutter Basin Ecological Management Zone depend extensively on conditions or elements in other zones. Anadromous fish, for example, are highly migratory and depend on conditions in the mainstem Sacramento River, the Delta, San Francisco Bay, and the nearshore Pacific Ocean. Because these fish are affected by stressors throughout their range, such as unscreened diversions, toxic contaminants, degraded water quality, and harvest, restoring populations in the Feather River/Sutter Basin Ecological Management Zone will require corresponding efforts in other zones.

Reducing or eliminating stressors in the downstream Ecological Management Zones and improving or recreating habitat in those zones are important steps in restoring healthy fish, wildlife, and plant communities in the Feather River/Sutter Basin Ecological Management Zone. Efforts in the Sutter Basin, particularly those relating to the Sutter Bypass and Butte Slough, will greatly benefit the other Ecological Management Zones and units of the upper Sacramento River.

RESTORATION TARGETS AND PROGRAMMATIC ACTIONS

ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOWS

TARGET 1: More closely emulate the seasonal streamflow pattern in the Feather River by providing March flow events of 4,000 to 6,000 cfs in dry years, 6,000 to 8,000 cfs in below-normal years, and 8,000 to 10,000 cfs in above-normal years. In addition, evaluating the minimum flows recommended by DFG (1993) will provide a basis to refine the flow needs in the Feather River better. Flow events will be provided only if they are less than or equal to Oroville Reservoir inflow (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate the benefits of supplemental Feather River flows to ecological processes and riparian and riverine aquatic habitats.

PROGRAMMATIC ACTION 1B: Evaluate alternative flow schedules in the Feather River to optimize the ecological benefits for fish and plant communities and ecological processes such as stream meander, sediment transport, and temperature control.

TARGET 2: Evaluate the potential benefits to increased natural production of salmon and steelhead in the Feather River of releasing 2,500 cfs from Oroville Dam during September through May and 1,100 cfs during June through August in wet and normal years, and 1,700 cfs during September through May and 800 cfs during June through August in dry years (◆◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to supplement Feather River flows with water acquired from new water sources, water transfers, and willing sellers in accordance with applicable guidelines or negotiated agreements.

TARGET 3: Supplement flows in the Yuba River with March flow events of 2,000 to 3,000 cfs in dry years and 3,000 to 4,000 cfs in normal years to improve conditions for all chinook salmon, steelhead, and American shad life stages. In addition, provide minimum flows recommended at Marysville by DFG (1993). See table below. Flows will be provided only if inflow to Englebright and New Bullards Bar Reservoirs is sufficient to meet the flow requirements (◆◆).

Minimum Streamflow Recommendations for Yuba River at Marysville

Period	Flow in All Water-Year Types
October 1-March 31	600-700 cfs
April 1-June 30	1,000 cfs minimum
July 1-September 30	450 cfs

PROGRAMMATIC ACTION 3A: Supplement flows in the Yuba River below Englebright Dam with water acquired from new water sources, water transfers, and willing sellers, consistent with applicable guidelines or negotiated agreements to provide flows recommended by DFG (1993) to improve conditions for all chinook salmon and steelhead life stages. See table above.

TARGET 4: Supplement flows in the Bear River to improve conditions for all chinook salmon and steelhead life stages. Provide a flow event of 300 to 500 cfs in dry years. See table below for recommended minimum streamflows (◆◆).

Minimum Streamflow Recommendations for Bear River

Month	Flows (cfs)
October 1-14	100
October 15-December 15	250
January-March	250
April-June	250
July-September	10

PROGRAMMATIC ACTION 4A: Supplement flows in the Bear River with water acquired from new water sources, water transfers, and willing sellers consistent with applicable guidelines or negotiated agreements to provide flows that will improve conditions for all chinook salmon and steelhead life stages.

RATIONALE: *The proposed March supplemental flows were selected as a representative value for impact analysis in the Programmatic EIS/EIR. Throughout the ERP, the need to determine optimal streamflow for ecological processes, habitats, and species is repeated. The issues of supplemental flows are complex in term of ecosystem improvements. The frequency, magnitude, duration, timing and rate of change of streamflows that form channels, create and maintain riparian habitat (including all species of vegetation), and promote all life stages of the various aquatic species dependent on a particular stream will never occur within a single year. An optimal flow regime will have to vary, perhaps significantly, from year to year. The supplemental flow recommendations will be an intensive exercise in adaptive management and must be based on credible scientific underpinnings.*

The streams in the Feather River/Sutter Basin Ecological Management Zone provide extremely valuable habitat for spring-run chinook salmon and steelhead trout. Key benefits of streamflow in this Ecological Management Zone are successful upstream of adult fish passage and downstream passage of juvenile fish. In addition, flow drives many ecological functions and processes linked to stream-channel morphology, riparian communities, and fish habitat. The best flow schedule for providing maximum ecological benefits in the Feather River has not been agreed upon. The California Department of Fish and Game (1993) recommended the following flows and temperatures below Thermalito Afterbay:

Period	Streamflow (cfs)	Temperature
Jan-Apr	2,000	56 °F
May 1 - 15	3,000	60
May 16 - June 15	4,000	60
June 16 - Oct 15	1,000	NF
Oct 16 - Dec 31	1,700	56

The increased flow in the DFG recommendation is partially designed to provide a large flow for American shad spawning. The temperature recommendation, however, is too low for shad as they require a spawning temperature about 5 ^{0}F higher than recommended.

Technical agreement on Feather River flows and temperatures has not been reached. This is an area that needs to be addressed by the CALFED approach to adaptive management. Additional monitoring and/or research may be required to develop consensus on these issues. The CALFED approach also goes beyond the flow and temperature requirements of anadromous fish by also including the flows needed for coarse sediment transport, overbank flooding, and riparian maintenance and regeneration. The recommended flow targets provide a basis for on-going and future evaluations using adaptive management as a tool to reach agreement.

Supplementing flows on the Yuba River by acquisition of water from willing sellers depends on whether or not there are any willing sellers. Findings from a detailed hydrologic and operations assessment *of the Yuba River system to develop water-year-type-specific instream flow recommendations indicate that, with the exception of wet years, insufficient water would be available within the system always to meet the recommended flows (Beak 1996). In years when flow augmentation is required, a decision will have to be made regarding use of acquired water in the spring to either meet DFG's recommendation of 1,000 cfs at Marysville during the April-June period, or to use this water to 1) provide higher flows and, therefore, greater thermal protection to steelhead during July-September, or 2) supplement flows during the October-December period to benefit fall-run chinook salmon spawning.*

Studies conducted in the lower Yuba River during 1976-1978 revealed that the lower Yuba River is not a season-long nursery area for American shad (Meinze 1979). That may reflect drought condition during part of the study period but the study did reveal that newly hatched shad fry are rapidly transported downstream and into the Feather River. Larvae are swept out by currents before they grow large enough to maintain their position in the river. Juvenile shad spend several weeks to several months in the Feather and Sacramento rivers and in the Delta, which is considered the primary rearing habitat for American shad (Painter et al. 1977, Painter et al. 1979, Meinze 1979, SWRCB 1992). Consequently, higher spring flows in the lower Yuba River may provide minimal increased benefits for young shad.

COARSE SEDIMENT SUPPLY

TARGET 1: Maintain existing erosion and gravel recruitment levels in tributaries that sustain an adequate level of gravel recruitment, or restore desirable levels by directly manipulating and augmenting gravel supplies where the natural fluvial process has been interrupted by dams or other features that retain or remove the gravel supply (◆◆).

PROGRAMMATIC ACTION 1A: Evaluate spawning gravel quality in areas used by chinook salmon and steelhead in the Feather River. If indicated, renovate or supplement gravel supplies to enhance substrate quality by importing 4,000 to 8,000 tons of additional gravel below the hatchery as conditions require.

PROGRAMMATIC ACTION 1B: Evaluate spawning gravel quality in areas used by chinook salmon and steelhead in the Yuba River. If indicated, renovate or supplement gravel supplies to enhance substrate quality.

PROGRAMMATIC ACTION 1C: Evaluate the quality of spawning gravel in areas used by chinook salmon and steelhead in the Bear River. If indicated, renovate or supplement gravel supplies to enhance substrate quality

RATIONALE: *Sediment transport is the process whereby flows carry away finer sediments that fill gravel interstices (i.e., spaces between cobbles). Gravel cleansing is the process whereby flows transport, grade, and scour gravel. Gravel transport and cleansing, by flushing most fines and moving bedload, are important processes to maintain the amount and distribution of spawning habitat in the Sacramento-San Joaquin River basin. Human activities have greatly reduced or altered these processes. Opportunities to maintain and restore these processes include changing water flow, sediment supplies, and basin geomorphology; removing stressors; or manipulating channel features and stream vegetation directly. Gravel deposits in Feather River/Sutter Basin Ecological Management Zone streams are essential to maintain spring- and fall-run chinook salmon, steelhead trout, and other resident native fish spawning and rearing habitats. Although additional evaluations are required to define the magnitude of flows required to move coarse sediments in each of the streams in this ecological management zone better, it appears that flows exceeding 20,000 cfs in the Feather River are probably sufficient to achieve this important ecological event.*

Opportunities to maintain and restore gravel recruitment include manipulating natural processes and controlling or managing environmental stressors that adversely affect recruitment.

STREAM MEANDER

TARGET 1: Preserve and expand the stream-meander belts in the Feather, Yuba, and Bear Rivers by adding a cumulative total of 1,000 acres of riparian lands to the meander zones (◆◆◆).

PROGRAMMATIC ACTION 1A: Acquire riparian and meander-zone lands by purchasing them directly or acquiring easements from willing sellers, or provide incentives for voluntary efforts to preserve and manage riparian areas on private land.

PROGRAMMATIC ACTION 1B: Build local support for maintaining active meander zones by establishing a mechanism whereby property owners would be reimbursed for lands lost to natural meander processes.

PROGRAMMATIC ACTION 1C: Develop a cooperative program to improve opportunities for natural meander by removing riprap and relocating other structures that impair stream meander.

RATIONALE: *Preserving and improving the stream-meander belts in the Feather River/Sutter Basin Ecological Management Zone will ensure that this important natural process is maintained. Typically, these reaches are important for spawning and rearing salmon and steelhead. A natural meander process will provide near-optimal habitat for spawning (through gravel recruitment), rearing (channel configuration, cover, and foodweb), and migration. There is limited potential for natural channel migration in narrowly leveed sections. Overall, the program must be consistent with flood control requirements and in the longer term, should reduce need for future flood control efforts by using natural system resilience and flood control characteristics.*

NATURAL FLOODPLAIN AND FLOOD PROCESSES

TARGET 1: Restore and improve opportunities for rivers to flood their floodplain seasonally (◆).

PROGRAMMATIC ACTION 1A: Conduct a feasibility study to construct setback levees in the Feather, Yuba, and Bear lower river floodplains.

PROGRAMMATIC ACTION 1B: Restore, as needed, stream channel and overflow basin configurations within the floodplain.

PROGRAMMATIC ACTION 1C: Minimize effects of permanent structures, such as bridges and diversion dams, on floodplain processes.

PROGRAMMATIC ACTION 1D: Develop a floodplain management plan for the Feather River.

PROGRAMMATIC ACTION 1E: Develop a floodplain management plan for the Yuba River.

PROGRAMMATIC ACTION 1F: Develop a floodplain management plan for the Bear River.

PROGRAMMATIC ACTION 1G: Develop a floodplain management plan for the Sutter Basin and Sutter Bypass.

RATIONALE: *Setback levees will provide greater floodplain inundation, room for stream meander, and more riparian forest and seasonal wetland habitats along the lower rivers. Channel configuration adjustments may be necessary to accelerate natural floodplain habitat restoration and to restore and maintain configurations that may not occur naturally due to remaining constraints from new setback levees. Permanent structures, such as bridges and diversions dams, can interrupt and impair natural floodplain processes and habitat development and succession. Thus, it may be necessary to remove or rebuild some structures or require continuing maintenance or mitigations to minimize their effects.*

CENTRAL VALLEY STREAM TEMPERATURES

TARGET 1: Improve water quality conditions in the Feather, Yuba, and Bear rivers to benefit anadromous fish (◆◆).

PROGRAMMATIC ACTION 1A: Develop and use a temperature model as a tool for managing the Feather River.

PROGRAMMATIC ACTION 1B: Maintain a daily average water temperature of 60°F in the low-flow section of the Feather River from June 1 through September 30 to benefit over-summering steelhead juveniles.

PROGRAMMATIC ACTION 1C: Develop a cooperative program to identify and remove physical and water quality barriers in the Feather River that impede access for white and green sturgeon to spawning habitat, or facilitate passage around these barriers.

PROGRAMMATIC ACTION 1D: Develop a cooperative program to maintain mean daily water temperatures below 65°F for at least 1 month from April 1 to June 30 for American shad spawning in the Feather River. This is consistent with actions to protect chinook salmon and, steelhead and, when hydrologic conditions are adequate, to minimize adverse effects on water-supply operations.

PROGRAMMATIC ACTION 1E: Develop a cooperative approach to operating reservoirs in the Yuba River watershed to provide adequate water temperatures for anadromous fish.

PROGRAMMATIC ACTION 1F: Evaluate whether improving water temperature control with shutter configuration and present coldwater pool management at New Bullards Bar Dam on the Yuba River are effective. Modify the water release outlets at Englebright Dam if these improvements are effective.

PROGRAMMATIC ACTION 1G: Maintain a daily average water temperature of 60°F from Englebright Dam to Daguerre Point Dam in the Yuba River from June 1 through September 30 to benefit over-summering steelhead juveniles.

PROGRAMMATIC ACTION 1H: Develop a cooperative program to maintain mean daily water temperatures below 65°F for at least 1 month from April 1 to June 30 for American shad spawning in the Yuba River. This is consistent with actions to protect chinook salmon and steelhead and, when hydrologic conditions are adequate, to minimize adverse effects on water-supply operations.

PROGRAMMATIC ACTION 1I: Develop a cooperative approach to providing adequate water temperatures in the Bear River (see following table) for all chinook salmon and steelhead life stages.

RATIONALE: *Aquatic species have very specific water temperature requirements that vary by stage in their life cycles. Water temperatures are typically high during the late summer and early fall, when water management flexibility below the major reservoirs is typically limited. Water temperatures should be addressed through integrated water and temperature management programs that seek to conserve cool water reservoir pools for release later in the summer and by investigating feasibility of modifying water release outlets on existing dams to provide a greater ability to utilize the cold water in the reservoir fully.*

Operating to provide specific water temperatures at the appropriate times in systems where aquatic resources have differing temperature requirements can be difficult. In situations where water temperature requirements may conflict, water temperature operations should first address the needs of listed species, then native species, and then introduced species. On the Feather and Yuba rivers, the water temperature requirements of anadromous salmonids (chinook salmon and steelhead) have priority. After their temperature needs are met, then the temperature requirements of American shad can be addressed.

Required Water Temperatures in the Bear River for Chinook Salmon and Steelhead

Month	Flows (cfs)	Temperature (°F)	
		Wheat-land	Highway 70
October 1-14	100	60	60
October 15-December 15	250	58	57
January-March	250	56	57
April-June	250	60	60
July-September	10	65	65

HABITATS

SEASONAL WETLANDS

TARGET 1: Assist in protecting 500 acres of existing seasonal wetland habitat through fee acquisition or perpetual easements consistent with the goals of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan (◆◆).

PROGRAMMATIC ACTION 1A: Develop and implement a cooperative program to improve management of 500 acres of existing, degraded seasonal wetland habitat in the Sutter Bypass Ecological Management Unit.

TARGET 2: Develop and implement a cooperative program to enhance 3,090 acres of existing public and private seasonal wetland habitat consistent with the goals of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan (◆◆).

PROGRAMMATIC ACTION 2A: Restore and manage seasonal wetland habitat throughout the Sutter Bypass Ecological Management Unit.

RATIONALE: *Restoring seasonal wetland habitats along with aquatic, permanent wetland, and riparian* *habitats is an essential element of the restoration strategy for the Feather River/Sutter Basin Ecological Management Zone. Restoring these habitats will also reduce the amount and concentrations of contaminants that could interfere with restoring the ecological health of the aquatic ecosystem. Seasonal wetlands support a high production rate of primary and secondary food species and large blooms (dense populations) of aquatic invertebrates.*

Wetlands that are dry in summer are also efficient sinks for the transformation of nutrients and the breakdown of pesticides and other contaminants. The roughness of seasonal wetland vegetation filters and traps sediment and organic particulates. Water flowing out from seasonal wetlands is typically high in foodweb prey species concentrations and fine particulate organic matter that feed many Delta aquatic and semiaquatic fish and wildlife. To capitalize on these functions, most of the seasonal wetlands of the Colusa Basin Ecological Management Zone should be subject to periodic flooding and overland flow from river floodplains.

RIPARIAN AND RIVERINE AQUATIC HABITATS

TARGET: Provide conditions for riparian vegetation growth along river sections in the Feather River/Sutter Basin Ecological Management Zone (◆◆).

PROGRAMMATIC ACTION 1A: Purchase streambank conservation easements from willing sellers or establish voluntary incentive programs to improve salmonid habitat and instream cover along the Yuba River.

PROGRAMMATIC ACTION 1B: Evaluate the benefits of restoring stream-channel and riparian habitats on the Yuba River, including creating side channels to serve as spawning and rearing habitats for salmonids.

PROGRAMMATIC ACTION 1C: Purchase streambank conservation easements from willing sellers or establish voluntary incentive programs to improve salmonid habitat and instream cover along the Feather River.

PROGRAMMATIC ACTION 1D: Purchase streambank conservation easements from willing sellers or establish voluntary incentive programs to improve salmonid habitat and instream cover along the Bear River.

RATIONALE: *Many wildlife species, including several listed as threatened or endangered under the State and federal Endangered Species Acts and several special-status plant species in the Central Valley, depend on or are closely associated with riparian habitats. Riparian habitats support a greater wildlife species diversity than all other habitat types in California. Riparian habitat degradation and loss has substantially reduced the habitat area available for associated wildlife species. Loss of this habitat has reduced water storage, nutrient cycling, and foodweb support functions.*

Improving low- to moderate-quality shaded riverine aquatic habitat will benefit juvenile chinook salmon and steelhead by improving shade, cover, and food. Wildlife in this Ecological Management Zone will also benefit from improved habitat. Protecting and improving shaded riverine aquatic habitat may involve changes in land use that will require the consensus of local landowners and local, State, and federal agencies. Limitations on land suitable or available for restoration will require establishing priorities, with efforts directed at acquiring high-priority, low-cost sites first.

FRESHWATER FISH HABITAT AND ESSENTIAL FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination (◆◆).

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitat and essential fish habitat. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of the Feather, Yuba, and Bear rivers* *and their floodplains, and in maintaining and restoring riparian and riverine aquatic habitats.*

AGRICULTURAL LANDS

TARGET 1: Cooperatively manage 57,578 acres of agricultural lands consistent with the objectives of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan (♦♦).

PROGRAMMATIC ACTION 1A: Increase the area of rice fields and other crop lands flooded in winter and spring to provide high-quality foraging habitat for wintering and migrating waterfowl and shorebirds and associated wildlife.

RATIONALE: *Following the extensive loss of native wetland habitats in the Central Valley, some wetland wildlife species have adapted to the artificial wetlands of some agricultural practices and have become dependent on these wetlands to sustain their populations. Agriculturally created wetlands include rice lands; fields flooded for weed and pest control; stubble management; and tailwater circulation ponds.*

Managing agricultural lands to increase forage for waterfowl and other wildlife will increase the survival rates of overwintering wildlife and strengthen them for migration, thus improving breeding success (Madrone Associates 1980)

Creating small ponds on farms with nearby waterfowl nesting habitat but little brood habitat will increase production of resident waterfowl species when brood ponds are developed and managed properly. Researchers and wetland managers with the DFG, U.S. Fish and Wildlife Service and the California Waterfowl Association have found that well managed brood ponds produce the high levels of invertebrates needed to support brooding waterfowl. Other wildlife such as the giant garter snake will also benefit. Restoring suitable nesting habitat near brood ponds will increase the production of resident waterfowl species.

Restoring nesting habitat, especially when it is near brood ponds, will increase the production of resident waterfowl species. When the restored nesting habitat is properly managed, large, ground predators are less effective in preying on eggs and young of waterfowl and other ground nesting birds. Managing agricultural lands to increase forage for waterfowl and other wildlife will increase the overwinter survival rates of wildlife and strengthen them for migration, thus improving breeding success (Madrone and Assoc. 1980)

REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS

TARGET 1: Improve the survival of juvenile anadromous fish in the Yuba River by installing, upgrading, or replacing fish screens (♦♦♦).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to upgrade or construct screens that meet current Department of Fish and Game and National Marine Fisheries Service screening standards at the Hallwood-Cordua and Brophy-South Yuba Canal water diversion, and other unscreened diversions on the Yuba River.

TARGET 2: Improve the survival of juvenile anadromous fish in the Bear River by installing, upgrading, or replacing fish screens (♦♦♦).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to evaluate and screen diversions in the Bear River to protect all anadromous fish life stages.

TARGET 3: Improve the survival of juvenile anadromous fish in the Feather River by installing, upgrading, or replacing fish screens (♦♦♦).

PROGRAMMATIC ACTION 3A: Develop a cooperative program to evaluate and screen diversions in the Feather River to protect all anadromous fish life stages.

RATIONALE: *Water diversion, storage, and release in the watershed directly affect fish, aquatic organisms, and nutrient levels in the system and indirectly affect habitat, foodweb production, and species abundance and distribution. Unscreened diversions cause direct mortality to young fish; the level of mortality is likely influenced by the number of young fish present, diversion size, and diversion timing.*

The fish screens on the water diversions at Daguerre Point Dam on the Yuba River (Hallwood-Cordua and Brophy-South Yuba Canal) are inadequate and do not meet current DFG or NMFS screening criteria

(DFG 1991). The Hallwood-Cordua Fish Screening Facility is funded and staffed by DFG, but because of limited funding, DFG does not operate the facility after the peak of chinook salmon emigration has occurred (sometime in June). Unscreened diversions continue throughout the summer and fall, and significant numbers of juvenile steelhead are entrained and lost. The Brophy-South Yuba diversion utilizes a rock levee to prevent fish from entering the diversion, however, the levee has been shown to be permeable to small fish even when the diversion is not operating, and significant numbers of juvenile chinook salmon are entrained (DFG 1991). Fully-functioning fish screens that meet current criteria and are adequately funded, staffed, and operated throughout the irrigation season need to be implemented at both diversions.

DAMS AND OTHER STRUCTURES

TARGET 1: Increase adult and juvenile anadromous fish passage in the Yuba River by providing access to 100% of the available habitat below Englebright Dam (◆◆◆).

Programmatic Action 1a: Develop a cooperative program to improve anadromous fish passage in the Yuba River by removing dams or constructing fish ladders, providing passage flows, keeping channels open, eliminating predator habitat at instream structures, and constructing improved fish bypasses at diversions.

PROGRAMMATIC ACTION 1B: Facilitate passage of spawning adult salmonids in the Yuba River by maintaining appropriate flows through the fish ladders or modifying the fish ladders at diversion dams.

TARGET 2: Increase the number of naturally produced chinook salmon and steelhead in the Yuba River drainage and contribute to each species long-term sustainability (◆).

PROGRAMMATIC ACTION 2A: Conduct a cooperative study to determine if introduction of wild chinook salmon and steelhead to the Upper Yuba River watershed is biologically, environmentally, and socio-economically feasible over the long term.

TARGET 3: Improve chinook salmon and steelhead passage in the Bear River by providing access to 100% of the available habitat below the SSID diversion dam (◆◆).

PROGRAMMATIC ACTION 3A: Improve chinook salmon and steelhead passage in the Bear River by negotiating with landowners to remove or modify culvert crossings on the Bear River.

RATIONALE: *Dams and their associated reservoirs block fish movement, alter water quality, remove fish and wildlife habitat, and alter hydrologic and sediment processes. Other structures may block fish movement or provide habitat or opportunities for predatory fish and wildlife, which could be detrimental to fish species of special concern.*

It is estimated that 82% to 95% of historical salmon and steelhead spawning and rearing habitat in the Central Valley has been lost due to impassable dams (Reynolds et al. 1993; Yoshiyama 1996). Perhaps the greatest potential for anadromous fish restoration in the Central Valley can be realized by reestablishing access to some of these former habitats, especially for those fish that are dependent upon habitat in mid- to upper-elevation stream reaches, such as steelhead and spring-run chinook salmon. Restoring access at Englebright Dam would allow salmon and steelhead to utilize a considerable amount of historical habitat in the Yuba River system, primarily in the South and Middle forks, and would have a substantial effect on restoration on a basin-wide level. Providing access to historical habitats could also reduce the reliance on low-elevation, valley-floor reaches that require large amounts of water to maintain suitable temperatures, thus could potentially reduce overall water costs for anadromous fish restoration. Compared to other major Central Valley tributaries, the Yuba River has greater potential than most to reestablish access to a substantial amount of former habitat. To resolve issues related to introducing anadromous fish to the watershed above Englebright Dam on the Yuba River, the Upper Yuba River workgroup has identified six key issues for feasible study. These issues include 1) condition of upstream habitat for anadromous fish, 2) affects of reoperating or modifying Englebright Dam on the condition of downstream habitat and fisheries, 3) economic effects and social impacts, 4) impact to water supplies, 5) impact to downstream flood control, and 6) quantity of sediments and heavy metals trapped by the dam.

HARVEST OF FISH AND WILDLIFE

TARGET 1: Develop harvest management strategies that allow wild, naturally produced fish spawning populations to attain levels that make full use of existing and restored habitat, and focus harvest on hatchery-produced fish (◆◆◆).

PROGRAMMATIC ACTION 1A: Control illegal harvest by increasing enforcement efforts.

PROGRAMMATIC ACTION 1B: Develop harvest management plans with commercial and recreational fishery organizations, resource management agencies, and other stakeholders to meet target levels.

PROGRAMMATIC ACTION 1C: Reduce harvest of wild, naturally produced steelhead populations, by continuing to mark all hatchery-reared fish and continuing to institute selective harvesting.

PROGRAMMATIC ACTION 1D: Evaluate a marking and selective fishery program for chinook salmon.

RATIONALE: *Restoring and maintaining chinook salmon and steelhead populations to levels that take full advantage of habitat may require restricting harvest during and after the recovery period. Involving the various stakeholder organizations should help ensure a balanced and fair harvest allocation. Target population levels may preclude existing harvest levels of wild, naturally produced fish. For populations supplemented with hatchery-reared fish, selective harvesting may be necessary to limit wild fish harvest while harvesting hatchery-produced fish to reduce their potential to disrupt the genetic integrity of wild populations. The Fish and Game Commission recently adopted DFG recommendations to establish a selective fishery for hatchery steelhead and to reduce incidental hooking of wild steelhead on all Central Valley streams.*

ARTIFICIAL PROPAGATION OF FISH

TARGET 1: To protect naturally produced salmon and steelhead, minimize the likelihood that hatchery-reared salmon and steelhead produced in the Feather River Hatchery will stray into non-natal streams (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate the benefits of stocking hatchery-reared salmon and steelhead in the Feather River. Stocking levels may be reduced in years when natural production is high.

TARGET 2: Reduce superimposition of chinook redds in the low flow section of the Feather River (◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to evaluate alternative means of reducing the number of spawners in the upper section and increasing the number of spawners in the high flow section below Thermalito.

TARGET 3: Limit hatchery stocking if populations of salmon or steelhead can be sustained by natural production (◆◆◆).

PROGRAMMATIC ACTION 3A: Augment fall-run chinook salmon and steelhead populations only when alternative measures are deemed insufficient to provide population recovery.

TARGET 4: Minimize further threats of hatchery-produced fish interbreeding with wild chinook salmon and steelhead stocks (◆◆◆).

PROGRAMMATIC ACTION 4A: Adopt methods for selecting spawning adults for the hatchery from an appropriate cross section of the adult population available to the hatchery.

RATIONALE: *In watersheds such as the Sacramento River and Feather River, where dams and habitat degradation have limited natural spawning, hatchery supplementation may be necessary to sustain fishery harvest at former levels and to maintain a wild or natural spawning population during adverse conditions, such as droughts. Hatchery augmentation, however, should be limited to protect recovery and maintain wild populations. Hatchery-reared salmon and steelhead may directly compete with and prey on wild salmon and steelhead. Hatchery-produced fish may also threaten the genetic integrity of wild stocks by interbreeding with wild fish. Although irreversible contamination of wild stocks has taken place, additional protective measures would minimize further degradation of genetic integrity. Development on the Sacramento and Feather Rivers might necessitate stocking of chinook salmon and steelhead to rebuild and maintain stocks that will sustain sport and commercial fisheries.*

Superimposition of chinook salmon redds in the low flow section of the Feather River is a problem that reduces the success of naturally spawning fish. The mechanisms leading to overuse of the low flow (upper) section of the Feather River are poorly understood. Potential causes may be linked to *hatchery release practices such as trucking to distant release sites, differing flows between the low flow and high flow stream reaches, or genetic history of fish using the upper section. Spring-run chinook have adapted to moving further upstream than their fall-run counterparts. The fall spawning chinook in the Feather River are know to by introgressed with spring-run which may provide one avenue of research to determine why the upper section is over-utilized by spawners while high quality spawning gravel in the high flow section is highly underutilized.*

STRANDING

TARGET 1: Reduce or eliminate the stranding of juvenile chinook salmon on floodplains, shallow ponds, and levee borrow areas (◆◆).

PROGRAMMATIC ACTION 1A: Conduct surveys of stranding in the Feather River under a range of flow conditions and develop recommendations to resolve the problem.

PROGRAMMATIC ACTION 1B: Conduct surveys of stranding in the Sutter Bypass under a range of flow conditions and develop recommendations to resolve the problem.

RATIONALE: *Under many flow conditions, stranding is likely a minimal problem. However, under conditions in which rivers reach high flows and flow is diverted into the flood bypasses, and then flow quickly recede, stranding is likely a serious problem. Timing also plays a important role in determining the severity of the problem. Flood plain inundation prior to young salmon emerging is less of a problem that inundation after most of the fry have emerged.*

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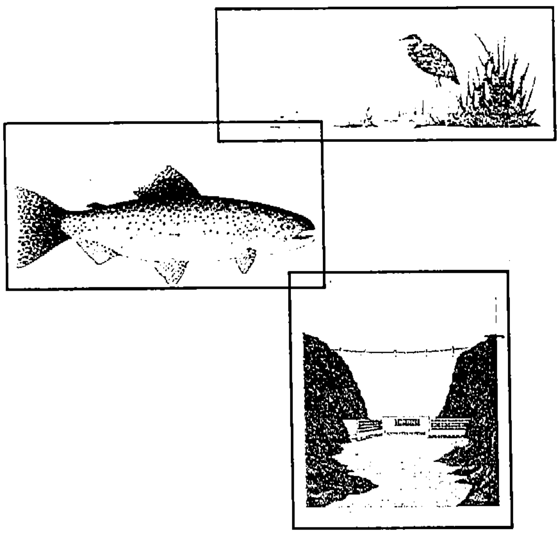
◆ AMERICAN RIVER BASIN ECOLOGICAL MANAGEMENT ZONE



INTRODUCTION

The American River Basin Ecological Management Zone is located east of the Sacramento River and lies between the Bear River to the north and the Cosumnes River to the south. The total watershed encompasses about 2,000 sq. mi. (California State Lands Commission 1993). The zone consists of several watersheds adjacent to and including the American River. These watersheds includes smaller creeks that drain into the Natomas Cross Canal (NCC), the Natomas East Main Drainage Canal (NEMDC), Morrison Creek, and the lower American River below Folsom and Nimbus Dams. The NCC and NEMDC form the watersheds of the American Basin including the Natomas Basin, located east of the Sacramento River between the Bear River and American River watersheds. Morrison Creek is a small watershed located just south of Sacramento and the American River that drains into the north-eastern portion of the Delta in the Stone Lakes area.

The health of the Sacramento-San Joaquin River Delta depends on the condition of the streams that make up its watershed. The American River is one of the largest tributaries within the Delta's watershed. The other streams of the basin are minor but potentially important contributors. Water, sediment, and nutrients from the American River and the other watersheds are important factors governing the ecological health of San Francisco Bay and Delta, including many estuarine fish species and their foodwebs. The American Basin was once an important wintering area of waterfowl the use the Central Valley portion of the Pacific flyway.

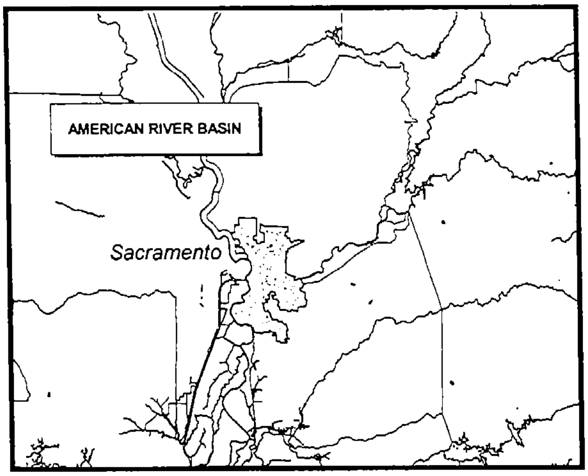
The American River is also an essential watershed for the spawning, rearing, and migrating fall-run chinook salmon, steelhead, striped bass, and American shad, which must pass through the Bay and Delta during portions of their life cycle. Although their period of residence in some cases (e.g., steelhead) in the Bay and Delta may be brief, it constitutes an important part of the life cycles of these fish species. Hence, the population status of these anadromous fish species is influenced by human activities that affect both their freshwater riverine and Bay-Delta estuarine habitats.

The two ecological factors with the greatest influence on anadromous fishes of the lower American River are seasonal stream flow and water temperature. In addition spawning gravel, stream-channel dynamics, shaded riverine aquatic (SRA) and riparian habitats also are important factors. Stressors such as dams, legal and illegal harvest, water quality (e.g., water temperature and toxins from urban runoff), and artificial propagation of anadromous fish further affect the population dynamics of anadromous fish in watersheds of the zone.

DESCRIPTION OF THE MANAGEMENT ZONE

The American Basin Ecological Management Zone is located in the east-central portion of Central Valley. Its eastern boundary is the Sierra foothills. The western boundary is the Sacramento River and Delta. The northern boundary is the Feather River Ecological Management Zone. The southern boundary is the Cosumnes River Ecological Management Zone. This Ecological Management Zone has two Ecological Management Units:

- American Basin, and
- Lower American River.



Location Map of the American River Basin Ecological Management Zone.

List of Species to Benefit from Restoration Actions in the American River Basin Ecological Management Zone

- fall-run chinook salmon
- steelhead trout
- splittail
- native resident fishes
- lamprey
- American shad
- giant garter snake
- neotropical migratory birds
- Swainson's hawk
- waterfowl
- non-native warmwater gamefish
- plants and plant communities.

Descriptions of Ecological Management Units

American River Basin Ecological Management Unit

The American River Basin Ecological Management Unit includes the watersheds between the American and Feather River systems on the east side of the Sacramento Valley. The streams included from North to South are Coon Creek, Markham Ravine, Auburn Ravine, Pleasant Grove Creek, Curry Creek, Dry Creek, and Arcade Creek. These creeks enter the floodplain drainage systems of the Natomas Cross Canal (NCC) and the Natomas East Main Drainage Canal (NEMDC) in southern Sutter and northern Sacramento counties. The NCC drains into the Sacramento River just south of the Feather River, while the NEMDC drains into the Sacramento River just to the north of the American River. The NEMDC watershed is comprised of the Dry Creek and Arcade Creek watersheds. Dry Creek's headwater watersheds include Linda Creek, Cirby Creek, Miners Ravine, and Antelope Creek, which come together and form Dry Creek near the City of Roseville in southern Placer County. Dry Creek then flows southwest through Sacramento County to the NEMDC in the City of Sacramento. The NCC watershed includes Coon Creek with its main tributary Doty Creek, Markham Ravine, Auburn Ravine with its main tributary Dutch Ravine, Pleasant Grove Creek, and Curry Creek.

Once large wetland areas, the American Basin floodplain is now principally rice fields in the north and central areas, with the metropolitan area of the City of Sacramento in the south. The Sacramento River levee marks the western boundary of the unit. The northern boundary is the Bear River watershed. The southern boundary is the American River watershed. The eastern boundary is the upper watersheds of the Bear and American Rivers. Above the floodplain the creeks pass through the rolling hills of Placer County, and the cities of Lincoln, Roseville, and Rocklin. This central portion of the creek watersheds is a mixture of agricultural lands, grasslands, and oak woodlands. The upper eastern portion of the unit consists of the upper watersheds of Coon Creek, Auburn Ravine, and Dry Creek that extend upslope into Sierra foothills near the City of Auburn. Here lands are a mixture of oak-pine woodlands and orchards, intermixed with other agricultural and municipal developments.

The unit has a Mediterranean climate with wet winters and dry summers. With only a maximum elevation of about 1,500 ft, little or no snow melt enters the upper watershed of the unit. The eastern foothill portion of the unit receives more rainfall (about 40 inches) than the valley portion (about 20 inches). Of the streams, Coon, Doty, Auburn Ravine, Dry Creek, Linda Creek, Miners Ravine, Secret Ravine, and Antelope Creek have sufficient summer flow from diversions from other basins, ground water, storm drains, irrigation returns, or sewage treatment effluent to be considered perennial. Water is also diverted from the upper Bear and American River watersheds into the Coon Creek, Auburn Ravine, and Dry Creek watersheds for irrigating lands in the American Basin.

Stream flows have been modified by water diversions, subsidence in ground water tables, and watershed activities such as grazing, road building, wetland management, forest management, and agriculture. In wetter periods all the streams are essential in carrying stormflow. Drains and ditches in the lower floodplain convey floodwaters to the NCC, NEMDC, and RD 1000 pumping plants on the Sacramento River.

In drier periods, creeks of the unit are used to carry drain water, convey irrigation water, or are intermittent. During the spring through fall irrigation season, much of the water in these streams is diverted along their paths to irrigation. In the lower floodplain, water is pumped into the basin from the Sacramento River and dispersed through the system of irrigation canals maintained by the Natomas Central Mutual Water Co. (NCMWC) for irrigation.

In all but wetter years, winter-spring rainwater is conveyed from the natural floodplain of the American Basin to the Sacramento River via the NCC, NEMDC, and drainage ditches. In wettest years large portions of the floodplain are subject to flooding from overtopping levees or simply filling with rainwater. Floodwaters are eventually drained and pumped to the Sacramento River.

The American Basin Ecological Management Unit has two distinct geomorphological areas: the hilly east side in the Sierra Foothills and the valley floodplain on the western side adjacent to the Sacramento River. The western portion of the unit in the Sacramento Valley floodplain is best described as an agricultural belt with some managed wetlands. Most of the land is in rice production and is 20 to 30 feet of elevation or less.

The NCC's northern extension, the East Side Canal, and its southern extension, the Pleasant Grove Creek Canal capture the flows of the creek's of the NCC watershed and convey them to the NCC and west to the Sacramento River. The NCC has a capacity of 22,000 cfs, which in high water years is insufficient to carry flood flows, thus water tends to back up into the lower creek drainages despite channel capacities totaling 36,000 cfs. The NEMDC captures the flows of Dry and Arcade Creeks and conveys them to the Sacramento River just upstream from the mouth of the American River.

Lands west of Pleasant Grove Creek Canal and the NEMDC to the Sacramento River are in the Natomas Basin. These lands and those west of the East Side Canal were once floodplain marshes connected to the Sacramento River, and are now protected from flooding by levees and a series of drainage canals operated by Reclamation District 1000 that drain rainwater, floodwaters, and irrigation return water back to the Sacramento River via a system of drainage ditches and pumping stations. In the southern portion of Natomas Basin there are extensive developments including the Sacramento Metropolitan Airport, Arco Arena, Interstate Highways 5 and 80, and the City of Sacramento. Of the approximately 50,000 acres in Natomas Basin, approximately 40,000 are croplands (mostly rice), 5,000 are urban, 1,500 are roads, 1,500 are vacant, and 3,000 are wetlands or open water.

East of the Natomas Basin and East Side Canal the floodplain extends up the watersheds of the creeks. Rice field dominate the low lands, while grasslands and oak woodlands with mixed agriculture and pasture lands occur between the creek bottoms. Elevation rises gradually from west to east from 30 feet to about 100 feet elevation. Lincoln, Roseville, and other Sacramento suburbs are located in this portion of the unit.

Further to the east begins the foothills to the east of Lincoln, Roseville and Sacramento. Here the watersheds of Coon Creek, Auburn Ravine, and Dry Creek tributaries rise quickly to elevations near 1,000 feet near the City of Auburn in Placer County. The creeks flow through forested ravines. The hills are a mixture of orchards, woodlands, grasslands, pastures, and other agricultural and municipal developments. In some locations the creeks are dammed creating small ponds and wetlands. Some areas have quality riparian forests, while others are degraded from livestock grazing or other land use activities.

Important habitats in the unit are wetlands, riparian forests, and grasslands. Marshes, once the most widespread habitat in the American Basin floodplain, are now restricted to remnant patches. There have been extensive reclamation of emergent wetland habitat to agricultural development. Most of the remaining wetlands lack adjacent upland transition habitat and other attributes of fully functioning wetlands. Seasonal wetlands include portion of the floodplain that flood in winter and spring, especially in high rainfall years. Most of this habitat is located in the Valley floor adjacent to the Sacramento River. Seasonal wetlands once covered large areas of the Basin during the winter rainy season or after seasonal flooding. With reclamation, flooding occurs primarily from accumulation of rainwater behind levees, from inflow to the basin of flood waters carried by the foothill creeks, or from water diverted to leveed lands (e.g. rice lands and managed wetlands). Seasonal wetlands are important habitat to many species of fish, waterfowl, shorebirds, and wildlife. Vernal pool habitat is common in the central and eastern portion of the floodplain.

Riparian habitat, both forest and shrub, is found on the water and land side of levees and along creek channels of the unit. This habitat ranges in value from disturbed (i.e., sparse, low value) to relatively undisturbed (i.e., dense, diverse, high value). The highest value riparian habitat has a dense and diverse canopy structure with abundant leaf and invertebrate biomass. The canopy and large woody debris in adjacent aquatic habitat provide shaded riverine aquatic habitat on which many important fish and wildlife depend on during some portion of the life cycles. The lower value riparian habitat is frequently mowed, disced, or sprayed with herbicides, disturbed by livestock grazing and watering, resulting in a sparse, habitat structure with low diversity. Riparian habitat is used by more wildlife than any other habitat type. From about 1850 to the turn of the century most of the riparian forests in the Central Valley were decimated for fuelwood as a result of the gold rush, river navigation, and agricultural clearing. Remnant patches are found on levees, along stream channels, and along the margins of marshes. Riparian habitats and their adjacent shaded riverine aquatic habitat benefit many species of fish and wildlife. There is little riparian habitat in the western, floodplain portion of the unit. Riparian habitat is more prevalent along the creeks from the valley floor to the basin headwaters, but suffers in places from effects of livestock grazing and watering, as well as urban development.

Upland habitats are found on the eastern floodplain and foothills and consist primarily of grasslands and oak woodland and oak savanna. Of these perennial grasslands are an important transition habitat for many wildlife species and are buffers to protect wetland and riparian habitats. Much grassland habitat associated with wetland and riparian habitat has been lost to agriculture (i.e. pasture, grain, vineyards, and orchards) and development (i.e., airports, sports complexes, industrial parks, home construction, golf courses). Grasslands are important buffers of wetland and riparian habitat and provide habitat for many plant and animal species.

Agricultural habitats are also important habitat as they support populations of small animals, such as rodents, reptiles, and amphibians, and provide opportunities for foraging shorebirds, waterfowl, and raptors. Nonflooded fields and pastures are also habitat for pheasants, quail, and doves. Preferred habitat of raptors consists of tall trees for nesting and perching in proximity to open agricultural fields, which support small rodents and insects for prey. Both pasture land and alfalfa fields support abundant rodent populations. Rice lands provide invertebrates and amphibians for shorebirds, waterfowl, and snakes.

Important biological resources in this Ecological Management Unit include the giant garter snake, Swainson's hawk, fall-run chinook salmon, steelhead, waterfowl, as well as many other native plants and wildlife found within the diversity of habitat types. Though creeks of the basin contain chinook salmon and steelhead in small numbers, the creeks are primarily warm water habitats that sustain largemouth and smallmouth bass, catfish, sunfish, suckers, and minnows including squawfish and carp.

The giant garter snake (GGS) is a State and federally listed threatened species whose habitat is marsh lands with adjacent uplands used for shelter from flooding and winter hibernation. There have been numerous observations of the GGS in this unit. They appear to do well in the systems of drainage and irrigation canals and rice fields, and other seasonal wetlands.

Swainson's hawks are a State listed threatened species found primarily along the riparian corridor of the Sacramento River on the west side of this unit. At one time they were likely found in the riparian corridors of the floodplains of the creeks of this unit. They forage widely over the unit in grasslands and agricultural areas.

Wild juvenile fall-run chinook salmon have been found in small numbers in Coon Creek, Doty Creek, Auburn Ravine, and the upper creek watersheds of Dry Creek, including Secret Ravine, Antelope Creek, and Miners Ravine. Juvenile salmon raised in the Feather and American River hatcheries have been stocked since 1983 in several streams including Coon Creek, Auburn Ravine, and tributaries of Dry Creek. With Bear and American water present in many of these creeks, salmon from these rivers may stray into the creeks of the American Basin. Both Coon Creek and Auburn Ravine have been stocked with fingerling fall-run chinook salmon during the 1990s. Dry Creek, Auburn Ravine, Doty Ravine, Secret Ravine, and Coon Creek received plants of Feather River spring-run chinook salmon in the mid 1980s. Adult salmon carcasses have been observed in Antelope Creek, Miners Ravine, and Secret Ravine in the late fall. In 1963 and 1964 DFG surveys indicated 300-800 wild fall-run chinook salmon spawned successfully in Secret Ravine, where spawning gravels were once adequate for over 1,000 salmon. DFG surveys indicate that Doty Ravine has sufficient spawning habitat for 400 salmon redds. Salmon are limited by low flows and high water temperatures in the fall during the upstream migration of adults and in the spring during the downstream migration of juveniles.

Rainbow trout/steelhead fry have been found in Coon Creek, Auburn Ravine, Dry Creek and, tributaries of Dry Creek, particularly Secret Ravine and Miners Ravine. Adult steelhead have been observed in Auburn Ravine and steelhead smolts have been found in Dry Creek, Secret Ravine, and Miners Ravine. Steelhead/rainbow trout require cool waters and sufficient flow through the summer and fall to sustain their populations. Such habitat still exists in the upper watersheds of these creeks. Inter-basin diversions into these creeks from the Bear and American River watersheds probably helps sustain steelhead.

Native fishes resident in the creeks of the unit include Sacramento squawfish, Sacramento sucker, hitch, California roach, and hardhead. These fish are adapted to higher winter-spring and low summer fall flows and warmer summer-fall water temperatures of the creeks.

Splittail migrate from the Bay-Delta into the lower rivers to spawn in late winter and early spring. They seek flooded lands to spawn including those of the Yolo and Sutter Bypasses. In wet years they likely migrate upstream into the lower NCC and NEMDC and spawn in flooded portions of creeks of this unit.

LOWER AMERICAN RIVER ECOLOGICAL MANAGEMENT UNIT

The American River is a major tributary to the Sacramento River, with their confluence located at the City of Sacramento. It provides approximately 15% of the total Sacramento River flow. The American River ranges in elevation from 23 feet to more than 10,000 feet and drains a watershed of approximately 1,900 square miles. Average annual precipitation in the watershed ranges from 23 inches on the valley floor to 58 inches at the headwaters. Approximately 40% of American River flow results from snowmelt. The American River has three major branches: the South, Middle, and North Forks, all of which drain into Folsom Reservoir. Average historical unimpaired runoff at Folsom Dam is 2.8 million acre-feet (af).

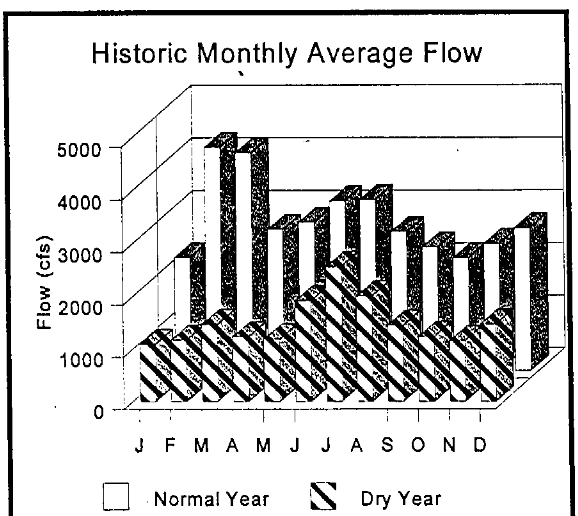
The American River meanders through a 4,800-acre floodplain that is bordered, for the most part, by low bluffs in its upper course and levees along its lower course. Most of the floodplain between the levees and opposite the bluffs has been acquired by either the City or County of Sacramento and is managed cooperatively as the American River Parkway. The lower American River, below Nimbus Dam, is also listed as a State and federal Wild and Scenic River and designated as "recreational".

Development on the American River began in the early days of the Gold Rush when numerous small dams and canals were constructed. Today, the drainage has three major and 10 smaller reservoirs with a total storage capacity of 1.9 million af. Folsom Lake, the largest reservoir in the drainage, was constructed in 1956 and has a storage capacity of 974,000 af. Proposed additional water project developments in the basin are the 2.3-million-af Auburn Dam and the 225,000-af South Fork American River project. Folsom Dam, located approximately 30 miles upstream from the mouth of the American River, is a major element of the federal

Central Valley Project (CVP), operated by the U.S. Bureau of Reclamation (Reclamation) as an integrated system to meet contractual water demands and instream flow and water quality requirements.

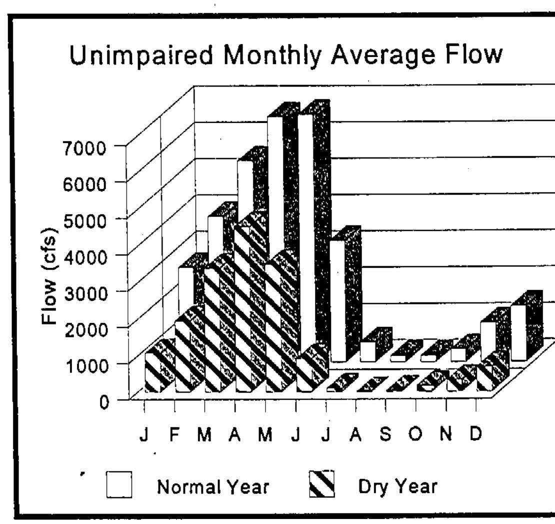
The American River has a natural pattern of moderate flows in winter, high flows in spring, very low flows in summer, and low flows in fall. This pattern is atypical of northern Sacramento Valley streams, which are fed by springs from the Cascade Range, and more similar to San Joaquin River tributaries. Flows in the Sacramento River and tributaries usually peak in March, whereas flows on American and San Joaquin River tributaries peak progressively later in spring from north to south. Natural (unimpaired) flows on the American River in dry and normal rainfall years generally peak from March to May.

Annual rainfall in the watershed is also highly variable. In the wettest years, unimpaired flows average 20,000-34,000 cubic feet per second (cfs) in winter months. In the driest years, unimpaired flows in winter months average only 200-800 cfs. Unimpaired spring flows, particularly in March through May, are generally more dependable, ranging from 1,300-1,500 cfs in driest years, 3,500-4,500 cfs in dry years, and 5,000-6,500 cfs in normal years. Unimpaired flows during summer and early fall are 0 cfs in the driest years, increasing to 1,000-6,000 cfs in the wettest years. In median rainfall years, unimpaired summer and early fall flows are generally 100-500 cfs.



Historic Monthly Average Flow on the American River below Nimbus Dam, 1962-1992 (Dry Year Is the 20th Percentile Year; Normal Year Is the 50th Percentile or Median Year)

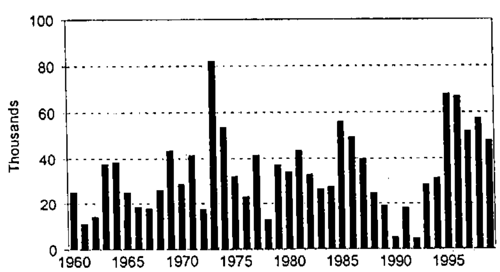
Because the watershed contains 13 reservoirs, the natural flow pattern of the lower American River has been altered extensively. Spring flows have been greatly reduced, summer and fall flows have increased substantially, and winter flows are relatively unchanged. Annual variability has been reduced by the release of water from Folsom Reservoir in drier years. Peak average monthly flows in high rainfall years remain unchanged from unimpaired flows. Summer and early fall flows in the driest years average 300-900 cfs, whereas unimpaired flows average 0 cfs. Dry- and normal-year flows in summer and early fall months consistently average 1,200-3,200 cfs, whereas unimpaired flows average less than 500 cfs. Fall and winter flows have increased slightly in dry and normal years. Spring flows (March through May) have decreased from an unimpaired level of 3,500-4,500 cfs to 1,200-1,500 cfs in dry years. In normal rainfall years, spring flows are 2,800-4,200 cfs, compared to unimpaired flows of 5,500-6,800 cfs. A similar decline in spring flows has occurred in wet years.



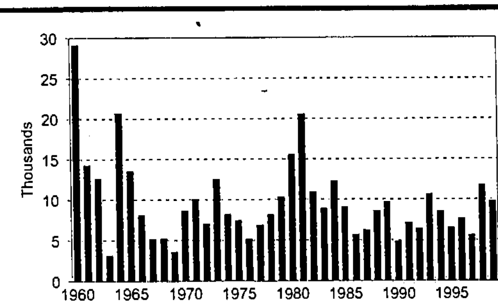
Unimpaired Monthly Average Flow on the American River below Nimbus Dam, 1962-1992 (Dry Year Is the 20th Percentile Year; Normal Year Is the 50th Percentile or Median Year)

Important aquatic resources that depend on the Lower American River and its riparian habitats include naturally spawning fall-run chinook salmon, steelhead, American shad, other native fish assemblages, amphibian populations, and lower trophic organisms. Important aquatic habitats include holding, spawning, rearing, and migration habitats for all fish species; sufficient quantities of high-quality water at the appropriate temperature; and riparian and SRA habitats.

The American River historically supported steelhead trout and chinook salmon that spawned principally in the upper watershed above the valley floor. There is historical documentation of chinook salmon in the North, Middle, and South forks, and steelhead in the North Fork and Middle Fork as far upstream as the rubicon River (Yoshiyama et al. 1996). Each population probably exceeded 100,000 fish. Salmon and steelhead runs have declined significantly in the lower American River because of the combined effects of dams blocking traditional spawning and rearing areas (nearly all of the steelhead historical spawning and rearing habitat is located above Nimbus Dam (McEwan and Nelson 1991), altered seasonal flow regimes resulting from dam operations, severe flow fluctuations that dewater redds and strand juveniles, and high water temperatures during crucial periods of salmon and steelhead development.



Fall-run Chinook Salmon Returns to the American River (excluding returns to Nimbus Hatchery), 1960-1999 (CDFG 1999).



Fall-run Chinook Salmon Returns to Nimbus Hatchery on the American River, 1960-1999 (CDFG 1999).

Historically, over 125 miles of riverine habitat were available for anadromous fish in the American River system. Since the 1890s a dam, which included a semi-functional fish ladder which passed relatively low numbers of spring-run chinook salmon and steelhead, was located at Folsom. A relatively large run of fall-run chinook salmon became established in the reach of the river below the old Folsom Dam (Clark 1929). Counts of steelhead passing through the fishway on the old Folsom Dam from 1943 to 1947 indicate that the majority of the steelhead were spring-run which ranged in number from 200 in 1944 to 1,252 in 1948 (USFWS and CDFG 1953). These fish passed through the fishway from May through July en route to their upstream spawning and rearing areas. In 1950, flood waters destroyed the ladder, eliminating upstream spawning and rearing areas and in 1955 Nimbus Dam was closed and became the upstream terminous of anadromous fish migration. The native spring-run steelhead was probably eliminated at this time.

Decision 893 (D-893), issued by the California State Water Resources Control Board (SWRCB), established the minimum allowable riverflow in the lower American River as 500 cfs from September 15 through December 31 and 250 cfs from January 1 through September 14. This flow regime is inadequate to maintain anadromous fish in the present spawning and rearing areas of the lower American River below Nimbus Dam. Except for drought years such as 1976-77 and water-years 1989-1992, flows have seldom dropped to these minimum levels.

Since Folsom Dam and Reservoir were constructed, Reclamation has made releases that are legally constrained by the outdated fish flow requirements of D-893, which allows flows in the river during dry years to be as low as 250 cfs. Nevertheless, Reclamation voluntarily releases amounts sufficient to meet D-1400 (discussed below) when water is available. In recent years, Reclamation has made an attempt to voluntarily implement the flow objectives established by the Anadromous Fish Restoration Program (AFRP).

SWRCB Decision 1485 (D-1485) established water quality standards for the Delta that require additional releases from upstream storage facilities, including Folsom Reservoir. Reclamation has relied on releases from Folsom Reservoir to help meet the standards imposed by D-1485 because of its location near the Delta and the high probability of refill in the winter. This change in operation has reduced the carryover storage in Folsom Reservoir, which has resulted in less cold water being retained through summer and fall in the reservoir. This, in turn, has often resulted in high summer and fall water temperatures (above 70°F) in the lower American River.

In 1993, the Sacramento Area Flood Control Agency (SAFCA) prepared and distributed environmental documentation associated with operating to a new flood control diagram, known as the 400-670 Variable Flood Control Diagram. As part of the SAFCA work to provide a net beneficial effect to the salmonid resources of the American River, water temperature modeling and hydrologic modeling were conducted to evaluate the beneficial effect of the shutter reconfiguration at Folsom Dam.

The California Department of Fish and Game's recently completed the Lower American River Steelhead Management Plan identifies poor habitat conditions in the lower American River as a problem for steelhead. Cold water temperatures cannot be maintained year round in the lower American River because of the limited amount of cold water present in Folsom Reservoir that is available for releases to the river. In addition, the practice of clearing trees and other objects from the river to eliminate hazards to recreationists reduces instream cover for juvenile steelhead rearing in the river.

Among the most significant factors affecting the American River ecosystem are altered natural runoff patterns, impaired channel maintenance processes, and loss of connectivity between upstream spawning and rearing habitats and the lower river following construction of Folsom and Nimbus Dams. These changes have resulted in the following:

- exclusion of salmon and steelhead from many of their historic upstream spawning and rearing areas,
- altered seasonal river flow and water temperature,
- significant reduction in high-quality spawning and rearing habitats,
- armoring of existing instream gravel resources,
- elimination of natural stream meanders, and
- loss of islands and riparian vegetation.

Because of these changes, the lower American River is managed to provide or emulate, as much as possible, the conditions that formerly existed upstream of Folsom Dam.

Other important habitats have been severely disrupted by water storage and diversions, as well as levee construction and maintenance. Rapid flow fluctuations strand salmon and steelhead eggs and juveniles on higher terraces and in side channels. The present condition of migration, spawning, and nursery habitat for American River salmon and steelhead limits and impairs recruitment and survival of juvenile fish. Boating and rafting safety programs remove woody debris and overhanging SRA habitat from the river, thereby reducing the quality of important rearing habitats

Rearing habitat quality for young salmon and steelhead also has been reduced by low flows and associated high water temperatures, especially in drought years. Folsom Dam has a limited capacity for selective withdrawal of cold water from deeper portions of the reservoir to control downstream water temperatures. At Nimbus Dam, turbine intakes draw in the heated surface waters of Lake Natoma rather than the cooler, deeper flows from Folsom Dam. When turbines are not operating at Nimbus Dam, heated surface water from Lake Natoma is released over spillways to the river below the dam.

Some of the gravel beds in the river below Nimbus Dam have either been washed downstream or become armored and, therefore, are no longer moved by seasonal peak flows. Floods wash gravel downstream or onto high terraces along the river, where it is of little value. Many natural side channels still retain the scars of extensive dredger mining from nearly a century ago; others have been eliminated and no longer provide nursery or rearing habitat for juvenile salmon and steelhead. In some cases the river is connected to former dredger ponds (e.g., near Arden Pond and at the Sailor Bar pond), that may increase already high river water temperatures locally, and can provide refuges for predatory, non-native warm water fishes such as smallmouth and largemouth bass. Reduced river flows, rip-rap bank protection, and levees contribute to the decline or impairment of natural sediment transport and channel maintenance processes, which have combined to substantially reduce natural gravel recruitment and transport in the river.

Another factor limiting production of naturally spawning salmon and steelhead is the presence of large numbers of native and non-native predators and competitors. The highly modified flow regime and altered instream habitat have provided potential advantages to striped bass, Sacramento squawfish, suckers, smallmouth and largemouth bass, resident trout, and American shad. Sport and commercial harvest also remove chinook salmon and steelhead adults from the natural spawning population.

VISION FOR THE ECOLOGICAL MANAGEMENT ZONE

The vision for the American River Basin Ecological Management Zone includes restoring important fishery, wildlife, and plant communities by restoring ecological processes, habitats and reducing the adverse affects of stressors. The vision for this Ecological Management Zone focuses on restoring an ecologically based streamflow plan, improving the supply and accessibility of sediments, maintaining the existing stream meander configurations, maintaining water temperatures in the lower American River to support anadromous fish, and supporting the development of locally sponsored watershed planning. The vision also encourages restoring a variety of aquatic, riparian, and terrestrial habitats for fish, wildlife, and plant communities.

VISIONS FOR ECOLOGICAL MANAGEMENT UNITS

AMERICAN BASIN ECOLOGICAL MANAGEMENT UNIT

The vision for the American Basin Ecological Management Unit includes improved water quantity and quality from the basin to sustain aquatic, wetland, riparian, and upland habitats that support natural production of an abundance of resident fish and wildlife, as well as waterfowl and other migrant birds that use the Pacific Flyway each winter. The vision includes improving, restoring, and enlarging areas of remaining native habitats and establishing connectivity of those areas. Native habitats include riparian, emergent wetlands, season wetlands, and grasslands.

The vision focuses on improving watershed, stream channel, and floodplain processes that would lead to increased seasonal flows of quality water in the creeks, and area wetlands, and reducing the input of agricultural waste runoff and associated contaminants into unit watersheds and wetlands, and the Sacramento River. Improvements in the quality and quantity of water supplies provided to publicly and privately managed wetlands will reduce stresses on waterfowl populations. Additional water quality improvements can be achieved by tertiary water treatment plants to improve effluent discharges. Improvements in water quality and quantity to unit creeks and the Sacramento River will directly benefit fish and wildlife of the Sacramento River and the Bay-Delta.

Floodplain habitat improvement would be the focus of efforts in the western portion of the unit. Riparian and stream channel improvements would be the focus of efforts in the middle and upper watersheds. Seasonal wetlands for migratory species such as waterfowl and shore birds would be expanded and improved. Present restoration efforts can be expanded by ensuring adequate supplies of high quality water to the seasonal wetlands. Water supplies can be improved by reducing or eliminating diversions in streams and sloughs that flow into wetlands. Restoring natural watershed, stream, and floodplain processes along creek watersheds will promote natural habitat restoration. Emphasis should also be placed on connecting habitats and providing habitat corridors necessary for species such as the giant garter snake, Swainson's hawk, waterfowl, and neotropical birds.

Throughout much of the central and upper (eastern) portion of the unit creek restoration would provide higher quality water and improved habitats for salmon and steelhead. Exclusion of cattle along the streams and creeks, limitation of gravel mining, and reduction of diversions would improve stream channels and riparian corridors. Reforestation of cottonwood and other riparian forest species has not been possible because cattle range through the creek bottoms and land owners divert water for irrigation. Facilitating passage at numerous seasonal dams would allow better access to upstream spawning and rearing habitat.

The narrow strips of grasslands and riparian vegetation along levees, irrigation canals, and drainage ditches would be protected and restored where possible. More environmentally sound means of applications of pesticides and herbicides will be sought throughout the unit. Vegetation control practices would be modified to support the recovery of native plants such as perennial grasses and wetland species. The health of the upper creek watersheds will be enhanced by reducing the potential for wildfires in riparian and forest woodlands through forest fuels management and improved fire suppression.

Limited wetland areas located in the eastern portions of the unit adjacent to the Sacramento River should be protected and expanded. Stream flow into the wetland-slough complexes should be improved. Water quality should also be improved. Natural floodplain processes should be enhanced through set-back levees, stream meanders, and seasonal flood overflow basins, which in turn should reduce peak flood flows to the Sacramento River and water levels in flood-prone portions of the unit.

LOWER AMERICAN RIVER ECOLOGICAL MANAGEMENT UNIT

The vision for the Lower American River Ecological Management Unit focuses on restoring important fishery, wildlife, and plant communities to a condition in which the status of specific resources is no longer considered to be of concern within the unit. Restoration within the American River will, in turn, contribute to restoring aquatic resources of the Bay-Delta. This vision will be accomplished by restoring or reinitiating important ecological processes and functions that create and maintain important habitats for fish, wildlife, and plant communities along the lower American River. Numerous and diverse actions may be implemented taken on a broad scale to restore and maintain sustainable, naturally spawning stocks of chinook salmon and steelhead in the American River, including improving seasonal flow and temperature regimes, in-channel and riparian habitats, fishery regulations, and hatchery operations.

Restoration efforts will emphasize benefits to naturally spawning chinook salmon and steelhead populations, which coexist with non-native American shad and striped bass and hatchery stocks of chinook salmon and steelhead. Harvest of naturally produced chinook salmon and steelhead will be regulated to ensure sustained recovery. Recreation along the river will be enhanced by improving flows and habitats and expanding populations of salmon, steelhead, American shad, and striped bass. These actions will also help to sustain the natural aesthetic quality of the stream channel and the associated riparian corridor and floodplain while allowing both consumptive and nonconsumptive uses of the fish, wildlife, and plant resources of the area.

The American River Flood Control Project, the lower American River Parkway, operations of Folsom and Nimbus dams of the CVP, and the designation of the parkway as a State and federal Wild and Scenic River are essential elements that will guide the restoration of ecological health of the American River Basin Ecological Management Zone.

Restoration activities are directed at improving seasonal stream flow and water temperatures, spawning gravel resources, and stream channel configuration and habitat, and riparian corridor management. These processes, in turn, will support development and maintenance of spawning and rearing habitat (e.g., physical habitat, water temperature, and food supply). To support populations of naturally spawning steelhead trout, fall-run chinook salmon, American shad, and resident native fishes, the natural stream flow pattern and spawning and rearing habitat need to be improved. Of these actions, improving seasonal stream flow and water temperature have been identified by the Lower American River Technical Team as being of greatest importance in restoring anadromous fish populations in this river.

For the American River, improving spring (i.e., March through May) flows would help steelhead and American shad move upstream into the American River during their traditional spring migrations. Such flows during these months could also benefit older juvenile fall-run chinook salmon and steelhead migrating downstream to the estuary and ocean after rearing for an extended time. Moreover, improved spring flows would also benefit stream channels, gravel transport and cleansing, and riparian vegetation in the lower river, which, in turn, will benefit fish. Improved flow from the American River in spring would also enhance survival of American and other river anadromous fish during their passage downstream through the Delta to the Bay and ocean.

In addition to spring flows, flows are also needed in other seasons to protect juvenile salmon and steelhead rearing and migrating in the river. In some cases, flow needs exceed natural, unimpaired river flows below Nimbus Dam, because these juvenile fishes must rear in the non-traditional habitats of the lower river instead of the upstream reaches above the dams. Managing flows and water temperatures is necessary to optimize use of limited water resources. Doing so would require alternative operation of the water release shutters at Folsom Reservoir's power penstocks and physical modifications to the urban water intake structures to facilitate the diversion of water from Folsom Dam at elevations other than 317 ft (msl).

Habitat improvements in the lower American River are necessary to increase spawning and rearing habitat quality and quantity for salmon and steelhead to improve natural production of these anadromous fish species. Improved spawning habitat will lead to increased production of young salmon and steelhead. Improved stream channel and riparian vegetation will increase the availability of essential spawning and rearing habitat available for chinook salmon and steelhead. Some changes to the stream channel could reduce warming of the river and provide fewer refuges for warm water predators.

Many of the deficiencies identified in ecosystem processes in the American River can be remedied by improving water management and modifying aquatic and terrestrial habitats. For example, side channels can be restored along with SRA habitat to provide rearing habitat and reduce heating of the river. Much of the needed gravel for the river is stored in and along the river but is unavailable because of armoring or is stored on higher terraces and in dredger tailings. Restoration efforts can focus on reconfiguring the existing channel, redistributing available gravel supplies and restoring riparian vegetation while maintaining or improving the flood capacity of the channel.

Ameliorating or eliminating these problems would require long-term intervention and maintenance beyond simply replenishing the gravel supply of the American River. Although redistributing available gravel and improving the gravel permeability of salmonid spawning grounds is an important element of the vision, reconstructing and maintaining the channel also would be critical aspects of the effort. For example, much of the natural channel has become incised and armored, because sand and gravel appropriate for spawning have been continually eroded without being replaced.

Adequate seasonal flows to sustain salmon and steelhead populations are not always available in the American River. This is especially true for flows during spring through fall in drier than normal water-years. Additional water releases will be made possible from Folsom Lake storage, through purchases of CVP water from willing sellers for fish and wildlife, revised guidelines for operation of the CVP and State Water Project (SWP), water transfers, and/or purchases of water conserved from other sources using available restoration funds.

Reaching this vision for the American River Ecological Management Unit will also require reducing the adverse effects of illegal and legal harvest, hatcheries, and contaminants from urban drainage on lower American River aquatic resources. The following section describes additional visions or objectives for restoring key ecological processes, habitats, and important species of the American River.

VISIONS FOR ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOW: Though many of the streams in the American Basin are naturally intermittent, maintenance of the natural winter and spring flows in the streams is important for maintaining floodplain processes such as meander belts and stream channel configurations, as well as riparian and wetland habitats. Stream flows also attract salmon and steelhead to the creeks of the basin beginning in fall, and transport young salmon and steelhead downstream in winter and early spring. Adequate streamflows are important for maintaining native rainbow trout/steelhead through the summer in upper Coon Creek, Auburn Ravine, and Dry Creek. Some stream flow is also needed to support native resident fishes through the summer-fall irrigation season. The vision for stream flow is where possible natural streamflows will be retained in creeks to support riparian habitat and important species. This may involve reduced diversions or increased inflows either from increased inter-basin diversions or other sources of water (i.e., groundwater or recycled water).

Streamflows shape river channels, support riparian vegetation, and provides habitat for fish and other aquatic organisms. The vision for streamflow in the

American River below Nimbus Dam is to more closely emulate the natural flow regime of the river through operating changes in the allocation of the available water supply of reservoirs and reducing demands on water supply in drier years to maximize direct benefits to lower American River anadromous fishery resources. Improvement in spring flows also will provide indirect benefits by supporting naturally occurring seasonal flow patterns in dry and normal years that supports many ecological processes/features essential to the health of anadromous fish populations.

COARSE SEDIMENT SUPPLY: Sediment supply is an important watershed attribute that contributes to stream channel meander and maintenance of riparian systems. Sediment supply and gravel recruitment on the American River is impaired because recruitment from upstream is blocked by Folsom and Nimbus dams. The vision is to redistribute and/or supplement gravel to provide continual replenishment of gravel for chinook salmon and steelhead spawning habitat. Activities implemented to reach this vision will be consistent with flood control requirements.

STREAM MEANDER: A natural stream-meander process in the American River is no longer possible because of dams, flood-control levees, remnant effects of dredger mining, and altered flow patterns. The vision is to sustain some semblance of a natural stream meander corridor to the extent possible to sustain the diversity of habitats that depend on a natural meander, and to dissipate the energy of the river.

NATURAL FLOODPLAIN PROCESSES: In addition to changes in stream flow, floodplains processes have been altered by floodplain development including flood control levees, reclamation of wetlands for agriculture, gravel mining, and other land uses. The vision is where possible natural floodplain processes will be preserved by allowing winter-spring flows to overflow into riparian and wetland habitats. Natural stream meanders will be encouraged by removing where possible constraints on meander belts such as levees and bank protection in the lower floodplain portions of the creeks. Natural floodplain overflow will help to collect floodwaters and sediment, and help to dissipate the erosive forces of flood waters.

CENTRAL VALLEY WATER TEMPERATURES: Beginning in spring when streamflows in the creeks decline after the rainy season, water temperatures in the creeks increase naturally with the warm Valley air temperatures. The creeks do not cool again until fall. Water diversions, irrigation returns, riparian habitat degradation, and urban runoff alter this natural pattern. Springs, diversions from other watersheds, and higher elevations maintain cool water habitat in the upper watersheds of Coon Creek, Auburn Ravine, and Secret Ravine. The vision is provide cooler spring through fall water temperatures in these watersheds by protecting and enhancing stream flow where possible, enhancing riparian vegetation along creeks, reducing warm water discharges to the creeks, and reducing diversions from the creeks.

High summer and fall water temperatures limit salmon and steelhead production in the American River. The vision is to control water temperatures in the lower American River, to the extent possible, to maintain and contribute to the restoration of chinook salmon and steelhead populations and to avoid high water temperatures which cause mortality or result in other adverse effects to young steelhead (e.g., reduced growth), or delay fall spawning of salmon.

VISIONS FOR HABITATS

SEASONAL WETLANDS: Seasonal wetlands, including vernal pools, are important habitat for many species of fish, wildlife, and waterfowl. The vision is to protect existing areas of seasonal flooding and to maintain or expand sources of water to promote higher quality wetlands especially in drier years. Areas where seasonal flooding develops seasonal wetlands will be expanded. Flooding easements will be obtained from willing landowners to provide seasonal wetlands in flood prone areas such as Natomas Basin and lowlands to the east.

RIPARIAN AND RIVERINE AQUATIC HABITAT: The vision is to fully protect and restore riparian and riverine aquatic habitats to maintain and enhance to support aquatic and terrestrial species, particularly those of primary management concern.

Riparian habitats are important to fish, wildlife including giant garter snake, and waterfowl. The vision is to protect and expand riparian and riverine aquatic habitat, both forest and shrub, along creeks, drainage ditches, irrigation canals, and wetlands.

Remnant patches of high-quality riparian habitat will be protected. Areas of disturbed habitat will be restored where possible. Agricultural and grazing practices will be modified in riparian zones to encourage recovery of riparian and SRA habitat along the creeks. Improvements in stream flows will also benefit riparian zones. Riverine aquatic habitat is essential to spawning and rearing salmon and steelhead in the upper basins of Coon Creek, Auburn Ravine, and Secret and Miners Ravines. Stream channel and SRA habitat should be protected and enhanced.

FRESHWATER FISH HABITAT: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native and anadromous fish species. The Lower American River is typical of a fall chinook salmon spawning stream (Moyle and Ellison 1991). The quality of freshwater fish habitat in the Lower American River will be maintained through actions directed at streamflows, coarse sediment supply, stream meander, natural floodplain and flood processes, and maintaining and restoring riparian and riverine aquatic habitats.

ESSENTIAL FISH HABITAT: The Lower American River has been identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). Key features of EFH to maintain or restore in the Lower American River include substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

PERENNIAL GRASSLANDS: Upland habitats are important for waterfowl, giant garter snakes, and raptors such as the Swainson's hawk. The vision for upland habitats is to protect and expand around the outer edges of wetlands, and to restore grasslands and remnant oak woodland and oak savanna where possible.

AGRICULTURAL LANDS: Agricultural habitats are important to waterfowl and wildlife. The vision is to foster agricultural practices that provide valuable wildlife habitat. Where sufficient water is available, rice lands will be flooded after harvest rather than burned to provide winter waterfowl areas and reduced air pollution. Riparian and upland habitats will be protected and expansion encouraged. Wildlife friendly agricultural practices will be encouraged.

VISIONS FOR REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS: The vision for water diversions is to: 1) prevent loss of fish at diversion facilities; and 2) prevent the take of water from inhibiting the maintenance and/or restoration of riparian and riverine aquatic habitats. Water diversions from streams and adjacent marshes divert streamflow that is important to habitat and species of the unit. The vision is to reduce water diversions along creeks and floodways where possible to protect fish and enhance riparian and wetland habitats. Greater streamflows especially in drier years will provide for greater amounts of riparian habitat and sustain salmon and steelhead, as well as native resident fishes.

LEVEES, BRIDGES, AND BANK PROTECTION: Levee construction and bank protection have led to the loss of riparian, wetland, and shallow-water habitat along the river and adjacent marshes. The vision is to restore riparian vegetation along levees and protected banks. The vision is to selectively remove or setback levees and limit bank protection along streams and marshes to allow natural stream processes and habitat development.

INVASIVE RIPARIAN AND MARSH PLANTS: Invasive plant species can outcompete and displace valuable native species. Invasive plants often have little or no value to native wildlife and are de-stabilizing natural ecosystem functions and processes. The vision is that invasive plants will be controlled to allow native riparian plant species to naturally propagate.

CONTAMINANTS: Toxins continue to enter the river from municipal, industrial, and agricultural discharges. The toxins have had a demonstrated effect on the health, survival, and reproduction of waterfowl, fish, and wildlife. The vision is to reduce the input of toxins entering the streams and wetlands to improve health, survival, and reproduction of many important waterfowl and other wildlife, as well as reduce contaminant effects on fish in the American River, the Sacramento River, and the Bay-Delta.

HARVEST OF FISH AND WILDLIFE: The vision is to reduce or eliminate that illegal harvest of anadromous fish and to assure that legal harvest will not compromise efforts to rebuild fall-run chinook salmon and steelhead populations in the lower American River.

ARTIFICIAL PROPAGATION OF FISH: The vision for the artificial propagation of fish is that Nimbus Hatchery will contribute to the rebuilding of fall-run chinook salmon and steelhead populations without impairing the genetic identity of naturally spawning populations. Also, minimizing the interactions of wild and hatchery fish will contribute to reducing the potential for predation on and competition with the natural spawning populations.

STRANDING: The vision for stranding is to implement remedial measures that will reduce the frequency and extent of stranding losses within the American Basin Ecological Management Zone.

VISIONS FOR SPECIES

CHINOOK SALMON: The vision for chinook salmon is to recover all stocks presently listed or proposed for listing under ESA and CESA, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries. Fall-run chinook salmon will benefit from improved flows. Late winter and spring flows will provide attraction for downstream migrating fall-run chinook. Summer and fall base flow improvements will benefit over-summering juvenile steelhead as well as upstream migrating fall-run chinook salmon. Improvements in wetland, riparian, and SRA habitats; stream channel and meander; and gravel recruitment will also improve and fall-run chinook salmon spawning and rearing habitat. Screening unscreened and poorly screened diversions will improve young salmon production. Limiting harvest will help ensure adequate numbers of spawners.

STEELHEAD TROUT: The vision for steelhead trout is to recover this species listed as threatened under the ESA, and achieve naturally spawning populations of sufficient size to support inland recreational fishing and that use fully existing and restored habitat. Steelhead will benefit from improved peak flow events, especially in dry and normal years. Late winter, early spring flow events will provide attraction for upstream migrating adults and support downstream migrating juveniles. Improved summer-fall base flows are needed to maintain over-summering physical habitat and lower water temperatures. Steelhead will also benefit from improved gravel spawning habitat, and stream rearing habitat, especially if summer river heating is reduced in the process. Screening unscreened and poorly screened diversions will improve young steelhead production. Limiting harvest to hatchery steelhead will help to protect wild steelhead.

STRIPED BASS: The vision for striped bass is to maintain healthy populations, consistent with restoring native species, to their 1960s level of abundance to support a sport fishery in the Bay, Delta, and tributary rivers. Striped bass will benefit from larger late winter, early spring flow events in the lower American River. The higher flow will provide upstream attraction flows and improve transport of eggs from spawning areas in the lower American and Sacramento Rivers.

AMERICAN SHAD: The vision for American shad is to maintain a naturally spawning population, consistent with restoring native species, that supports a sport fishery similar to the fishery that existed in the 1960s and 1970s. Improved spring flows should benefit American shad runs in the lower American River. Greater magnitude flow events in spring will provide attraction flows for adults to lower river spawning areas. Higher spring through fall base flows should improve spawning and early rearing, post-spawning adult survival, and juvenile shad survival and downstream migration.

SPLITTAIL: The vision for splittail is to achieve the recovery of this federally listed threatened species. ESA. Improvements in the riparian and stream meander corridors, wetlands, and floodplain overflow basins will improve spawning and early rearing habitat of splittail and other native resident fish species. Improved late winter and early spring flows will provide attraction flows for upstream migrating adult splittail from the Delta, and improve transport of larvae splittail downstream to the lower rivers and Bay-Delta.

WATERFOWL: The vision for waterfowl is to maintain and restore healthy populations at levels that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses, through protection and improvement of habitats and reduction in stressors. Waterfowl will benefit from improved riparian corridors, floodplain overflow basins, and more wetlands.

NATIVE RESIDENT FISH: The vision for native resident fish species is to maintain and restore by distribution and abundance of species such as Sacramento blackfish, hardhead, tule perch, Sacramento sucker, and California roach.

LAMPREY: The vision for anadromous lamprey is to maintain and restore population distribution and abundance to higher levels than at present. The vision is also to better understand life history and identify factors which influence abundance. Better knowledge of these species and restoration would ensure their long-term population sustainability.

NEOTROPICAL MIGRATORY BIRDS: The vision for neotropical migratory birds is to maintain and increase populations through restoring habitats on which they depend.

GIANT GARTER SNAKE: The vision for the giant garter snake is to contribute to the recovery of this State and federally listed threatened species in order to contribute to the overall species richness and diversity. Achieving this vision will reduce the conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. Protecting existing and restoring additional suitable wetland and upland habitats will be critical to achieving recovery of the giant garter snake. The proposed restoration of aquatic, wetland, riparian, and upland habitats in the American Basin Ecological Unit will help in the recovery of these species by increasing habitat quality and area.

SWAINSON'S HAWK: The vision for the Swainson's hawk is to contribute to the recovery of this State-listed threatened species to contribute to the overall species richness and diversity. Improvements in riparian and agricultural wildlife habitats will aid in the recovery of the Swainson's hawk. Increased abundance and possibly some nesting would be expected in the Delta as a result of improved habitat.

NON-NATIVE WARMWATER GAMEFISH: The vision for non-native warmwater gamefish is to maintain self-sustaining populations, consistent with restoring native species, in order to provide opportunities for consumptive uses such as angling.

PLANT SPECIES AND COMMUNITIES: The vision for plan species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland and riparian and riverine aquatic habitats.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

In restoring the stream channel and riparian habitats, close coordination is required with government agencies responsible for the lower American River and American Basin. The City and County of Sacramento, which administers the American River Parkway Plan, and the Secretary for Resources and the Secretary of the Interior, who administer the State and federal Wild and Scenic Rivers Acts, will be essential participants in the restoration program for the lower American River. In addition, the Corps and the Sacramento Area Flood Control Agency are responsible for ensuring the flood control capacity of the river and American Basin is retained, while retaining as much as possible the ecological resources of the river. Both agencies are cooperating to develop plans to improve habitat and flood control on the lower river and American Basin.

The following list includes the most active programs in the American Basin Ecological Management Zone that can contribute to restoring ecological health to the basin. Attaining the visions described above for the American River will require cooperative and coordinated efforts on the part of stakeholders and agencies with management interests in the river.

CENTRAL VALLEY HABITAT JOINT VENTURE

The Central Valley Habitat Joint Venture is a component of the North American Waterfowl Management Plan of the USFWS with funding and cooperative projects of the federal, State, and private agencies. New sources of funding including CALFED restoration funds are being sought to implement the Joint Venture. The Joint Venture has adopted an implementation plan that includes the American Basin. Objectives include protection of wetlands through acquisition of fee-title or conservation easements, enhancement of waterfowl habitat in wetlands and agricultural lands. The objectives and targets of the Joint Venture have been adopted by the ERPP.

SACRAMENTO WATER FORUM

The Water Forum is a diverse group of business and agricultural leaders, environmentalists, citizen groups, water managers, and local governments. Together, the participants in the Water Forum have agreed upon two co-equal objectives for the lower American River to address future water shortages, environmental degradation, contamination, threats to groundwater reliability, limits to economic prosperity, and competition for American River water. The dual Water Forum objectives are to: 1) provide a reliable and safe water supply for the region's economic health and planned development through to the year 2030; and 2) preserve the fishery, wildlife, recreational, and aesthetic values of the lower American River.

Important elements sponsored by the Water Forum that will contribute to improving ecological health of the lower American River include an improved pattern of fishery flow releases from Folsom Reservoir and habitat mitigation. The flow pattern being developed will be 'fish friendly' and would significantly benefit fall-run chinook by improving river flows and temperatures at critical times. Changes in the operations of the water release shutters at the power penstocks of Folsom Dam is anticipated to improve water temperatures in the lower American River in summer and fall. In addition, the Water Forum, in partnership with other management agencies on the lower American River, is proposing a series of fishery studies and pilot projects to determine what additional operations, modifications, and mitigation projects should be implemented to help restore lower American River chinook salmon and steelhead populations.

AMERICAN RIVER OPERATIONS GROUP

The American River Operations Group is composed of representatives of fishery agencies, water agencies, local governments, and stakeholders. The Ops Group meets regularly to identify and recommend actions involving water operations on the American River that will optimize conditions for steelhead and chinook salmon.

SACRAMENTO AREA FLOOD CONTROL AGENCY (SAFCA)

SAFCA with other resource agencies and private entities is developing a Floodway Management Plan (FMP) for the lower American River. A Lower American River Task Force has been working toward developing a FMP that provides protection to resources in the floodway. Their focus is on protection and restoration of riparian habitat in the floodplain of the lower American River. SAFCA is also active in protecting and restoring habitat in the Natomas Basin of the American Basin Ecological Management Unit. Planning efforts are being conducted to improve flood protection for the Natomas Basin. SAFCA has developed a Natomas Area Flood Control Improvement Project that provides additional levee protection and surface transport of floodwaters, and also addresses special status plant and animal species, vernal pool and wetland habitats, and upland and riparian habitats.

SAFCA has funded extensive work on designing environmental features into bank protection projects. SAFCA and the U.S. Army Corps of Engineers continue to develop habitat conservation/-mitigation/enhancement elements to be incorporated into the levee improvement and bank protection program for the Lower American River. These elements include design and construction of multi-stage bench areas at specific water surface elevations in order to provide littoral rearing habitat for salmonids, as well as increasing the habitat complexity and diversity in portions of the Lower American River.

NATOMAS BASIN HABITAT CONSERVATION PLAN (HCP)

A habitat conservation plan was developed in 1996 to provide a practical program to promote biological conservation along with economic development and continuation of agriculture in the Natomas Basin, the south-west subunit of the American Basin Ecological Management Unit. The program outlined in the Plan establishes a multi-species, multi-habitat conservation program to mitigate the expected loss of habitat values and incidental take of protected species that would result from urban development, operation of irrigation and drainage systems, and agricultural activities in the Natomas Basin. Funds are obtained from developers to purchase habitat reserves and conduct studies. The HCP establishes a Natomas Basin Conservancy to cover activities associated with managing reserves, populations status surveys, and general scientific research. The HCP covers wetlands, riparian, and upland habitats and associated plant and animal species, and does not cover aquatic habitat or fish species.

COORDINATED RESOURCE MANAGEMENT AND PLANNING (CRMP)

CRMP programs are being established at least for the Auburn Ravine Creek watershed. Coordinated land management and planning activities are being undertaken between agencies and private entities and MOU's developed to focus on water quality, fisheries improvement, and fire safe communities in order to promote public safety, watershed stability, and high quality waters in Auburn Ravine through cooperation, information development, and education. The CRMP deals with erosion and sedimentation, habitat quality, habitat loss and depletion of biodiversity, rural homes and fire hazards, and the need to maintain overall stability of the watershed. Watershed quality is to be improved through forest fuels management, preventing discharge of pollutants, sustaining fish and their habitats, and creating and sustaining diverse habitat and wildlife diversity. The role of the creek for conveying irrigation water and as a flood channel are also to be protected.

CALFED BAY-DELTA PROGRAM

CALFED has funded two ecosystem restoration projects in the American River Basin. One project developed a watershed plan for the American River. Another Restoration project planned watershed restoration actions on the Middle and North Forks of the American River, Auburn Ravine Creek, and Coon Creek.

CENTRAL VALLEY PROJECT IMPROVEMENT ACT

The CVPIA added 'mitigation, protection and restoration of fish and wildlife' as a purpose of the Central Valley Project and required the implementation of a program that makes all reasonable efforts to increase the natural production of anadromous fish in Central Valley rivers and streams to not less that twice the average levels present from 1967-1991.

The U.S. Fish and Wildlife Service and the Bureau of Reclamation are implementing the CVPIA which provides for restoration of habitats and species and minimization of stressors. Key elements of the CVPIA program include the Anadromous Fish Restoration Program (USFWS 1995) and the Anadromous Fish Screening Program. Other elements are directed at spawning gravel replenishment on the lower American River, water acquisition, and other measures that will contribute to restoring the health of the Sacramento River and Sacramento-San Joaquin Delta Ecological Management Zones.

Activities with direct application to the American Basin include a program to restore small tributaries to the Sacramento River. Local entities such as Resource Conservation Districts are being funded to identify problems, develop solutions, and implement actions to address small-scale restoration projects on tributary streams. CVPIA's Comprehensive Assessment and Monitoring Program (CAMP) is funding efforts to provide information on the anadromous fish runs in tributary streams. Funding is also being provided for regional conservation planning of watersheds in the basin that support salmon and steelhead. Funding is also available for evaluating the potential contribution of intermittent tributary streams like those in the American Basin as spawning and rearing habitat for chinook salmon. Funding is also available to reduce fish passage and screening problems.

A Water Management Plan is being developed to guide water supply development for anadromous fish under CVPIA's 3406(b)(2) and (b)(3) projects. Dedicated CVP water and supplemental water purchased from willing sellers will be used to enhance flows for anadromous fish. Such water supply can be used to enhance salmon and steelhead populations in American Basin streams and in the lower American River.

SALMON, STEELHEAD TROUT AND ANADROMOUS FISHERIES PROGRAM ACT

Established in 1988 by Senate Bill 2261, this Act directs the California Department of Fish and Game to implement measures to double the numbers of salmon and steelhead present in the Central Valley (DFG 1993, 1996). The Department's salmon and steelhead restoration program includes cooperative efforts with local governments and private landowners to identify problem areas and to assist in obtaining funding for feasibility studies, environmental permitting, and project construction. Reaching the goals and targets developed to restore ecosystem functions of the American River Basin and the associated biotic community will require close coordination among State, federal, and local agencies, with participation by water developers and stakeholders.

PLANNING BY CITIES AND COUNTIES

The cities of Roseville, Auburn, Lincoln, Rocklin, and Sacramento, and the counties of Sutter, Sacramento, and Placer are all involved in planning activities that related to ecological resources and restoration in the American Basin Ecological Management Zone. Activities include a Roseville Regional Wastewater Treatment Service Area Master Plan that involves collection, treatment, and disposal of waste water, water quality, and public health. Cities and Counties of the Basin are pressed with the need to conserve biological resources, habitats, and ecosystem quality, while addressing large scale growth and land use changes in the cities and counties that may affect the flood capacity, water quality, and general environmental health of the watersheds.

LINKAGE TO OTHER ECOLOGICAL MANAGEMENT ZONES

Many of the habitats, processes, and stressors found within this Ecological Management Zone are similar to those found in the Feather/Sutter, Cosumnes, Delta, Yolo Basin, and Colusa Basin Ecological Management Zones. Efforts within one Ecological Management Zone should be similar to those in adjacent zones providing connectivity where needed and cumulative benefits to the system.

RESTORATION TARGETS AND PROGRAMMATIC ACTIONS

ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOWS

TARGET 1: Develop and implement an ecologically based streamflow regulation plan for the American Basin creeks and lower American River. The lower American River should meet the recommended minimum flows and flow targets for the lower American River (presented in Tables 8 and 9). Lower American River flow events should be coordinated with similar flows that occur naturally in the Sacramento Valley and with storage releases from Shasta and Oroville Reservoirs (◆◆◆).

PROGRAMMATIC ACTION 1A: Provide target flows by modifying CVP operations and acquiring water as needed from willing sellers, with consideration given to reservoir available carryover storage and flows needed to meet needs determined by the water temperature objective discussed under Target 3 below.

PROGRAMMATIC ACTION 1B: Develop and implement a comprehensive watershed management plan for the American Basin and lower American River to protect the channel (e.g., maintain flood control capacity and reduce bank erosion) and preserve and restore the riparian corridor. Upper watershed health should be improved by reducing the potential for wildfire and implementing other watershed improvement practices to protect streamflows, stream channel morphologies, spawning gravel condition, and riparian habitats, and minimize sediment input to the stream.

PROGRAMMATIC ACTION 1C: Acquire water from willing sellers to augment river flow during dry years to provide fishery benefits.

TARGET 2: Minimize flow fluctuations below Nimbus Dam that can dewater salmonid redds and reduce survival of juvenile anadromous fishes due

Table 9. Average Monthly Minimum Flow Targets (cfs) on the American River.

Month	Water-Year Type			Critical Relaxation
	Wet	Above and Below Normal	Dry and Critical	
October	2,500	2,000	1,750	800
November-February	2,500	2,500	1,750	1,200
March-May	4,500	3,000	2,000	1,500
June	4,500	3,000	2,000	500
July	2,500	2,500	1,500	500
August	2,500	2,000	1,000	500
September	2,500	1,500	500	500

Table 10. Average Flow Targets for 10-Day Pulse (cfs) on the American River, Coordinated with Flows from Shasta and Oroville Reservoirs.

Month	Water-Year Type			Exceptions
	Wet	Above and Below Normal	Dry	
March	6,000-7,000	4,000-5,000	3,000-3,500	Only when inflows are sufficient
Late April or early May	7,000-8,000	5,000-6,000	3,500-4,000	Only when inflows are sufficient

to stranding and/or isolation from the main channel. (◆◆◆).

PROGRAMMATIC ACTION 2A: Complete on-going collaborative efforts to develop flow ramping criteria and operationally implement these criteria to reduce adverse affect of flow fluctuations on lower American River fishery resources.

PROGRAMMATIC ACTION 2B: To minimize dewatering of salmon and steelhead redds, flows exceeding 2,500 cfs after the onset of chinook salmon spawning should be maintained at least at this level until April 30.

TARGET 3: Provide flows of suitable quality water that more closely emulate natural annual and seasonal streamflow patterns in American Basin watersheds (◆◆).

PROGRAMMATIC ACTION 3A: Enter into agreements with water districts and wetland managers to provide return flows of high quality water from irrigated agriculture and seasonal wetlands to the American Basin.

PROGRAMMATIC ACTION 3B: Enter into agreements with landowners and water districts to limit diversions of natural flows from creeks to improve stream flows.

PROGRAMMATIC ACTION 3C: Limit diversion of natural stream flows from American Basin creeks into irrigation canals and ditches by providing other sources of water or through purchase of water rights from willing sellers.

RATIONALE: *Natural streamflow patterns are important in maintaining geomorphology of watersheds, as well as riparian and floodplain vegetation along stream banks. Streamflow is also essential for the well being of valley wetlands and for upstream passage of adult anadromous fish, spawning, successful rearing, and downstream migration of juveniles. In addition, streamflows influences stream channel morphology, riparian communities, and fish habitat. Base flows and flow events will be provided by releasing water from Folsom Reservoir, reducing diversions from the American River. Flood-control releases from Folsom*

Reservoir that occur during winter and spring months are beneficial in sustaining gravel recruitment, transport and cleaning processes. Late non-flood control releases during the winter and/or early-spring period flow will be maintained at levels events of sufficient magnitude to attract and sustain adult steelhead and American shad spawning runs. Moreover, spring and early summer flows will be maintained at levels that provide sufficient physical space for improve transport of juvenile salmon, steelhead, and shad rearing as well as favorable downstream migration conditions. Both high-level flood-control releases and lower base-flow releases from reservoir storage during winter and spring will be managed within the operational constraints of the reservoir to sustain riparian habitats and sustain gravel recruitment, transport, and cleansing processes. Sufficient minimum

flows are necessary to maintain adequate conditions for adult holding, spawning, egg incubation, and juvenile rearing and migration, especially because these functions must now occur below Nimbus Dam. The target minimum flows (Table 8) are consistent with historic and unimpaired flows for the American River in dry and normal years that, in some years, may not occur under the present level of project development and operation.

Opportunity to succeed in providing optimum, rather than minimum, flows will rely on collaborative efforts that include stakeholder groups such as the American River Water Forum, State and federal agencies, and local governments. Developing a long-term water management plan for the American River will meet a diversity of needs, including providing streamflows needed to maintain ecological processes and functions; maintaining habitats; and supporting restoration of chinook salmon, steelhead, and other anadromous and resident fish populations below Nimbus Dam. This plan may involve options presently being considered by the American River Water Forum, including diverting water from near the mouth of the river or at the Fairbairn Water Treatment Plant, rather than from Nimbus Dam, or Fairbairn Water Treatment Plant to meet the needs of water users. Opportunities for adjusting seasonal streamflow and carryover storage patterns to benefit fish and lower American River habitats, while maintaining other beneficial uses, will be explored. These opportunities may include acquiring water rights from willing sellers or developing supplemental supplies (e.g., conjunctive use and/or recycled water programs).

The target level of the flow events must be implemented conservatively because of the potential impact on water supply. If a flow event equal to or greater than the target flow has not taken place during uncontrolled releases from Folsom Dam by March, then supplementing base flows or augmenting small, natural flow events or reservoir spills with additional reservoir releases is the only means to provide the necessary flows. Such releases would be allowed only if an equivalent or greater inflow to Folsom Lake occurs. Flow fluctuations within the range of 1,000 to 4,000 cfs can desiccate redds and fluctuations within the range of 3,000 to 10,000 cfs can strand juvenile salmon and steelhead in pools that become isolated from the main channel. Flow reduction criteria (ramping rates) need to be implemented to minimize this problem.

March through May is the logical period during which to provide such flow events because this is the period when natural flow events occurred historically in dry and normal years, and because opportunities for such flow to occur naturally as a function of normal project operation would have passed. Forecasts regarding the water-year type (dry or normal) would also be available by February or March and will be used as the basis for decisions that balance fishery flows with water-supply needs.

The March flow event would be expected to travel unimpaired to the Delta because few if any diversions from the American and Sacramento Rivers occur during March. (Note that additional flow events are prescribed for the Feather and Sacramento Rivers in March, which will further enhance Sacramento River flows below the confluence with the American River.) A March flow event would also help satisfy Delta outflow requirements. Further, the prescribed flow event in late April and early May would add to flow events prescribed from the Mokelumne, Stanislaus, Tuolumne, and Merced rivers to the south, which together will also satisfy Delta outflow requirements.

These prescribed flows cannot usurp individual water rights established subject to California law. ERPP does not include any adjudication or involuntary reallocation of water rights.

Managing for appropriate seasonal flow regimes in the lower American River and American Basin creeks will restore and sustain anadromous and resident fish populations, help promote natural channel formation processes, establish and maintain riparian vegetation, and will sustain numerous foodweb functions. Minimum flows also attract adult steelhead and fall-run chinook salmon during fall and winter.

COARSE SEDIMENT SUPPLY

TARGET 1: Maintain, improve, or supplement gravel recruitment and natural sediment transport in the lower American River and American Basin watersheds to maintain natural ecological processes linked to stream channel maintenance, erosion and deposition, maintenance of fish spawning areas, and the regeneration of riparian vegetation (◆◆).

PROGRAMMATIC ACTION 1A: Monitor spawning gravel conditions in the lower American River and American Basin watersheds, and identify specific sites where mechanical cleaning or gravel introductions would be beneficial to enhance or increase gravel spawning habitat.

PROGRAMMATIC ACTION 1B: Implement a pilot study to assess the benefits of mechanical cleaning to improve gravel permeability.

PROGRAMMATIC ACTION 1C: Develop a collaborative program to investigate erosion, bedload movement, sediment transport, and depositional processes and their relationship to the formation of point bars and riparian regeneration in the lower American River and American Basin watersheds.

RATIONALE: *Gravel is an essential element of spawning and rearing habitats for salmon, steelhead trout, and other native fishes. Gravel supplies are not thought to currently limited salmonid production in the lower American River but may become limiting in the near future, especially in the area immediately below Nimbus Dam. Some gravel is provided naturally when the river cuts into dredger tailings during high flows; however, this input is not sufficient to maintain high-quality spawning habitat for the target levels of naturally produced fall-run chinook salmon and steelhead. Gravel recruitment can be supplemented by providing additional gravel for the river to capture under its controlled flow regime.*

The Lower American River Technical Team reported that the availability of spawning habitat does not appear to be an immediate problem as there are adequate amounts of appropriately sized gravel in the river; and there is a large amount of gravel along the banks and in the bars of the lower American River that provide sources for gravel recruitment.

Simply adding gravel to the stream channel may not improve spawning conditions because an impermeable clay lens under the deposited gravel could limit upward percolation and , therefore, fish use for spawning., and other site-specific habitat characteristics. Hence, the specific river location were gravel deposition occurs will largely dictate the benefits to fishery resources of deposition gravel.

Natural sediment supply from the watershed above Folsom Dam has been eliminated. The long-term adverse effects of this have not been adequately investigated. Lack of sediment recruitment from the upper watersheds, ranging from fine sands to cobbles, may adversely influence the structural characteristics of the stream channel, impair riparian and riverine aquatic habitats, and reduce habitat complexity required by anadromous and resident fish species. Investigations into these issues will provide additional insight into finer resolution of long-term opportunities to improve the ecological health of the American River.

The sediment regimes of American Basin creeks have not been investigated. However, because these streams do not have dams on them, natural sediment supplies are probably available. The condition of the watershed and spawning habitats in the upper watersheds of Coon Creek, Auburn Ravine, and Dry Creek should be investigated.

NATURAL FLOODPLAIN AND FLOOD PROCESSES

TARGET 1: Maintain the existing stream meander configuration along the American River between Nimbus Dam and the Sacramento River (◆).

PROGRAMMATIC ACTION 1A: Maintain a stream meander configuration along the lower American River by working with involved parties to develop a floodplain management program consistent with flood control needs. These parties include the Corps, the California Reclamation Board, the Sacramento Area Flood Control Agency, the Lower

American River Task Force, and the American River Water Forum.

PROGRAMMATIC ACTION 1B: Where possible, maintain mainstem and side channel habitats typical of a natural river that provide salmon and steelhead spawning and rearing habitat.

TARGET 2: Restore natural stream meanders in the floodplains of American Basin creeks (◆).

PROGRAMMATIC ACTION 2A: Where possible within flood control constraints, restore natural meander belts along the lower creeks through setback of levees or removal of bank protection, or other physical structures impeding a natural meander process.

TARGET 3: Maintain and enhance floodplain overflow areas in the lower American River and floodplain of the American Basin (◆◆).

PROGRAMMATIC ACTION 3A: Setback levees in the floodplains of creeks and canals of the American Basin.

PROGRAMMATIC ACTION 3B: Protect existing overflow areas from future reclamation.

PROGRAMMATIC ACTION 3C: Develop floodway detention basins in the floodplains of the American Basin to temporarily store floodwaters.

PROGRAMMATIC ACTION 3D: Enter into agreements with willing landowners and irrigation districts to set back levees and allow floodplain processes such as stream meander belts.

PROGRAMMATIC ACTION 3E: Expand existing floodplain overflow basins by obtaining easements of titles from willing sellers of floodplain lands.

PROGRAMMATIC ACTION 3F: Reduce or eliminate gravel mining from active stream channels.

RATIONALE: *Natural river floodplain processes permit natural stream-channel development that supports for riparian vegetation and provides spawning and rearing habitat for chinook salmon and steelhead. Natural stream processes in alluvial systems transport and deposit sediments; provide transient habitats important to algae, aquatic invertebrates, and fish; and provide surfaces colonized by natural vegetation that support wildlife. Overbank flooding is an important regenerative process needed to maintain riparian forests and woodlands. In addition, much of the nutrient input is derived from infrequent overbank flooding of the riparian/floodplain zone. Opportunities to restore floodplains and flood processes along the lower American River are constrained by the flood control requirements provided by Folsom Dam and the levee system throughout in the lower river reach. Adaptive management including focused research and monitoring will be important elements to guide the level to which floodplain processes can be maintained and restored in the lower American River. These processes are closely linked to maintaining and restoring the riparian corridor which supports a variety of aquatic and terrestrial species.*

Remnant effects of devastating dredger mining along the American River also hinder natural stream-channel processes. Because of these constraints, artificial means are necessary to maintain natural stream-channel processes that will provide the habitats needed by salmon and steelhead normally created by these processes.

In the American Basin project levees channel flows in lower creeks into the NCC and NEMDC, which carry floodwaters to the Sacramento River. Levees along the lower creeks typically fail to hold back water as water backs up at the Sacramento River. Widening the floodplain and setting back levees along the NCC, NEMDC, and lower creeks provides more flood carrying capacity and a more natural floodplain process that would promote riparian and wetland habitat development.

CENTRAL VALLEY STREAM TEMPERATURES

TARGET 1: Maintain lower American River water temperatures in the spawning and rearing reach between Arden Bar and Nimbus Dam at or below 60°F beginning as early in October as possible, based on annual coldwater pool availability and maintain water temperatures in the upper portion of the reach between Nimbus Dam and Sunrise Bridge below 65°F from spring through fall (◆◆◆).

PROGRAMMATIC ACTION 1A: Optimally manage Folsom Reservoir's coldwater pool via real-time operation of the water-release shutters to provide the maximum equitable thermal benefits to lower American River steelhead and chinook salmon throughout the year, within the constraints of reservoir coldwater pool availability.

PROGRAMMATIC ACTION 1B: Reconfigure Folsom Dam shutters to improve management of Folsom Reservoir's coldwater pool and maintain better control over the temperature of water released downstream.

PROGRAMMATIC ACTION 1C: Install a temperature control device on the municipal water intakes at Folsom Dam.

PROGRAMMATIC ACTION 1D: Investigate opportunities to improve the manner in which the water-release shutters at Folsom Dam are physically installed, removed, and maintained annually, as well as opportunities to improve their efficiency in releasing water from desired elevations.

PROGRAMMATIC ACTION 1E: Evaluate the potential for creating side-channels thermal refuges for juvenile steelhead rearing over-summer in the lower American River. Such habitat could provide habitat slightly cooler than peak daytime river temperatures.

PROGRAMMATIC ACTION 1F: Evaluate options to reduce releases of warmer surface waters of Lake Natoma through the turbines at Nimbus Dam into the lower American River. Options may include a temperature curtain in the lake near the turbine intakes. Operations of Nimbus Dam during occasional spill events should also be evaluated to minimize the release of warm surface waters from Lake Natoma.

PROGRAMMATIC ACTION 1G: Provide a more direct supply of colder water to Nimbus Hatchery.

TARGET 2: Maintain a daily average water temperature below 65°F from June 1 through September 30 in the lower American River between Nimbus Dam and Watt Avenue and in the upper portions of Coon Creek, Doty Creek, Auburn Ravine, Miners Ravine, and Secret Ravine in the American Basin (◆◆).

PROGRAMMATIC ACTION 2A: Evaluate means of maintaining cool water temperatures as necessary in upper watersheds of Coon Creek, Auburn Ravine, and Dry Creek, including such measures as pumping ground water, enhancing riparian vegetation, reducing drainage inputs of warm water from agriculture and urban runoff, and supplementing creek flows with diversions of waters from the Bear and American River Basins.

RATIONALE: *SAFCA used an iterative modeling approach to develop a monthly target release temperature regime on the Lower American River (as part of the DEIR/EIS for P.L. 101-514 CVP Water Supply Contracts). This effort developed a monthly target release temperature regime that mitigated project-related potential water temperature impacts of steelhead and also reduces average annual early life stage mortality for chinook salmon. Modeling analyses revealed that managing Folsom Reservoir's coldwater pool in this alternative manner would: (1) provide water temperatures during the July through September period that would be lower than those realized under the Base Case condition, thereby providing more favorable conditions for over-summering juvenile steelhead; and (2) reduce average annual early life stage losses of chinook salmon caused by elevated Lower American River water temperature during September, October, and November.*

Improved operation of the water-release shutters configuration at Folsom Dam can reduce the temperature of water released into the lower American River. Improved temperatures of water released from Folsom Dam and improved channel habitats are needed to provide adequate over-summer rearing habitat for juvenile steelhead. Releases from Folsom Reservoir's coldwater pool are also required to provide adequate spawning temperatures for fall-run chinook salmon in October and November. However, the low end-of-year storage levels allowed in Folsom Reservoir currently for flood-control purposes will make temperature control for salmon spawning difficult in late summer and early fall of most water-years.

While managing the cold-water pool in Folsom Lake is a priority for maintaining cool water temperatures in the lower American River, lessor but significant benefits can also attained by managing releases from Nimbus Dam. Surface waters (top several feet) of Lake Natoma can heat up to 5 to 10°F from late spring through early fall. Water released into the lower American could be 1 to 2°F lower if warmer surface waters were not included in releases. Because summer temperatures often reach near or above 65°F, 1 to 2°F additional heating is significant. On rare *occasions when water from Lake Natomas spills from the spillways rather than coming from the turbines, an even greater proportion of warmer surface waters from the lake can be released to the river.*

Installing a temperature control device at the municipal water supply intake, which is the lowest outlet at Folsom Dam, would allow water from higher elevations of the reservoir to be diverted for municipal purposes, which would preserve the reservoir's cold water pool for releases to the lower American River. The device, which is estimate to cost about $3 million, was authorized by Congress in 1998, but funding was not appropriated.

The Nimbus Hatchery water supply does not provide sufficiently cool water at times during the summer months, and this creates disease problems for steelhead in the hatchery. On occasion, water temperatures are so high that all fish must be removed from the hatchery and transported to nearby hatcheries for rearing. Hatchery temperature requirements can also conflict with Folsom Reservoir cold water pool management for in-river salmonids. When cool water is released for the hatchery, it requires that the entire amount being released to the river be at the desired hatchery temperature even though the hatchery uses a very small portion of the flow. This can exhaust the cold water pool before the end of the summer.

The upper watersheds of the American Basin have historically provided sufficiently cool water to sustain naturally produced rainbow trout/steelhead through the summers. Protecting and enhancing remaining cool water habitat is an essential element of restoring steelhead to these watersheds.

To some degree, high water temperatures in summer and fall in the lower American River are natural; in part, they are a consequence of impaired stream-channel configurations that do not provide shaded side channels with cool groundwater flows. Coldwater releases from the dams and improved channel habitats are needed to provide adequate over-summer rearing habitat for juvenile steelhead.

HABITATS

SEASONAL WETLAND HABITAT

TARGET 1: Protect and enhance 5,150 acres of seasonal wetland habitat acreage in the American Basin consistent with the objectives of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan (◆◆).

PROGRAMMATIC ACTION 1A: Protect 2,000 acres of existing wetland habitat through fee acquisition and perpetual conservation easements.

PROGRAMMATIC ACTION 1B: Enhance 3,150 acres of existing wetlands.

RATIONALE: *Seasonal wetlands habitats include rice fields and vernal pools, both of which are prevalent in the American Basin. Seasonal wetland habitats provide unique micro habitat conditions that are utilized by fish for spawning and rearing, provide nesting and feeding habitat for waterfowl and wading birds, and provide otters and other mammals with suitable mating, feeding, and rearing habitats. Wetland/slough habitats increase the overall complexity of the aquatic environment, thereby supporting more diverse foodwebs and more diverse fish and wildlife communities. Expansion of seasonal wetlands is important in the Central Valley and American Basin, because much of such habitat has been lost to land reclamation for agriculture and urban development.*

RIPARIAN AND RIVERINE AQUATIC HABITAT

TARGET 1: Establish and/or maintain a sustainable continuous, sustainable corridor of riparian habitat along the lower American River and American Basin creeks (◆◆).

PROGRAMMATIC ACTION 1A: Develop riparian corridor restoration and management plans for the American Basin and lower American River.

PROGRAMMATIC ACTION 1B: Protect riparian habitat along water courses of the American Basin.

PROGRAMMATIC ACTION 1C: Plant riparian vegetation along water courses of the American Basin.

PROGRAMMATIC ACTION 1D: Reduce land use practices such as livestock grazing and watering along stream channels of the American Basin that cause degradation of riparian habitat.

TARGET 2: Enhance shaded riverine aquatic habitat in American Basin creeks and drainage canals and ditches and along the lower American River (◆◆◆).

PROGRAMMATIC ACTION 2A: Terminate or modify current programs that remove woody debris from the river and creek channels.

PROGRAMMATIC ACTION 2B: Restore side-channels along the lower American River to provide additional riparian corridors for increasing fish and wildlife habitat.

PROGRAMMATIC ACTION 2C: Improve levee management practices to protect and enhance riparian and SRA habitat.

RATIONALE: *Many species of wildlife, including several species listed as threatened or endangered under the State and federal Endangered Species Acts and several special-status plant species in the Central Valley, are dependent on or closely associated with riparian habitats. These habitats support a greater diversity of wildlife species than all other habitat types in California. Degradation and loss of riparian habitat have substantially reduced the habitat area available for associated wildlife species. In addition, loss of this habitat has reduced water storage and has altered nutrient cycling, and foodweb support functions. Controlled flows, lack of gravel recruitment, stream-channel confinement by the flood control system, and remnant dredger tailings limit the possible extent of a natural riparian corridor along the lower American River. Constructing and maintaining restored riparian habitats would improve the habitat needed by fish and wildlife dependent upon the river ecosystem.*

FRESHWATER FISH HABITAT AND ESSENTIAL FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination (◆◆).

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for American River Basin Ecological Zone ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitats. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of streams in this zone and their floodplains, and in maintaining and restoring riparian and riverine aquatic habitats.*

PERENNIAL GRASSLANDS

TARGET 1: Restore perennial grasses in the American Basin Ecological Management Unit associated with existing or proposed wetlands (◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to restore perennial grasslands by acquiring conservation easements or purchasing land from willing sellers.

RATIONALE: *Restoring wetland, riparian, and adjacent upland habitats in association with aquatic habitats is an essential element of the restoration strategy for this Ecological Management Zone. Eliminating fragmentation and restoring connectivity will enhance habitat conditions for special-status species.*

AGRICULTURAL LANDS

TARGET 1: Restore and maintain migration corridors (◆).

PROGRAMMATIC ACTION 1A: Purchase land or conservation easements from willing sellers on which to restore wildlife habitat to connect existing grassland or agricultural wildlife habitat.

TARGET 2: Enhance 20,948 acres of private agricultural land to better support nesting and wintering waterfowl consistent with the objectives of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan (◆◆).

PROGRAMMATIC ACTION 2A: Develop cooperative programs with farmers to conduct wildlife friendly practices.

RATIONALE: *Corridors of habitat are necessary between larger habitat areas to ensure potential recovery of giant garter snake and other wildlife. Waterfowl and wildlife using wetlands and aquatic habitats depend on adjoining agricultural lands for* *foraging and cover.*

STRESSORS

WATER DIVERSIONS

TARGET 1: Reduce losses of juvenile salmon and steelhead in the lower American River and American Basin creeks due to entrainment at water intakes structures (◆◆◆).

PROGRAMMATIC ACTION 1A: Upgrade the fish screens at the Fairbairn Water Treatment Plant to comply with DFG and NMFS fish screening criteria.

PROGRAMMATIC ACTION 1B: Screen diversions from the NCC, NEMDC, Dry Creek, Coon Creek, and Auburn Ravine that operate during times when salmon and steelhead juveniles would be present.

RATIONALE: *Diversion, storage, and release of water directly affect fish, aquatic organisms, and nutrient levels in the system and indirectly affect habitat, foodweb productivity, and the abundance and distribution of species. Diversions cause consumptive loss of water, nutrients, sediment, and organisms juvenile anadromous fishes of management concern. Hence, reducing such losses will contribute to increasing anadromous fish populations of the Central Valley.*

LEVEES, BRIDGES, AND BANK PROTECTION

TARGET 1: Reduce the adverse affect of levees and bank protection on aquatic and terrestrial species and their habitats along the lower American River and American Basin canals and creeks (◆◆).

PROGRAMMATIC ACTION 1A: Identify locations in the lower American River and American Basin creeks and canals where existing revetments could be modified to incorporate habitat features such as scalloped embayments and associated hard points, multi-stage bench areas, SRA habitat, and other features to aid in preservation and/or reestablishment of both berm and bank vegetation.

RATIONALE: *Riprap reduces the ability of vegetation to colonize river banks and, thereby reduces shading of river waters, decreases insect production and availability to fishes, reduces habitat complexity and diversity, and reduces instream cover.*

INVASIVE RIPARIAN AND MARSH PLANT SPECIES

TARGET 1: Reduce populations of invasive non-native plant species that compete with the establishment and succession of native riparian vegetation along the American River. This will help to reestablish native riparian vegetation in floodplains, increase SRA cover for fish, and increase habitat values for riparian-associated wildlife (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to monitor the distribution and abundance of non-native plants and develop cooperative control programs as needed.

RATIONALE: *Non-native plant species, such as false bamboo, salt cedar, eucalyptus, water hyacinth, and pepperweed, can undermine riparian habitat value to fish and wildlife, as well as the natural plant succession that contributes to the physical character of the riparian corridors. Arundo has become established in the American River floodway and can seriously alter ecological processes by inducing greater deposition of sediments, increasing evapotranspiration, and altering soil chemistry. Arundo has little value for native species of wildlife and outcompetes native riparian plant species.*

HARVEST OF FISH AND WILDLIFE

TARGET 1: Develop harvest management strategies for Central Valley chinook salmon and steelhead populations that allow populations of naturally spawned fish to attain levels that fully use existing and restored habitat (◆◆◆).

PROGRAMMATIC ACTION 1A: Control illegal harvest of chinook salmon and steelhead by increasing enforcement efforts.

PROGRAMMATIC ACTION 1B: Develop harvest management plans for chinook salmon and steelhead with commercial and recreational fishery organizations, resource management agencies, and other stakeholders to meet target escapement and production goals for the lower American River and American Basin creeks.

PROGRAMMATIC ACTION 1C: Evaluate the efficacy of a marking and selective harvest program for lower American River chinook salmon.

RATIONALE: *Restoring and maintaining populations of chinook salmon and, steelhead, and American shad to levels that make full use of habitat may require restrictions on harvest during and after the recovery period. Involving the various stakeholder organizations in the planning process should help to ensure a balanced and fair allocation of harvest. Target population levels may require that levels of harvest of naturally produced fish be reduced. For populations supplemented with hatchery-produced fish, selective harvesting may be necessary to limit the harvest of wild fish while harvesting hatchery-produced fish at a level that will reduce their potential to disrupt the genetic integrity of wild populations.*

ARTIFICIAL PROPAGATION OF FISH

TARGET 1: Evaluate hatchery production and stocking practices at the Nimbus and Feather River Hatcheries that affect American Basin creeks and the lower American River to reduce the proportion of returning, hatchery-origin chinook salmon and steelhead that stray into non-natal streams (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate the benefits of stocking hatchery-reared salmon and steelhead in American Basin creeks and in the lower American River.

TARGET 2: Limit hatchery stocking if populations of salmon or steelhead can be sustained by natural production (◆◆◆).

PROGRAMMATIC ACTION 2A: Augment populations of fall-run chinook salmon and steelhead only when alternative measures are insufficient to permit natural recovery of the populations.

TARGET 3: Minimize further threats of hatchery-reared fish contaminating wild stocks of chinook salmon and steelhead (◆◆◆).

PROGRAMMATIC ACTION 3A: Adopt methods for selecting spawning adults for the hatchery production from an appropriate cross section of the returning adult population available to the hatchery.

PROGRAMMATIC ACTION 3B: Develop a collaborative program to coded-wire tag a representative proportion of all fall-run chinook salmon produced at the Nimbus Hatchery.

PROGRAMMATIC ACTION 3C: Investigate replacing the Nimbus steelhead broodstock with the most genetically appropriate steelhead stock. This could be a native residualized rainbow trout isolated above Folsom Dam (if one exists) or another putative native steelhead stock from within the Central Valley.

RATIONALE: *In watersheds such as American Basin creeks and the American River where dams and habitat degradation, as well as extreme natural conditions have limited natural spawning, hatchery supplementation may be necessary to sustain fishery harvest at former levels and to maintain a naturally spawning population during droughts. Hatchery augmentation, however, should be limited to avoid inhibiting recovery and maintenance of wild populations. Hatchery-reared salmon and steelhead may directly compete with and prey on wild salmon and steelhead. Hatchery-reared fish may also threaten the genetic integrity of wild stocks by interbreeding with the wild fish. Although irreversible contamination of the genetic integrity of wild stocks has occurred, additional protective measures are necessary to minimize further genetic degradation and recovery of wild stocks. Because of the extent of development on the American River, stocking of chinook salmon and steelhead may be necessary to rebuild and maintain stocks to sustain sport and commercial fisheries. Stocking salmon and steelhead may also be necessary on American Basin creeks to build runs to self-sustaining levels and to maintain the runs through adverse conditions such as may occur during droughts.*

Nimbus Hatchery steelhead and naturally spawning fish in the American River exhibit genetic affinity to populations from the Eel River (NMFS 1997), reflecting the origin of this broodstock (McEwan and Nelson 1991). This stock has also been introduced to the Mokelumne River via the Mokelumne River Fish Installation. The feasibility and desirability of phasing-out the Nimbus strain in favor of a stock more genetically similar to the native Central Valley stock should be investigated. The Central Valley Steelhead Comprehensive Genetic Evaluation should be able to identify the most genetically appropriate stock to culture at Nimbus Hatchery, if one exists.

Traditional hatchery stocking programs are detrimental to the recovery of native stocks due to genetic dilution, straying diseases, increased angling pressure, and direct competition. Changes made to *traditional hatchery procedures can result in hatcheries becoming a tool to rebuild native stocks rather than one that degrades them. Decreasing the number of hatchery propagated fish in the Lower American River may increase the opportunity for native stock recovery. However, clear restoration goals for the Lower American River must be developed before the efficacy of such an action can be addressed.*

Potential changes at the Nimbus Fish Hatchery that could benefit the river's native stock include: (1) use of all available broodstock, including grilse, to increase genetic diversity of propagated fish. The practice of discarding broodstock under some arbitrary minimum length simple reduced the genetic diversity of hatchery propagated fish, and thus should be discontinued; (2) The emphasis must be placed on quality, not necessarily the quantity of hatchery production. This potentially means improving water quality and reducing densities of fish to create conditions less likely to be conducive to development and proliferation of disease; (3) Nimbus Fish Hatchery should consider treating their effluent waters to further guard against the introduction of new diseases which may impact native stocks. As recommended in the Steelhead Restoration Plan for the lower American River, the Nimbus Fish Hatchery should continue to improve and implement management practices by taking early migrant and late migrant fish for spawning, and randomly selecting egg lots that are to be raised to yearling size.

Annual hatchery operations and release strategies presently include trucking chinook salmon smolts to release sites in the western Delta. This practice was implemented due to the high loss of juvenile salmon released in the American River as they migrated down the Sacramento River and through the Delta. A long-term goal is to reduce the need to truck chinook salmon by increasing their inland survival. This will accomplished by restoration actions proposed for the American River, Sacramento River, and Sacramento-San Joaquin Delta Ecological Management Zones, and by developing and constructing alternative water conveyance facilities in the Delta.

CONTAMINANTS

TARGET 1: Reduce the application of herbicides, pesticides, fumigants, and other agents toxic to fish and wildlife on agricultural lands that have the greatest risk to fish and wildlife populations (◆).

PROGRAMMATIC ACTION 1A: Enter into conservation easements with willing landowners to modify agricultural practices in ways to reduce loads and concentrations of contaminants.

PROGRAMMATIC ACTION 1B: Provide incentives to landowners to modify agricultural or other land use practices that contribute to the input of contaminants into waterways.

RATIONALE: *Reducing the inputs of contaminants into waterways from the lands with the greatest inputs would provide significant improvement in water quality in streams and wetlands, as well as the Sacramento River and Bay-Delta.*

STRANDING

TARGET 1: Reduce or eliminate the stranding of juvenile chinook salmon on floodplains, shallow ponds, and levee borrow areas (◆◆).

PROGRAMMATIC ACTION 1A: Conduct surveys of stranding in the American River under a range of flow conditions and develop recommendations to resolve the problem.

PROGRAMMATIC ACTION 1B: Conduct surveys of stranding in the Natomas area under a range of flow conditions and develop recommendations to resolve the problem.

PROGRAMMATIC ACTION 1C: Develop a protocol for ramping flow reductions so that flows do not recede so quickly that juvenile fish become isolated and stranded in side-channels in large numbers. Identify threshold flows that define conditions of allowable flow fluctuations.

RATIONALE: *Under some flow conditions, stranding is likely a minimal problem. However, under conditions in which rivers reach high flows and water is diverted into the flood bypasses or spills onto the floodplain, and then quickly recedes, stranding is a serious problem. Stranding of juvenile fish has been a significant problem on the lower American River in the past, and has resulted in significant losses of* *salmon and steelhead. Timing also plays a important role in determining the severity of the problem for chinook salmon, flood plain inundation prior to young salmon emerging is less of a problem that inundation after most of the fry have emerged. Juvenile steelhead are present year-round, however, so fish are subject to isolating flows at all times of the year.*

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◆ Yolo Basin Ecological Management Zone

Photo © California Department of Water Resources

Introduction

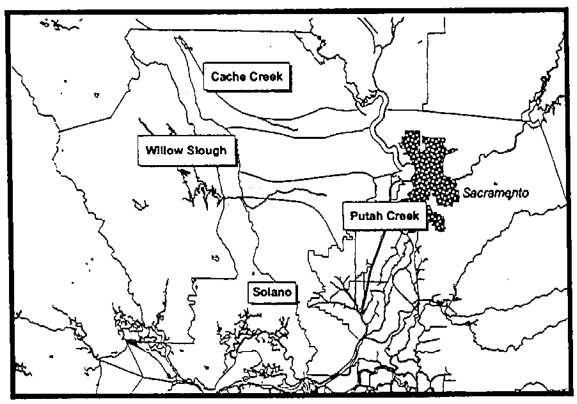
The health of the Sacramento-San Joaquin Delta depends on the health of its distinct watersheds. As with watersheds throughout California, ecological processes within the Yolo Basin Ecological Management Zone have been disrupted during the past century. Due to tenuous hydrological connections, this zone has historically made only marginal contributions to anadromous fish populations. As a result, the major focus in this zone is to increase the health of its important ecological processes, habitats, and fish, wildlife, and plant populations and make substantial contributions to the health of the Delta.

The Yolo Basin Ecological Management Zone provides diverse habitats for a wide variety of fish, wildlife, and plant communities, primarily native resident (nonmigratory) fishes, riparian communities, seasonally and permanently flooded wetlands, wildlife, waterfowl, and occasionally fall-run chinook salmon and possibly steelhead trout. The portion of the Yolo Bypass north of the Interstate 80 causeway is included in this zone and is an important migratory route during wet years for downstream migrant chinook salmon, steelhead, and other native and anadromous originating from up stream areas. When flooded, the Yolo Bypass provides valuable spawning habitat for native resident fish, including splittail.

Description of the Management Zone

The Yolo Basin Ecological Management Zone encompasses the southwest portion of the Sacramento Valley adjacent to the Delta. It includes the following Ecological Management Units:

- Cache Creek
- Putah Creek
- Solano
- Willow Slough



Location Map of the Yolo Basin Ecological Management Zone and Units.

Portions of the Yolo Basin Ecological Management Zone are extensively developed for urban and agricultural land uses. The basin includes the cities of Vacaville, West Sacramento, Woodland, Winters, and Davis. It also includes the northern end of the Yolo Bypass at the mouth of Cache Creek, between the Fremont weir and Interstate 80, and the Sacramento Bypass between the Sacramento River and the Yolo Bypass.

The Cache Creek Ecological Management Unit, at the northern end of the Yolo Basin Ecological Management Zone, encompasses the lower valley watershed of Cache Creek (downstream of Capay Dam near Esparto) and the northern end of the Yolo Bypass. The Putah Creek Ecological Management Unit is in the central portion of the zone, encompassing the Putah Creek watershed downstream of Monticello Dam (near Winters). The

Solano Ecological Management Unit includes the nontidal watershed of the Cache-Lindsey Slough complex of the North Delta Ecological Management Unit and the Montezuma Hills.

Important ecological processes within the Yolo Basin Ecological Management Zone include streamflow, stream erosion, and natural sediment supply. The most valuable habitats are riparian and riverine aquatic. Although restoration efforts within the Ecological Management Units have improved portions of the riparian corridors, many specific improvements are needed to more fully restore ecological health throughout the entire Ecological Management Zone. The greatest needs are to maintain processes more closely linked to the natural streamflow regime and to restore connectivity to the Yolo Basin and Delta. Developing additional sources of water to improve low flow conditions and restoring riparian and stream channel corridors will improve the ecological health of the lower basin watersheds. Restoring upper watersheds by reducing forest fuels, improving oak woodland, forest, and rangeland management, and reducing sources of bioavailable mercury will help ensure that a clean water supply is available in the basin.

Historically, fall-run chinook salmon, steelhead trout, many native resident fish species, waterfowl, shorebirds and wading birds, and riparian wildlife were abundant in areas within the basin. Agricultural and urban development, recreation, infrastructure, mining, and flood control projects have eliminated much of the fish and wildlife habitat. Salmon and steelhead migrations within the creeks are now limited to high flow events, when there is connectivity to the Delta. Opportunities to restore these anadromous fish populations should not be overlooked.

Important habitats within the Yolo Basin Ecological Management Zone include stream and slough channels for fish migration and holding, spawning, and nursery habitats. Seasonally flooded wetlands are prevalent throughout the lower basin, and these are important habitat areas for waterfowl, shorebird, and wading bird guilds. Riparian corridors along basin creeks and sloughs are important habitat areas and migration corridors for wildlife and waterfowl.

Notable stressors to ecological functions, processes, habitats, and species in this Ecological Management Zone are:

- water diversions and past gravel mining in the streams,
- insufficient available flow to maintain a continuous riparian corridor,
- mercury contamination from natural and previously mined sources that is taken up through the aquatic food chain, and
- poor quality agricultural tailwater entering the Yolo Bypass canals and sloughs.

The prevalence of non-native plant species (e.g., tamarisk, giant reed, eucalyptus, and water hyacinth) is a major factor limiting the quality and extent of riparian and riverine aquatic habitats, especially in areas adversely affected by past gravel mining, flood scour, and low streamflow.

LIST OF SPECIES TO BENEFIT FROM RESTORATION ACTIONS IN THE YOLO BASIN ECOLOGICAL MANAGEMENT ZONE

- chinook salmon
- steelhead
- native resident fishes
- plants and plant communities.

DESCRIPTIONS OF ECOLOGICAL MANAGEMENT UNITS

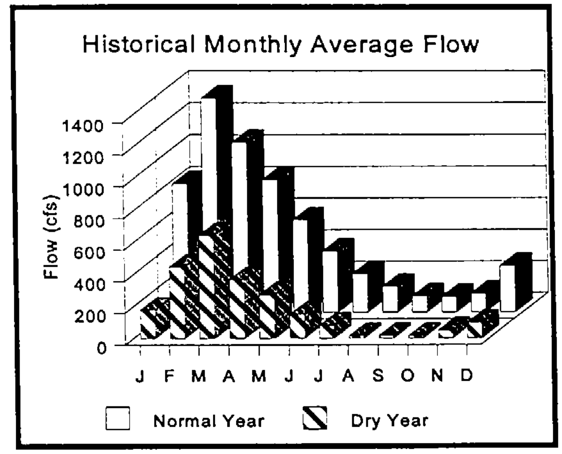
CACHE CREEK ECOLOGICAL MANAGEMENT UNIT

Cache Creek has a watershed of about 1,300 square miles and flows out of the coastal mountains to enter the Sacramento Valley floor near Esparto. Cache Creek enters the Yolo Bypass at Cache Creek settling basin (a reclaimed tule marsh-seasonal lake area) and then flows south into the Delta through the Conway Canal, Tule Canal, lower Cache Creek and other small sloughs in the bypass. Most of the flow is diverted in the spring and summer for irrigation. High winter and early spring flows move south through the flooded Yolo Bypass or connecting sloughs to enter the Delta through Cache Slough which then flows to the Sacramento River north of Rio Vista.

Cache Creek drains the Clear Lake, North Fork, and Bear Creek basins on the east side of the Coast Ranges. The water levels at Clear Lake and Indian Valley Reservoir are regulated for downstream irrigation diversions with a dam and gates constructed in 1915 and 1978, respectively. A powerhouse was added in 1985. The watershed upstream of Clear Lake is about 530 square miles, and the usable storage is about 300,000 acre-feet. Downstream of Clear Lake Dam is the 30-mile Cache Creek Canyon. The North Fork Cache Creek meets Cache Creek 8 miles downstream of Clear Lake Dam and is regulated by Indian Valley Dam, located 8 miles upstream of Cache Creek, with a watershed of 120 square miles and a capacity of 300,000 acre-feet. Cache Creek enters the valley floodplain at Capay Dam near Esparto, 18 miles upstream of the mouth.

No minimum flow requirements have been set for Cache Creek below Capay Dam. In some places between Capay Dam and the Yolo Bypass, the creek flows through areas where gravel mining has recently occurred, but which have not yet had time to recover naturally. In other areas, deep gravel deposits and low water tables inhibit the establishment of a sustained low-flow channel. Another major barrier to upstream fish migration is the recently enlarged outlet spillway of the Cache Creek Settling Basin. Levees confine the stream channel in the lower 8 miles of Cache Creek. These levees define a wide basin at the lower end and act as a sediment trap to preserve the flood capacity of the Yolo Bypass. The levees were raised 12 feet in 1993 to provide an additional 50 years of sediment capacity. Flows near the town of Yolo are very low during summer and fall of most years, but Cache Creek has a flashy but intermittent natural hydrograph.

Cache Creek has a natural flow pattern of high winter, moderate spring, and low summer-fall flows, typical of many western Sacramento Valley streams that originate from chaparral and oak studded foothills rather than higher snow-laden mountains. Portions of the stream are dry during summer and fall months, except for small sections upstream of Woodland receiving groundwater. Inflows to the lower basin at Rumsey in wettest years have averaged 5,000 to 10,000 cubic feet per second (cfs) in winter months and 300 to 700 cfs in summer months. There was a flood peak of 58,000 cfs in 1995. In driest years, flows may be near 0 cfs the entire year.



Cache Creek Streamflow from Upper Basin at Rumsey, 1962-1992
(Dry year is the 20th percentile year, normal year is the 50th percentile of median year.)

Low flows are further reduced by year-round diversions. The stream in the valley floor downstream of Capay Dam is often dry during summer and fall months. In dry years, average monthly winter flows peaked at 30 to 100 cfs. Unimpaired flows during March in dry years are reduced from an average of 650 to 60 cfs by diversions. Unimpaired flows during May are reduced from 260 to 0 cfs. In normal rainfall years, May flows are reduced from 590 to 10 cfs.

Because of barriers, fall-run chinook salmon and steelhead are believed to have migrated up Cache Creek and only on an infrequent basis. Anecdotal historic evidence suggests that in wet years, when flows in Yolo Bypass and Cache Creek are high, some fish may have reached the spawning gravels of lower Cache Creek from the Delta. In dry years, no passable connection exists for salmon and steelhead between the Delta and the mouth of Cache Creek. Fish passage may also impaired at the Cache Creek settling basin spillway and headworks.

Potentially, juvenile salmon and steelhead produced in wetter years may be lost during the spring when Yolo Bypass flows cease and juvenile salmon become trapped in the creek or ponds and dead-end sloughs of the Yolo Bypass and settling basin. In years when Cache Creek flows are high enough in winter or spring, some juvenile salmon and steelhead can migrate downstream to the Delta through the flooded bypass or the network of agricultural drains crossing the Yolo Bypass to Tule Canal.

Numerous studies performed by both state and federal agencies indicate that Cache Creek transports significant amounts of mercury into the Delta. The mercury is often associated with suspended sediment loads that occur during high flow events, when Cache Creek is hydrologically connected to the Yolo Bypass. A powerful neurotoxin, mercury can cause developmental damage in both wildlife and humans. More importantly, mercury bioaccumulates through the food chain, affecting not only aquatic organisms but higher order species that feed upon them.

Improving streamflows, gravel spawning, and riparian habitats and providing permanent connections between the mouth of the creek and the Delta would only marginally help to increase steelhead trout and fall-run chinook salmon populations. Although Cache Creek can make minor contributions to fall-run chinook salmon populations in some years, significant resources would be required to provide the necessary holding, spawning, rearing, and migration habitat. However, steelhead populations, unlike chinook salmon, can exist in streams that have infrequent connectivity to the ocean. The variable life-history of steelhead/rainbow trout populations allow them to persist in the mid- to high-elevation stream reaches indefinitely if there are suitable habitat conditions, despite the loss of connectivity to the ocean. Although these sub-populations may be small, they are important to the persistence of the basin-wide population as a whole and contribute to the overall population viability when access is restored in wet years (IEP Steelhead Project Work Team 1999), and should not be overlooked.

The riparian corridor must be improved significantly in several areas; some areas have been denuded and will require a more intensive revegetation effort. This has been aided by the elimination of commercial instream gravel mining in the creek bed under Yolo County's new Cache Creek Area Plan, with all new mine permits restricted to off-channel sites. In addition, several replanting projects by non-profit organizations and government agencies are currently underway. Recent proposals to create off-channel storage facilities using water conveyed from Cache Creek in winter and spring would also permit recharge of groundwater resources that may improve the survivability of vegetation during low-flow seasons.

There are several factors that combine to constrain efforts to establish salmon and steelhead habitat. The natural geomorphology of the stream is not conducive to supporting a continuous, year-round stream. The need to maintain the flood control capacity of the river floodplain and the Yolo Bypass restrict the feasibility of creating a natural riparian system in the lower creek. Most important of all, the high levels of mercury contamination measured in the creek are a direct and significant threat to the health of the species. Until such time as the source of the mercury is identified and the contamination remediated, Cache Creek should not be considered as healthy habitat for many aquatic species.

Salmon and steelhead migrations within the creeks have historically been limited to high flood events, when there was connectivity to the Delta. However, salmon and steelhead have not been documented to be present in Cache Creek for many years. Their use of Cache Creek is restricted to occasional efforts at colonization when high flows support up-and downstream migration. Opportunities to restore these anadromous fish populations continue to be limited and restoration efforts will emphasize restoration of ecological processes and the elimination or reduction of stressors such as mercury contamination and invasive plants.

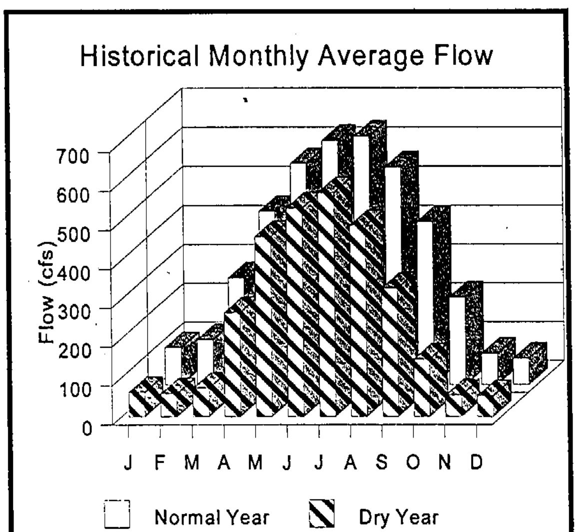
Supporting the involvement of local citizens and interested parties in existing organizations such as the Cache Creek Conservancy and Cache Creek Stakeholders Group would help to restore and maintain Cache Creek. Similarly, developing and implementing a comprehensive watershed management plan as required under the Cache Creek Resource Management Plan (approved in 1996 by Yolo County as a regulatory and planning document to maintain flood control capacity, reduce bank erosion in the channel, and preserve and restore the riparian corridor) could facilitate restoring and maintaining Cache Creek. Upper watershed health can also be improved by reducing forest fuels and implementing other watershed improvement practices to protect streamflows, stream channels, and riparian habitat and minimize sediment input to the stream.

Riparian habitat can be restored by providing adequate streamflows when available, protecting the natural sediment supply, promoting the conservation and expansion of the active floodplain, and protecting shorelines from livestock grazing upstream of Capay Dam. Planting vegetation or regrading the disturbed channel and floodplain will hasten and sustain recovery in some areas. Major efforts are required to control or eradicate tamarisk and giant reed infestations which interfere with natural vegetation succession by native tree species.

PUTAH CREEK ECOLOGICAL MANAGEMENT UNIT

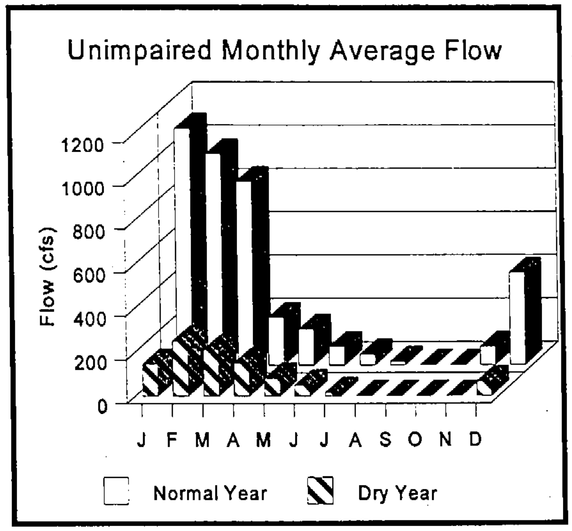
Putah Creek has a watershed of about 710 square miles and flows out of the coastal mountains to enter the Sacramento Valley floor near Winters. Putah Creek flows into the Yolo Bypass at the Putah Creek sinks (a historical tule marsh-lake area). In most wet years, the creek flows to the Yolo Bypass and then flows south through Tule Canal to the Sacramento River. Monticello Dam (constructed in 1956) forms Lake Berryessa from Putah Creek on the east side of the coastal range. Below Monticello Dam, the creek flows into Solano Lake, formed by the Solano Diversion Dam (constructed in 1959). Below Solano Diversion Dam, the creek flows east through Winters and Davis.

Most of Putah Creek's flow below Monticello Dam originates from Lake Berryessa, which has an average outflow of approximately 350 cfs. Unimpaired flows into the Lake Berryessa watershed formerly peaked in winter. In wettest years, winter flows averaged 4,000 to 9,000 cfs. Lowest flows occur in summer and fall.



Putah Creek Streamflow below Monticello Dam, 1961-1991 (Dry year is the 20th percentile year, normal years if the 50th percentile year or median year.)

In driest years, flows in winter months averaged only 20 to 70 cfs. In wetter years, summer and early fall flows averaged 20 to 100 cfs.

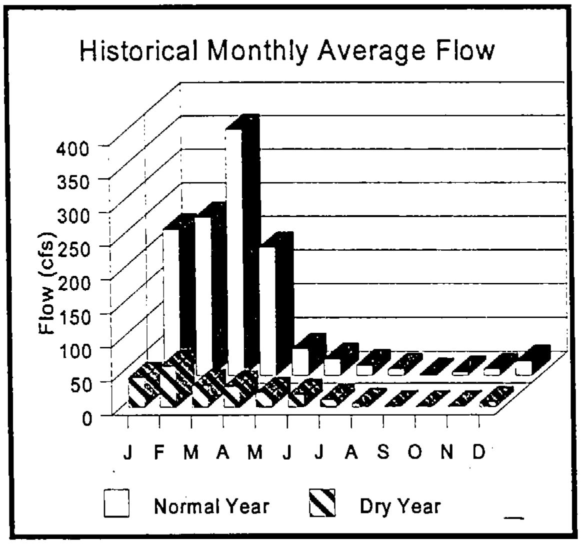


Putah Creek Unimpaired Streamflow at Lake Berryessa, 1961-1991 (Dry year is the 20th percentile year, normal year is the 50th percentile or median year.)

The natural flow pattern has been altered by water storage in Lake Berryessa and spring through fall irrigation releases. Flows from Monticello Dam are high in summer and low in winter in all but the wettest years. Wet-year spillage flows still average 4,000 to 8,000 cfs in winter; however, in normal and dry years, winter flows are generally less than 100 cfs. Even in the driest years, irrigation releases from late spring to early fall are 200 to 400 cfs above Solano Dam but near zero below the diversion dam.

The largest diversion is the Putah South Canal diversion at Solano Diversion Dam; this and other irrigation diversions reduce flows to very low levels in all but wet years and in all months. Flows near Davis are very low during summer and fall of most years, generally 0 to 60 cfs. Spillage flows reach 4,000 to 7,000 cfs in the winter of wet years, but only 4 to 20 cfs in driest years.

Historically, chinook salmon migrated at least as far as the town of Monticello (now under Lake Berryessa) (Yoshiyama et al. 1996). Solano Diversion Dam is now the upstream terminus of salmon and steelhead migration. Some fall-run chinook salmon and steelhead still migrate up Putah Creek in wet years (fall-run chinook adults were observed in 1997 and 1998). In dry years, no viable connection exists between the Delta and Putah Creek for salmon and



Putah Creek Streamflow near Davis, 1961-1971, 1973-1975, and 1978-1984 (Dry year is the 20th percentile year, normal year is the 50th percentile or median year.)

steelhead. In wet years, when Yolo Bypass and Putah Creek flows are high, fish can reach spawning gravels in lower Putah Creek from the Delta. Significant losses of juveniles can occur in spring if low flows or barriers limit connections in the Yolo Bypass, or in wet years when Yolo Bypass floodflows recede and juvenile salmon become trapped in seasonal ponds, disconnected canals, and sloughs in the bypass. If Putah Creek flows are high enough in winter or spring, some juvenile salmon and steelhead can migrate downstream through the Delta through canals along the east side of the Yolo Bypass.

Native fish species, such as hitch, squawfish, and suckers, are an important component of the Putah Creek watershed and are a primary focus for management and restoration efforts. Native fish populations are very low in lower Putah Creek except for the two-mile reach immediately below Solano Diversion Dam. The length of this reach is insufficient to insure the long-term viability of the native fish assemblage and a goal is to restore these native fishes to a stat of "good condition." Good conditions mean that fish of all ages are present in sufficient numbers over a large enough habitat area to afford the population the ability to recover form mortalities caused by unexpected disasters (i.e., pesticide spills; large, rapid sediment releases from Lake Solano, etc.); environmental factors; angling; and predation. Habitat conditions that promote successful reproduction, growth and survival of young fish, and the growth and survival of adult fish are essential (Trihey & Associates 1996).

Improving streamflow, spawning gravel, and riparian habitats and providing permanent connections between the mouth of the creek and the Delta will increase opportunities for steelhead trout and fall-run chinook salmon to use Putah Creek. Putah Creek can make minor contributions to fall-run chinook salmon and steelhead populations if adequate holding, spawning, rearing, and migration habitat are provided. Adequate streamflows are important to maintain and restore the connections between upstream spawning and nursery areas with the Delta.

Actions to restore and improve conditions for chinook salmon and steelhead are more likely to succeed during years of normal to above-normal rainfall. Supplementing flows from Monticello Dam (Lake Berryessa) through the Solano Diversion Dam during critical migration periods would help maintain and improve flows. Providing supplementary flows into and through the Yolo Bypass sloughs, either from the Colusa basin drain through the Knights Landing Ridge Cut Canal or the Sacramento River through the Fremont weir near Verona, would provide the necessary flows in drier years to let fish pass from the creek mouth to the Delta. The goal is to provide adequate flows for adult salmon migration in fall, fry rearing in winter, and spring juvenile outmigration in all but the driest years. Minimum flows in upstream summer rearing areas below Solano Diversion Dam would be required to sustain the steelhead population.

Inadequate spawning gravel may be a significant factor limiting salmon and steelhead production, especially in the upper reach below Solano Diversion Dam. Existing gravel sources should be protected, and the natural supply should be added to the creek where and when necessary. Past gravel mining operations along the stream channel, floodway clearing, and grading and bank protection in the floodplain and along Dry Creek (a major source of gravel to Putah Creek downstream of Solano Diversion Dam) may also inhibit gravel recruitment downstream. This reach offers excellent habitat for oversummer rearing of juvenile steelhead when flows and water temperatures are adequate.

The riparian corridor condition must be improved significantly in several areas. Some areas have been denuded and will require a more intensive revegetation effort. Gravel mining operations in the creek bed were discontinued in the 1960s, but the major gravel and sediment source for the lower creek was eliminated by the construction of Solano and Monticello Dams.

Developing and implementing a comprehensive watershed management plan for both the upper and lower watersheds, and implementing the lower Putah Creek management recommendations prepared in 1994 by the U.S. Fish and Wildlife Service (USFWS) and the Lower Putah Creek Coordinating Committee, would facilitate restoration and maintenance of Putah Creek. Above Lake Berryessa, upper watershed health should be improved by reducing forest fuels and the opportunity for catastrophic wildfire and implementing other watershed improvement practices to protect streamflows, stream channels, and riparian habitat and minimize sediment input to the stream. Below the lake, efforts should focus on protecting riparian habitat, providing adequate gravel spawning areas for salmon and steelhead, and improving stream channel conditions.

Riparian habitat can be restored or enhanced by providing adequate floodplains along the channel and protecting shorelines from grading, bank filling, and native vegetation removal to expand orchards or urban and industrial facilities. Planting vegetation or regrading the disturbed channel and floodplain will hasten and sustain recovery in certain areas. Major efforts are required to control or eradicate eucalyptus tamarisk and giant reed infestations, which interfere with natural vegetation succession by native tree species. These efforts will involve coordination with the local jurisdictions (Yolo County and the cities of Winters and Davis), University of California (UC) Davis, the U.S. Bureau of Reclamation (Reclamation), Solano County Water Agency, Putah Creek Landowners Association, and the Putah Creek Council.

Adequate screening systems are needed on the Putah South Canal diversion if fish passage is to be provided along Solano Diversion Dam. Small, unscreened diversions in Putah Creek need to be screened to protect juvenile fish.

Providing fish passage at Solano Diversion Dam would allow salmon and steelhead passage into the cold tailwaters of Monticello Dam. The interdam reach—several miles of high-quality riparian and shaded riverine aquatic (SRA) habitat—currently supports a native and stocked trout fishery. With appropriate spawning gravels, the 12-mile reach between Solano Diversion Dam and Monticello Dam could provide good spawning and rearing habitat for salmon and steelhead. This reach offers excellent habitat for oversummer rearing of juvenile steelhead.

SOLANO ECOLOGICAL MANAGEMENT UNIT

The southern portion of the Yolo Basin Ecological Management Zone is the Solano Ecological Management Unit. This unit encompasses small watersheds above the tidal Delta, south of Putah Creek and east to the Delta. Most of this area is within the Cache Slough and Lindsey Slough watersheds. The unit also includes the Montezuma Hills, which are not part of the Delta as it is legally defined.

Although salmon and steelhead are rarely found in this unit, native resident fish do occupy creeks and sloughs. Riparian corridors of these creeks and sloughs support vegetation, waterfowl, and wildlife. Upland habitats include vernal pools, valley oak woodlands, and grasslands. Scattered areas of seasonal and perennial wetlands and aquatic habitats exist throughout the unit.

Many of the vernal pools within this Ecological Management Unit are in a degraded condition due to land use practices (e.g., discing and cultivation) and could be improved. The potential for restoring native perennial bunch grass is high, as well as is restoring some of the rare vernal pool plant species.

WILLOW SLOUGH ECOLOGICAL MANAGEMENT UNIT

Willow Slough Ecological Management Unit is comprised of approximately 131,000 acres of productive farmland. The watershed is bounded and intersected by half a dozen natural riparian waterways, supporting an extensive irrigation and drainage system. Winter runoff from the Vaca foothills to the west enters this series of tributaries to terminate in the Yolo Bypass. Even during years of normal rainfall some downstream areas flood and larger events have involved parts of the cities of Davis and Winters. Very little winter water is held back or captured in the natural systems. Summer use links the natural system with Cache Creek diversions and the Yolo County Flood Control and Water Conservation Districts (FCD) canal system to deliver irrigation water and remove related drainage flows.

No major surface water impoundments exist within the watershed. The creeks have historically been managed by farmers and the FCD to remove water as quickly as possible. As a result, there is frequent downstream flooding, enormous movement of sediment, and lost riparian habitat, wildlife populations, and biodiversity. A consequence of traditional farming practices has been the elimination of functioning seasonal wetlands and loss or degradation of riparian systems. These systems historically transported anadromous species such as chinook salmon and steelhead in years when there was adequate streamflow. As recently as 1986, an adult steelhead was found in Willow Slough. Once health natural streamways are now barren or invaded by exotic plant species that contaminate fields and roadsides requiring high maintenance and chemical use with little ultimate control.

Agriculture is the primary economic enterprise throughout the watershed. Crops include lowland acres of alfalfa, irrigated row crops, and orchards. Dryland grains and rangeland grazing characterize the upland hills. The lower irrigated croplands are made up of highly productive deep alluvial soil as well as heavier clay and alkali soils. The latter are generally used for rice production. Intensive "clean" agricultural practices in the watershed have had significant negative impacts on riparian system, wetlands, upland wildlife habitat, water quality, and flooding. A change in land stewardship practices can correct the negative impacts while maintaining, and in some cases, improving the agricultural's economic base.

The highest elevations of the watershed consist of chaparral and blue oak woodlands. Most of the habitats are in relatively good condition, although heavy grazing pressure impacts the grasslands and riparian areas, especially in the lower reaches. The lower foothills are mixed blue oak woodlands and grassland or dryland grain areas. Much of this acreage is enrolled in the federal Conservation Reserve Program (CRP) and consists of non-native annual grasses and forbs.

Historically, the waterways across the county were rich and biologically diverse because of their system of interconnected streams, wetlands, and dry uplands. Some narrow remnants of these systems can still be found but most have been removed as part of agricultural practices. Much of what remains is of a weedy nature, and is not compatible with adjacent agriculture, and requires continuous maintenance.

Where areas of natural sloughs remain, seasonal flows support riparian vegetation consisting of valley oak, foothill pine, some willows, toyon, buckeye, wild rose, elderberry, and other associated species. Many wildlife species use these corridors including deer, quail, raptors, gray fox, and tree squirrels. The large trees provide important nesting sites for the endangered Swainson's hawk and other species. Thickets of elderberry, rose, button willow, mulefat, sedges, rushes, and grasses provide important food, cover, and migration corridors of many species. Intact riparian systems also provide important bio-filtering of runoff waters. By trapping sediments and chemicals, water quality improves in downstream aquatic systems of the Yolo Bypass and Sacramento River.

VISION FOR THE ECOLOGICAL MANAGEMENT ZONE

The vision for the Yolo Basin Ecological Management Zone is to protect natural ecological processes and habitats to a sufficiently healthy condition to support native resident fish populations in basin watersheds. The overall vision also includes visions for ecological processes, habitats, species, stressors, and the Ecological Management Units.

VISIONS FOR ECOLOGICAL MANAGEMENT UNITS

CACHE CREEK ECOLOGICAL MANAGEMENT UNIT

The vision for the Cache Creek Ecological Management Unit is that native resident fish will be sustained by improving streamflows, fish passage, riparian habitat, and spawning gravel recruitment and by screening unscreened diversions.

Putah Creek Ecological Management Unit

The vision for the Putah Creek Ecological Management Unit is that native resident fish will be protected and enhanced by improving stream channel characteristics, instream habitat, streamflows, fish passage, riparian habitat, and spawning gravel recruitment and by screening unscreened diversions. Opportunities to promote use by chinook salmon and steelhead trout will be further evaluated.

Solano Ecological Management Unit

The vision for the Solano Ecological Management Unit is that creeks and sloughs and the associated riparian, wetland, and upland habitats in the unit will provide connections to the North Delta. Populations of native resident fish, including Sacramento splittail and delta smelt, may be enhanced by improving conditions in these habitats.

Willow Slough Ecological Management Unit

The vision for the Willow Slough Ecological Management Unit is to integrate agriculture, natural habitats, and urban development in a manner to support ecological health.

Visions for Ecological Processes

Central Valley Streamflow: Streamflows shape channels, support riparian vegetation, and provide habitat for fish and other aquatic species. Streamflows also transport sediments, nutrients, and juvenile fish. The vision is that streamflows in Cache and Putah Creeks will support stream channel maintenance processes, such as sediment transport and meander (consistent with flood protection and adjoining land uses), a healthy riparian zone, and sustainable native resident fish populations.

Coarse Sediment Supply: The availability and quality of sediments within the active stream channel are important for supporting natural stream channel dynamics, channel maintenance, soil medium for vegetation, and stream substrate. Sediments also include gravel, which provides for fish spawning and invertebrate production. The vision for coarse sediment supply is that a sediment equilibrium will be achieved that balances sediment transport with sediment input to make suitably sized gravels available for fish spawning and enhances riparian plant life.

Natural Floodplain and Flood Processes: Stream-floodplain interactions are an important ecological process. Streams need the opportunity to inundate their floodplains on a regular cycle to support riparian regeneration, nutrient input to the system, and to erode and deposit sediments. The vision for floodplains in the Yolo Basin Ecological Management Zone is that Cache and Putah Creek will seasonally flood their active floodplains. The vision also anticipates that the flood capacity and biological productivity of the flood bypass system will be increased by improving conditions that support habitat and juvenile and adult fish survival.

Vision for Habitats

Riparian and Riverine Aquatic Habitats: A healthy riparian corridor provides a migratory pathway linking lower and higher elevation habitats for terrestrial species, such as mammals and birds. Health riparian systems also produce and contribute to shaded riverine aquatic (SRA) habitat, which can provide cover in the form of shade or woody debris. The vision for riparian and SRA habitats is that they will provide a migration corridor between the Delta and upstream habitats that support terrestrial and aquatic species.

Seasonal Wetland Habitat: The vision is that increased seasonal flooding of leveed lands, use of the Yolo Basin's natural flood detention capacity, protection and enhancement of existing wetlands, and development of cooperative programs with local landowners will contribute to increased habitats for waterfowl and other wetland dependent fish and wildlife resources.

Freshwater Fish Habitat: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native and anadromous fish species. The streams in the Yolo Basin Ecological Management Zone are a combination of fall-run chinook salmon spawning streams in some years of early rainfall but more typically hitch streams during most years (Moyle and Ellison 1991). The quality of freshwater fish habitat in Cache Creek, Putah Creek, and Willow Slough will be maintained through actions directed at streamflows, coarse sediment supply, stream meander, natural floodplain and flood processes, and maintaining and restoring riparian and riverine aquatic habitats.

ESSENTIAL FISH HABITAT: Both Cache Creek and Putah Creek are identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). Key features of EFH to maintain or restore in these creek include substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

VISIONS FOR REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS: Diversion can dewater stream reaches and cause direct mortality to juvenile fish by entrainment. The vision is that additional water supplies will be developed to ensure that diversions will not impair efforts to establish sustainable populations of native resident fish species.

GRAVEL MINING: Gravel mining can remove significant quantities of sediments from the active stream channel. This loss of sediments, often in the form of gravel and sand, can have significant adverse affects on stream channel dynamics and riparian succession. The vision is that intensive gravel mining activities will be relocated to sites outside the active stream channels while allowing for continued stream restoration, flood maintenance, and erosion control.

INVASIVE RIPARIAN AND MARSH PLANTS: Invasive plant species can outcompete and displace valuable native species. Invasive plants often have little or no value to native wildlife and are de-stabilizing natural ecosystem functions and processes. The vision is that invasive plants will be controlled to allow native riparian plant species to propagate naturally.

PREDATION AND COMPETITION: The presence of non-native fish populations in the streams of the Yolo Basin Ecological Management Zone has adversely affected native fish assemblages. This is largely a result of competition for food and space, though some of the non-native fish prey on native species. Improving habitat for native species will contribute to reducing, but not eliminating, predation and competition.

CONTAMINANTS: Reducing toxin inputs in discharges and from contaminated sediments is essential to maintain water quality. Reduced concentrations in waters entering the Delta should lead to lower concentrations in Delta water and in fish and invertebrate tissues. Fewer health warnings for human consumption of Delta fish and improved foodweb productivity would also be expected.

VISIONS FOR SPECIES

CHINOOK SALMON AND STEELHEAD: The vision is that the Yolo Ecological Management Zone will contribute to the recovery of fall-run chinook salmon and steelhead populations.

NATIVE RESIDENT FISH SPECIES: Many native fish species will benefit from improved aquatic habitats and stream channel/floodplain processes. Population abundance indices should remain stable or increase and population sizes should be large enough to recover from natural and human-induced disasters fully. The distribution of native resident fishes should increase with widespread habitat restoration.

PLANT SPECIES AND COMMUNITIES: The vision for plan species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland and riparian and riverine aquatic habitats.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

All efforts proposed in the Ecosystem Restoration Program Plan (ERPP) to improve habitat and reduce stressors will be coordinated with existing State and federal programs and with local stakeholder organizations. The ERPP also supports and complements restoration efforts already underway in the Yolo Basin, including the following.

CENTRAL VALLEY PROJECT IMPROVEMENT ACT

The Central Valley Project Improvement Act (CVPIA) which calls for efforts to double the salmon and steelhead populations in the Central Valley by 2002 through changes in flows and project facilities and operations.

Salmon, Steelhead Trout and Anadromous Fisheries Program Act

DFG is required under the Salmon, Steelhead Trout and Anadromous Fisheries Program Act of 1988 to restore salmon and steelhead runs in the Central Valley.

The Delta Native Fishes Recovery Plan

This plan prescribes efforts to assist the recovery of many fish species native to the Central Valley, including delta smelt, splittail, and other native fish species.

Endangered Species Act

The National Marine Fisheries Service (NMFS) is reviewing the status of steelhead trout in the Central Valley. Any restoration program developed under the federal Endangered Species Act (ESA) will be compatible with recommendations in the ERPP.

The health of the Ecological Management Units of the Yolo Basin Ecological Management Zone can be maintained and restored only with the active participation of local watershed groups, which include local landowners and concerned individuals.

Native Species Recovery Plan for Lower Putah Creek

A recovery plan for Lower Putah Creek native fish species was prepared in 1996. This plan is intended to re-establish and maintain: (10 a resident native cool water fish assemblage, (2) a mixed native warm-water fish assemblage, (3) a warm-water game fish assemblage, and (4) a native anadromous fish assemblage. Many of the ERPP targets and programmatic actions for Putah Creek are consistent with the recommendation in this plan

Watershed Organizations

Some watershed groups that already have been established in the Ecological Management Zone are:

- Cache Creek Conservancy,
- Cache Creek Stakeholders Group,
- UC Davis Putah-Cache Bioregional Project,
- Solano County Water Agency,
- Water Resources Association of Yolo County,
- Farm Bureau
- Putah Creek Landowners Association,
- Putah Creek Council,
- Yolo County Resource Conservation District,
- Yolo Basin Foundation,
- Flood Plain Management Group,
- Blue Ridge Ranchers, and
- Quail Ridge Conservancy.

Efforts in the Yolo Basin will be linked to similar work by the California Waterfowl Association, Ducks Unlimited, The Nature Conservancy (TNC), and the California Rice Industry. The overall success of these efforts will require cooperation from resource agencies, such as the California Department of Fish and Game (DFG), California Department of Water Resources (DWR), and USFWS, as well as participation and support from the U.S. Bureau of Reclamation (Reclamation), Natural Resources Conservation Service (NRCS), private organizations, water districts, county and city governments, and individual landowners. These groups will work together to maintain and restore streamflows and fish and wildlife habitat, develop additional water supplies to reduce impacts of diversions, and minimize poaching and degradation of habitat and water quality in basin streams. To support this effort, funding may be provided to enhance streamflows, reduce problems related to fish passage, install screens at diversions, restore habitats, and increase enforcement of the California Fish and Game Code to protect recovering populations of salmon and steelhead.

Willow Slough Integrated Resource Management Plan

To implement a set of resource management practices, the Yolo County Resource Conservation District (RCD) is working with local landowners, and local, state, and federal agencies under the Willow Slough Integrated Resource Management Plan. The goal of this plan is to enhance the natural resources of the watershed using voluntary, small-scale, on-farm, and reproducible management practices. The resources and problems that could be jointly managed include stormwater runoff, erosion, sedimentation, chemical use, wildlife habitat, and groundwater recharge.

A resource inventory completed during the plan development process found multiple benefits could be achieved. The analysis focused on opportunities for creating or enhancing wetland and riparian habitats, augmenting groundwater recharge, and decreasing flooding problems.

LINKAGE TO OTHER ECOLOGICAL MANAGEMENT ZONES

Many of the resource elements in the Yolo Basin Ecological Management Zone depend on conditions or elements in other zones, including the Sacramento River and Delta. The Yolo Basin Ecological Management Zone has important connection with the North Delta Ecological Management Zone. The major area that connects the two is the Yolo Bypass. The upper section of the bypass (above the Interstate 80 causeway) is in the Yolo Basin Ecological Management Zone and the section below the causeway is in the North Delta Ecological Management Unit.

The connections between these areas also include other ecosystem elements. Anadromous fish, for example, are highly migratory and depend on conditions in the mainstem Sacramento River, the Delta, the San Francisco Bay, and the nearshore Pacific Ocean. Because these fish are affected by stressors throughout their range, such as unscreened diversions, water quality deterioration, and harvest, restoring salmon and steelhead populations in the Yolo Bypass will require efforts in other zones.

RESTORATION TARGETS AND PROGRAMMATIC ACTIONS

ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOW

TARGET 1: More closely emulate natural seasonal patterns in Cache and Putah Creeks by providing additional flows, when available from existing water supplies. Flows in the Yolo Bypass would be supplemented, as needed, by the Colusa basin drain through the Knights Landing Ridge Cut Canal, extending the Tehama-Colusa Canal, and the Sacramento River through the Fremont weir. Supplemental flows may be needed in fall if water temperature and flow in the lower Yolo Bypass are insufficient for passage from Cache Slough to upstream areas in the Sacramento River. Supplemental flows may be needed in winter and spring to sustain downstream migrating juvenile salmon and steelhead on their journey through the Yolo Bypass to the Delta. Supplemental flows would be needed along with irrigation water from spring to fall to sustain native fish, wetlands, and riparian habitats in channel sloughs of the Yolo Bypass (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to provide water for summer flows in Cache Creek to maintain riparian vegetation by developing new conjunctive supplies, including groundwater.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to provide water for the target flows in Putah Creek from additional Lake Berryessa releases or reductions in water diversions at Solano Diversion Dam and in the creek downstream of the dam. Water would be obtained from willing sellers, water transfers, and by developing new supplies, including groundwater.

PROGRAMMATIC ACTION 1C: Cooperatively evaluate the feasibility of providing water for the upper Yolo Bypass portion of the Cache Creek Unit by redirecting water from Colusa basin drain through the Knights Landing Ridge Cut Canal, an extension of the Tehama-Colusa Canal, and the Sacramento River through the Grays Bend-Old River-Fremont weir complex.

RATIONALE: *Supplemental summer flows proposed in Cache Creek would sustain newly established riparian vegetation and provide refuge for native resident fish. Flows from the Colusa basin drain, Tehama Colusa Canal extension, and the Sacramento River are necessary to provide sufficient flow in the Yolo Bypass during the spring through fall irrigation season to sustain native fish, wetlands, and riparian habitat; additional supplemental flow may be needed during the late-fall through early spring salmon and steelhead migration season. These flows will sustain native resident fish species and salmon and steelhead using the Yolo Bypass route to and from the upper Sacramento River watersheds.*

Flow in this area would pass south along both sides of the Yolo Bypass, merging with any supplemental Cache and Putah Creek flows along the west side of the Yolo Bypass. A weir or screen will be placed at the Knights Landing Ridge Cut Canal outlet to keep salmon and steelhead from migrating upstream into the Colusa basin drain. Fish passage facilities will be constructed at the Grays Bend-Old River-Fremont weir complex to allow migrating adult salmon and steelhead moving upstream through the Yolo Bypass toward upper Sacramento River basins to enter the Sacramento River. Downstream migrating juvenile salmon and steelhead will not be discouraged from moving from the Sacramento River into the Yolo Bypass, because conditions should be optimal for rearing and migrating on their way to the Delta.

Improved streamflows are one of the most critical ecosystem elements required to promote healthy native fish populations in Putah Creek. Opportunities to provide the needed flows are presently limited, but that does not lessen the need to continue efforts to find a collaborative means by which to meet the needs for all the beneficial uses of Putah Creek water. There are four general classes of streamflow needs for Putah Creek native fishes: (1) flows for native fish rearing, (2) flows for native fish spawning, (3) flushing flows to push non-native pond fish downstream, and (4) anadromous fish flows. The first two streamflow needs are of higher priority at this time and alternatives to using streamflows to control non-native fish species need to be further examined. Restoring more natural channel characteristics, providing instream habitats such as woody debris, pools, overhanging vegetation, may provide native species with the advantage required to displace naturally or successfully compete non-native species such as the red shiner.

COARSE SEDIMENT SUPPLY

TARGET 1: Restore gravel recruitment in Cache and Putah Creeks to meet the needs of spawning fish, maintain natural stream channel meanders and bar formation where consistent with flood protection and adjoining land uses, and match existing rates of downstream displacement (◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to supplement gravel recruitment below Solano Diversion Dam as needed to replace natural gravel recruitment interrupted by the diversion dam.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to supplement gravel in areas downstream of the diversion dams where other structures or gravel mining has interrupted the gravel recruitment process.

RATIONALE: *Gravel recruitment has been severely interrupted in Putah Creek from dam construction. Replacement is necessary below the dam to sustain fish rearing habitat, feasible stream meander, and riparian corridors. Consistent with this is the need to improve the stream channel characteristic of Putah Creek downstream of Solano Diversion Dam. Of concern is the existing channel geometry including width and depth.*

NATURAL FLOODPLAIN AND FLOOD PROCESSES

TARGET 1: More closely emulate natural stream channel configurations in Cache Creek and Putah Creek, as well as in channels and sloughs of the upper Yolo Bypass, consistent with flood control requirements (◆◆).

PROGRAMMATIC ACTION 1A: Cooperatively evaluate the feasibility of modifying the cross sections and channel configurations in Cache and Putah Creeks to provide a more natural configuration, while maintaining consistency with flood control requirements and minimizing impacts to adjoining established land uses.

TARGET 2: Increase overbank flooding potential to floodplains, where feasible and consistent with flood protection, to support a desirable vegetation succession process (◆).

PROGRAMMATIC ACTION 2A: Evaluate opportunities to provide flow to Yolo Bypass from Colusa basin drain, extending the Tehama-Colusa Canal, and Sacramento River (through Fremont weir) in dry and normal water years, as well as normally occurring overflow in wetter years.

TARGET 3: Increase the area of flooding to the active Cache and Putah Creek floodplains during the wet season, where feasible and consistent with flood protection (◆◆).

PROGRAMMATIC ACTION 3A: Evaluate the feasibility of expanding floodplain overflow areas in the lower Cache and Putah Creek floodplains. Such areas would include sloughs and creek channels, setback levees, and wetlands, where feasible and consistent with flood protection.

TARGET 4: Establish a desirable level of floodwater retention potential by expanding, where feasible and consistent with flood protection, the floodplain area of the Yolo Bypass, lower Cache Creek, and lower Putah Creek, and by developing off-channel water storage facilities (◆◆).

PROGRAMMATIC ACTION 4A: Cooperatively evaluate the feasibility of reoperating and modifying the Yolo Basin to increase its capacity for floodwater detention and sediment retention by reconfiguring levees, channels, and other physical constraints to large-volume flow events.

RATIONALE: *Overbank flooding is a regular occurrence in the Yolo Bypass in flood years. Proposed actions will provide this valuable process in dry and normal water years when no flooding of the Bypass would normally occur. Flooding in the Bypass sustains wetlands and provides for the transfer of considerable amounts of nutrients and organic materials to the Delta and Bay, where it serves the valuable purpose of contributing to the estuarine foodweb. Developing floodplain overflow areas and off-channel water storage facilities along lower Cache and Putah Creeks will help reduce flood damage, provide supplemental flows during the summer, and improve fish, riparian, and wetland habitats, and further contribute nutrients and organic materials to the Bay-Delta foodweb.*

Natural floodplain overflow basins and off-channel water storage facilities serve to store sediment, nutrients, and water, making them available for other uses and to the rivers at other times. The subsurface water and sediment flow and nutrient retention also help form and maintain riparian habitats, which provide spawning and rearing habitat for native resident fish during higher water periods.

Successful restoration of the Yolo Basin streams will minimally require considerable stream channel reconfiguration. The intent is to restore channels to configurations that can be retained in a natural state by the proposed flows, natural erosion and sedimentation processes, riparian vegetation succession, and gravel-sediment regimes (patterns), where feasible with flood protection and adjoining land uses.

Increasing the flood capacity of the bypass may be necessary to develop and implement future riparian habitat restoration programs. Riparian vegetation reduces flood capacity, so an effective riparian restoration program in the Yolo Basin would need to be integrated with a program to offset any potential loss by increasing capacity.

HABITATS

RIPARIAN AND RIVERINE AQUATIC HABITAT

TARGET 1: Restore riparian vegetation along Cache Creek, Putah Creek, and Yolo Bypass and Solano Ecological Management Unit channels and sloughs, where possible, to provide cover and other essential habitat requirements for native resident fish species and wildlife (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to restore riparian vegetation, where possible and fill gaps in forest continuity.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to protect existing riparian corridors along creeks, streams, sloughs, and channels connecting to the Delta.

PROGRAMMATIC ACTION 1C: Develop a cooperative program to plant riparian vegetation and provide for early development until it becomes naturally self-sustaining.

PROGRAMMATIC ACTION 1D: Develop a cooperative control program for non-native riparian plants, where necessary, to promote development of healthy natural riparian corridors.

RATIONALE: *Healthy riparian corridors along creeks, sloughs, and channels, including those in the Yolo Bypass, provide essential cover, shade, and food for spawning, rearing, and migrating native resident fishes and other wildlife.*

FRESHWATER FISH HABITAT AND ESSENTIAL FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination (◆◆).

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for American River Basin Ecological Management Zone ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitats. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of streams in this zone and their floodplains, and in maintaining and restoring riparian and riverine aquatic habitats.*

REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS

TARGET 1: Screen all diversions in the Yolo Bypass channels and sloughs (◆◆◆).

PROGRAMMATIC ACTION 1A: Evaluate the feasibility of screening diversions in the Yolo Bypass with positive-barrier fish screens.

RATIONALE: *Reducing loss of juvenile salmon, steelhead, native resident fishes, nutrients, organic debris, and aquatic invertebrates is essential to restoring salmon, steelhead and native resident fish populations to the Yolo Bypass. Unscreened diversions are a significant threat to downstream migrating juvenile salmon and steelhead in late winter and early spring, and to oversummer rearing steelhead in upstream rearing areas. Salmon and steelhead populations from the upper Sacramento River watersheds will benefit from reduced stranding losses in the Yolo Bypass.*

DAMS AND OTHER STRUCTURES

TARGET 1: Improve fish passage between the Delta and spawning grounds in the upper watersheds (◆◆).

PROGRAMMATIC ACTION 1A: Evaluate the feasibility of constructing fish passage facilities at the Grays Bend-Old River-Fremont weir complex at the upper end of the Yolo Bypass.

PROGRAMMATIC ACTION 1B: Evaluate the feasibility of providing fish passage at the Solano Diversion Dam.

RATIONALE: *During floods, large numbers of adult late-fall-, winter-, and spring-run chinook salmon, as well as winter- and spring-run steelhead from the upper Sacramento River watersheds, migrate upstream through the Yolo Bypass. As floodwaters recede, some of these fish are delayed or stranded behind the Fremont weir. Additional releases from the Colusa basin drain and Fremont weir will further aggravate this existing problem. Ensuring fish passage into upper Sacramento River watersheds from the Yolo Bypass is essential to restoring these wild salmon and steelhead runs to the Sacramento River basin.*

Providing fish passage at Solano Diversion Dam would allow salmon and steelhead passage into the cold tailwaters of Monticello Dam. The interdam reach - several miles of high quality riparian and shaded riverine aquatic habitat - currently supports wild trout and stocked trout fisheries. With appropriate spawning gravels, the 12-mile reach between Solano Diversion Dam and Monticello Dam could provide good spawning and rearing habitat for salmon and steelhead. This reach offers excellent habitat for oversummer rearing of juvenile steelhead.

GRAVEL MINING

TARGET 1: Protect, enhance, and restore natural gravel recruitment within the active floodplain and remnant gravel pits (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to incorporate remnant gravel pits into active creek floodplains to increase the channel area and restore natural channel configurations, while providing for the maintenance of flood capacity and protection of adjoining land uses.

RATIONALE: *There are remnant gravel mining effects in lower Cache and Putah Creeks. Restoring the natural channels by integrating remnant pits with the active floodplain will ensure that juvenile native resident fish are not stranded in ponds and exposed to the unnatural levels of predatory fish that reside in these ponds. Increasing the width and variation of the channel in those areas altered by former gravel mining operations will restore gravel recruitment to the river and allow for the development of more natural and stable stream channels and riparian habitat.*

INVASIVE RIPARIAN AND MARSH PLANT SPECIES

TARGET 1: Reduce populations of invasive non-native plant species that compete with the establishment and succession of native riparian vegetation along Cache Creek and Putah Creek. This will help to reestablish native riparian vegetation in floodplains, increase SRA cover for fish, and increase habitat values for riparian-associated wildlife (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to monitor the distribution and abundance of non-native plants and develop cooperative control programs as needed.

RATIONALE: *Non-native plant species, such as false bamboo, salt cedar, eucalyptus, water hyacinth, and pepperweed, can undermine riparian habitat value to fish and wildlife, as well as the natural plant succession that contributes to the physical character of the riparian corridors.*

PREDATION AND COMPETITION

TARGET 1: Reduce predation and competition on native fish species (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to modify the stream channel and improve aquatic habitats. (*Refer to recommendations for streamflow, sediment supply, floodplain, and contaminants.)*

RATIONALE: *Habitat alteration often provides a competitive advantage to non-native fish species and native fish species decline as a result of poor habitat, predation, and competition for limited nutrients and habitat. Reducing the adverse effects of non-native species can be achieved by a program to restore ecological processes, habitats, and reducing other stressors to the extent possible.*

CONTAMINANTS

TARGET 1: Restore and maintain water quality in the Cache Creek watershed (◆◆).

PROGRAMMATIC ACTION 1A: Identify the sources and reduce the amounts of mercury and other contaminants coming into the watershed from upstream sources.

TARGET 2: Restore and maintain water quality in the Putah Creek Watershed (◆◆).

PROGRAMMATIC ACTION 2A: Develop and implement a Streamkeeper program on Putah Creek.

RATIONALE: *Implementing a "Streamkeeper Program" on Putah Creek would provide an effective means by which to monitor a variety of environmental factors that influence the watershed health below Monticello Dam. In addition to collecting water samples for chemical analysis a streamkeeper could (1) monitor telemetered stream gauges, (2) conduct frequent site visits, (3) identify and plan restoration projects, (4) provide local public outreach with private landowners, (5) monitor the native resident fishery, (6) act as a watchdog for the creek, and (7) provide useful information local government, and state and federal agencies regarding the health of Putah Creek.*

STRANDING

TARGET 1: Prevent adult salmon and steelhead stranding in the Yolo Bypass during their upstream migrations (◆◆).

PROGRAMMATIC ACTION 1A: Evaluate the feasibility of constructing fish passage facilities at the Grays Bend-Old River-Fremont weir complex at the upper end of the Yolo Bypass.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to construct a weir or screen at the lower end of the Knights Landing Ridge Cut Canal to keep adult salmon and steelhead from migrating upstream into the Colusa basin drain.

RATIONALE: *The stranding and subsequent losses of juvenile and adult fish in the Yolo Basin Ecological*

Management Zone have been observed in past years. Additional information is required to identify effective measures to reduce or eliminate these losses. Potential measures need to be consistent with the overall goal of restoring processes, habitats and species while maintaining or improving flood control capacity of the system.

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◆ Eastside Delta Tributaries Ecological Management Zone

Gravel Replenishment on the Mokelumne River.

Introduction

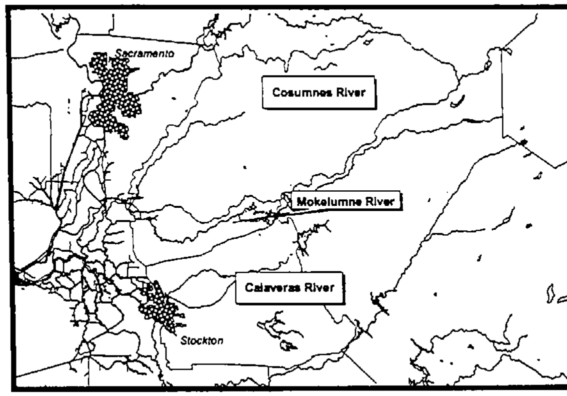
The health of the Delta is closely linked to the health of its component watersheds. The major watersheds contributing streamflow to the Delta include the Sacramento River, San Joaquin River, and the eastside Delta tributary streams. Cumulatively, these provide over 95% of the annual freshwater inflow to the Delta and provide migration, spawning, and rearing habitat for resident, anadromous, and some estuarine fish that depend on a healthy Delta ecosystem. The eastside Delta tributary streams can support increased abundances of resident, anadromous, and estuarine fish, such as steelhead, chinook salmon, and splittail, which will, in turn, contribute to the overall Delta health.

Description of the Management Zone

The Eastside Delta Tributaries Ecological Management Zone includes the three major tributaries entering the Sacramento-San Joaquin Delta on its east side:

- Cosumnes River Ecological Unit,
- Mokelumne River Ecological Unit, and
- Calaveras River Ecological Unit.

Important ecological processes within the Eastside Delta Tributaries Ecological Management Zone include streamflow, stream meander, gravel recruitment and cleansing, sediment transport, flood



Location Map of the Eastside Tributaries Ecological Management Zone and Units.

and floodplain processes, and water temperature. Important habitats include seasonal wetlands and riparian and shaded riverine aquatic (SRA) habitat.

Fish and wildlife resources in the basin include fall-run chinook salmon, steelhead, splittail, other native resident fish, and waterfowl. Fall-run chinook salmon and steelhead populations are generally unhealthy due to poor habitat conditions. Achieving healthy status for these salmonid populations, as well as for splittail, will depend on actions implemented in this zone and on complementary restoration actions in the Sacramento-San Joaquin Delta Ecological Management Zone. The confluences of the Mokelumne, Cosumnes, and Calaveras rivers, as they enter the Delta, are important backwater floodplain areas that support excellent riparian habitats. These areas provide important habitat for juvenile chinook salmon, delta smelt, splittail, giant garter snake, and sandhill crane.

Notable stressors to ecological functions, processes, habitats, and resources within the zone include:

- altered instream flows,
- altered water temperature regimes,
- separation of rivers from their floodplains,
- interruption of gravel recruitment and cleansing processes,
- reduced sediment transport,
- poor land use and livestock grazing practices,
- high levels of predation on juvenile salmonids,

- entrainment of aquatic organisms in water diversions,
- restriction of fish passage at dams and diversion structures,
- input of contaminants,
- illegal salmon and steelhead harvest, and
- riparian vegetation removal.

LIST OF SPECIES TO BENEFIT FROM RESTORATION ACTIONS IN THE EASTSIDE DELTA TRIBUTARIES ECOLOGICAL MANAGEMENT ZONE

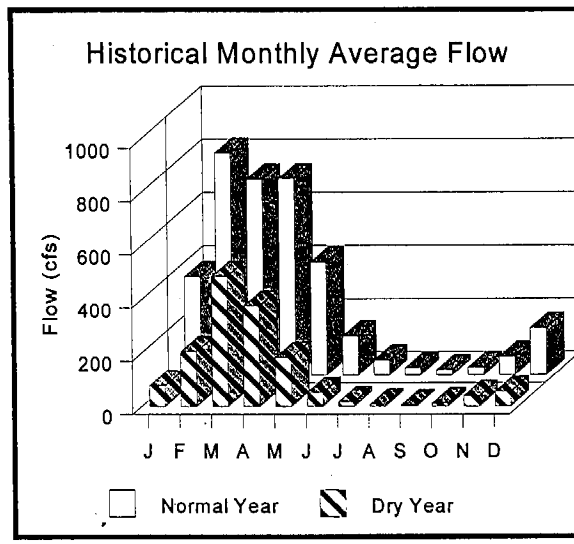
- splittail
- chinook salmon
- steelhead trout
- native resident fishes
- giant garter snake
- western pond turtle
- Swainson's hawk
- greater sandhill crane
- waterfowl
- plants and plant communities.

DESCRIPTIONS OF ECOLOGICAL MANAGEMENT UNITS

COSUMNES RIVER ECOLOGICAL MANAGEMENT UNIT

The Cosumnes River, with a watershed of approximately 1,265 square miles, drains the Sierra Nevada foothills and joins the Mokelumne River north of Thornton in the Delta. Flow records are available for Michigan Bar (535-square mile watershed), located near the base of the foothills as the river flows onto the valley floor. The Sly Park Dam (Jenkinson Lake) has a capacity of 40,000 acre-feet on the North Fork Cosumnes, with a watershed of 60 square miles. Releases are primarily into the Camino conduit for irrigation in Cosumnes and South Fork American River basins (average of about 25 cubic feet per second [cfs]). There are no other major impoundments in the Cosumnes River watershed, although several agricultural diversions are located between Michigan Bar and Thornton. Due to the low elevation of its headwaters, the river receives most of its water from rainfall rather than snowmelt. The entire Cosumnes River watershed is included in this Ecological Management Zone from its headwaters to the confluence with the Mokelumne River. The Cosumnes River floodplain lies primarily within the legally defined Delta boundary.

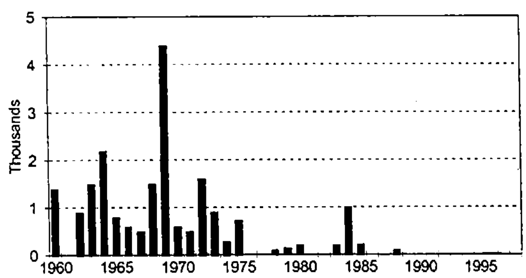
The Cosumnes River natural streamflow pattern is typical of Sierra foothill streams, with high late winter and early spring flows, moderate late spring flows, and very low summer and fall flows. Annual flows also vary greatly. Peak flows occur from February through April. In years with the highest rainfall, average monthly winter and early spring flows range from 4,000 to 6,000 cfs, but only from 80 to 120 cfs in August and September. In driest years, flows peak at only 30 to 50 cfs from February to May, while flows the remainder of the year are 0 to 20 cfs. Average monthly late winter and early spring flows in dry and normal years range from 400 to 800 cfs.



Cosumnes River Streamflow, 1962-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

The historic flows at Michigan Bar are very similar to unimpaired flows, because there are limited diversions from the upper watershed, and Jenkinson Lake does not provide substantial regulation of winter and spring runoff.

During the 1950s, the Cosumnes River supported an average annual run of approximately 5,000 fall-run chinook salmon. During recent years, it has been estimated that the average annual run consists of a few hundred fish. The river has limited gravel areas suitable for chinook salmon spawning but provides good rearing conditions for juvenile salmon. Spawning areas are located between Michigan Bar and Sloughhouse. Chinook salmon have been observed in the 40 miles of stream from the mouth to Michigan Bar. A natural migration barrier is located upstream from Michigan Bar.



Fall-run Chinook Salmon Returns to the Cosumnes River, 1960-1999 (CDFG 1999).

Low natural streamflow in summer and fall, particularly in low rainfall years, is the primary factor limiting the salmon run size in the Cosumnes River. In many years, the early portion of the run experiences difficulty negotiating the shallow bar and shoal areas, as well as high water temperatures. Only during normal and wet water years are winter and spring flows usually adequate for juvenile salmon emigration. Typically, 35 miles of the river between Twin Cities Road and Highway 16 are dry during the summer to early fall months.

Historically, the Cosumnes River overflowed its banks and deposited sediments, primarily sand, which formed natural levees. The area downstream of Wilton Road also had a mosaic of riparian (waterside) forest and freshwater emergent wetlands, whereas today, only remnant stands of valley oak woodlands remain.

Presently, the lower Cosumnes River between Dillard Road and Twin Cities Road is extensively leveed. Levees extend 15.8 miles along the right bank (facing downstream) and more than 3.6 miles along the left bank.

There are no water storage reservoirs on the mainstem Cosumnes River, and streamflows are altered primarily due to numerous small water diversions. There is one diversion dam (Granlees Diversion Dam) on the river, located approximately 1 mile upstream from the Highway 16 crossing. This dam has two fishways but their design is deficient by present standards. In addition, there are 157 registered appropriative water rights on the river. Most water is diverted out of the river from the first rains in the fall through early summer. This is the period when fall-run chinook salmon most need high flows.

Groundwater pumping is apparently the cause of a significant decline in the local groundwater table. This decline is responsible for the number of days of very little to no flow in the Cosumnes River, increasing from 82 days for water years 1942 through 1961 to 104 days for 1962 through 1982. Daily average flow data for the lower Cosumnes River have not been available since 1982, and the present number of very low to no flow days is probably greater. The decline in the groundwater table in the vicinity of the Cosumnes River and the increased days of very little to no flow limit access to the river by fall-run chinook salmon as they enter, or try to enter, the river in October and November.

Other factors limiting anadromous fish production in this ecological management zone include streambed incision and loss of spawning gravel due to the effects of levees, blocked upstream fish passage at small dams, entrainment of young salmon at water diversions, general climatic variations, oceanic conditions, and commercial and recreational fish harvest.

Opportunities to restore fall-run chinook salmon in the Cosumnes River are present. The major limiting factor is low or no flows in the lower river during the early upstream migration period (late September and October). In years when winter rains are late or lacking, salmon are not able to swim up the river and spawn.

The value of the Cosumnes River floodplain is becoming more apparent as recent studies have found splittail and juvenile chinook salmon utilizing that important habitat.

The lower Cosumnes River area also provides wintering habitat for greater sandhill cranes, roosting and foraging habitat for Swainson's hawk, and terrestrial and aquatic habitat for giant garter snake and western pond turtle.

Riparian habitat and channel conditions are affected by an extensive system of private levees along the lower Cosumnes River that are set close to the active channel. These levees are substandard and were breached in 14 locations during the January 1997 flood. Levee and channel maintenance often requires riparian vegetation removal.

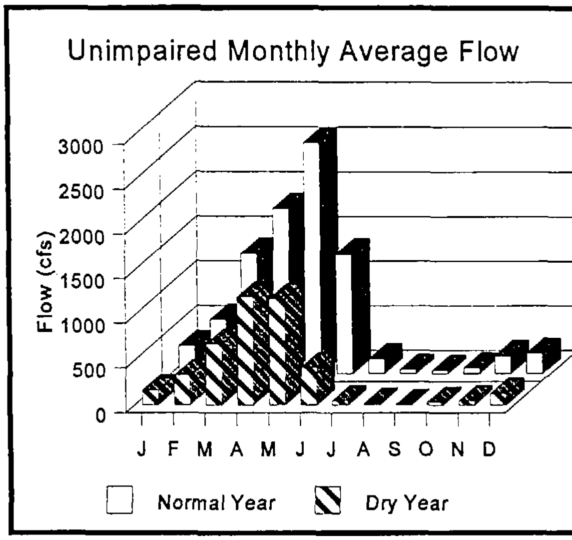
MOKELUMNE RIVER ECOLOGICAL MANAGEMENT UNIT

The Mokelumne River, the largest eastside Delta tributary, drains approximately 661 square miles, with its headwaters at 10,000 elevation feet on the Sierra Nevada crest. Downstream of the town of Thornton, the river splits into the North and South Fork channels. The Delta Cross Channel and Georgiana Slough divert water from the Sacramento River into the North Fork Mokelumne River channel. The river enters the lower San Joaquin River northwest of Stockton. The median historical unimpaired runoff is 696,000 acre-feet (af), with a range of 129,000 to 1.8 million af.

The Mokelumne River has had a long history of water development. Three major impoundments in the watershed, with a combined storage capacity of more than 750,000 af (Camanche, Pardee, and Salt Springs reservoirs), now control releases to the lower Mokelumne River. In 1929, East Bay Municipal Utility District (EBMUD) constructed Pardee Reservoir and the Mokelumne Aqueduct to supply water to 1.2 million people living in 20 cities and 10 unincorporated areas in Contra Costa and Alameda counties. The reservoir has a capacity of 197,590 af and the aqueduct can carry about 500 cfs from Pardee Reservoir. Camanche Dam, constructed in 1964 by EBMUD, is now the upstream boundary for anadromous fish migration.

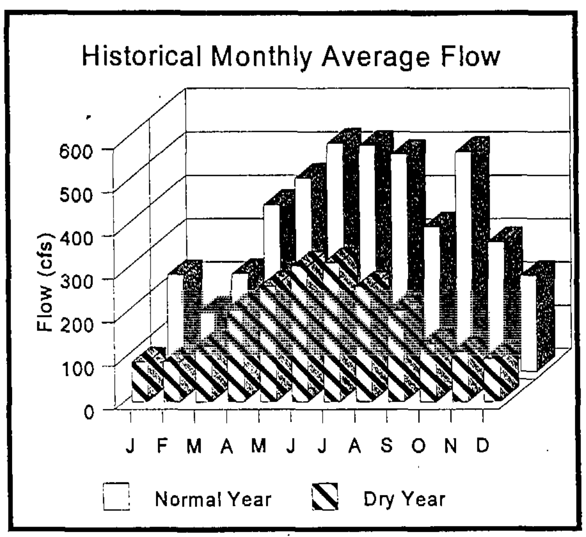
Camanche Reservoir, with a capacity of approximately 417,120 af, provides seasonal storage for downstream diversions and instream flows. Downstream of Camanche Reservoir, developments include both hydroelectric and irrigation facilities. At Lodi, the Woodbridge Diversion Dam supplies water to the eastern Delta agricultural area.

The natural Mokelumne River streamflow pattern is typical of streams in the central Sierra, with high spring flows, very low summer and fall flows, and moderate winter flows. Total annual inflow also varies greatly. Peak inflows occur in April and May. In years with the highest rainfall, average monthly inflows range from 4,000 to 6,000 cfs from January through June, but from only 200 to 500 cfs in August and September. In driest years, inflows peak at only 600 to 1,000 cfs in April and May, while summer and fall inflows are 0 cfs, and winter inflows are only 30 to 150 cfs. Typical average monthly spring inflows in dry and normal years range from 500 to 2,500 cfs.



Mokelumne River Unimpaired Streamflow at Pardee, 1972-1992
(Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

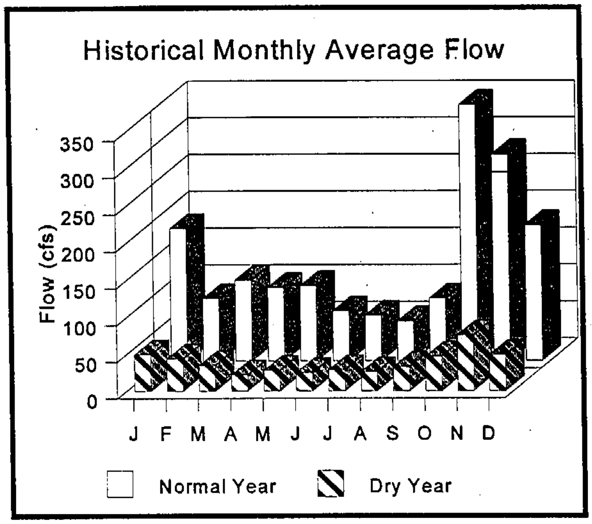
Pardee and Camanche Dams have markedly changed streamflow in the lower Mokelumne River below Camanche Dam. Winter and spring flows have been greatly reduced in all but high rainfall years, while summer and fall flows have increased. Flows in years



Mokelumne River Flow below Camanche Dam, 1972-1992
(Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

with the highest rainfall range from 1,400 to 2,800 cfs in summer and fall, and from 2,700 to 5,100 cfs in winter and spring. In driest years, spring and summer flows range from 120 to 250 cfs, while fall and winter flows range from 30 to 90 cfs.

Spring flows in dry years have declined from the 400 to 1200 cfs range to the 100-300 cfs range. Normal rainfall year spring flows have declined from the 1,400 to 2,600 cfs range to the 200-500 cfs range.

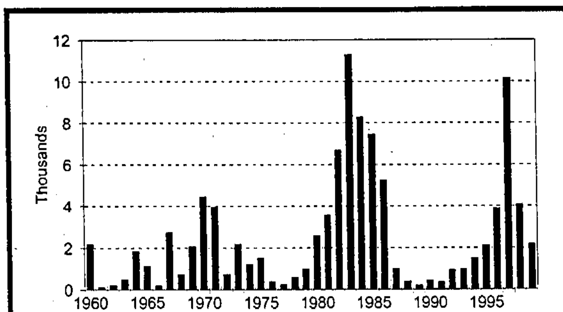


Lower Mokelumne River Flow at Woodbridge, 1972-1992
(Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Irrigation diversions along the Mokelumne River below Camanche Dam reduce the flow in the river during the irrigation season, typically late March through October. The largest diversion is at Woodbridge Diversion Dam near Lodi, approximately 15 miles upstream from the Delta. Streamflow below Woodbridge Diversion Dam is low in all but wet years, which is similar to the historic flow pattern in the lower Mokelumne River in late summer and fall. In driest years, monthly average flows range from 5 to 40 cfs. Average monthly flows in dry years range from 20 to 80 cfs. In normal flow years, spring and summer flows range from 50 to 100 cfs. Fall flows in normal to wet years range from approximately 200 to 800 cfs.

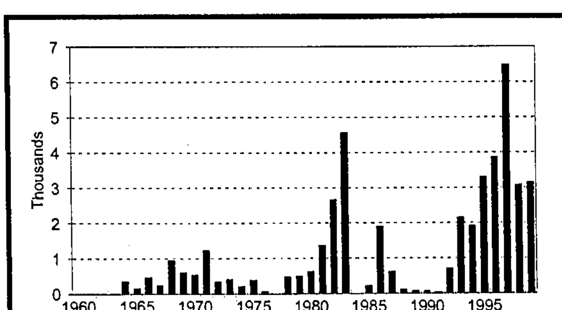
Fall-run chinook salmon and steelhead occur in the Mokelumne River below Camanche Dam. American shad and striped bass also occur in the river below Woodbridge Irrigation Dam. Highly variable flow and habitat conditions in the lower river have resulted in widely varying population levels of all these species. Before the completion of Camanche Dam in 1964, chinook salmon spawned primarily between the town of Clements and the canyon about 3 miles below Pardee Dam, with a few fish spawning upstream in the canyon below Pardee Dam and downstream between Clements and Lockeford.

Mokelumne River chinook salmon and steelhead populations have failed to consistently achieve population levels believed possible following the completion of Camanche Dam. The fall-run chinook salmon population reached a peak of slightly more than 11,000 in 1983, but declined to less 410 spawners in 1991. (Note: The 11,000 spawner estimate is not considered a reliable estimate as it was the result of an extrapolation of a hatchery vs naturally spawning chinook escapement regression line.) Since the 1987 through 1992 drought, the population rebounded to about 10,000 spawners in 1997.



Fall-run Chinook Salmon Returns to the Mokelumne River, 1960-1999 (CDFG 1999).

Presently, the majority of salmon spawning takes place in the 5 miles between Camanche Dam and Mackville Road, with 95% of the suitable spawning habitat within 3.5 miles of the dam. Instream flow releases following the completion of Camanche Dam



Fall-run Chinook Salmon Returns to the Mokelumne River Fish Installation, 1964-1999, (CDFG 1999).

provided insufficient habitat for anadromous fish spawning, rearing, and outmigration. Water temperature in the Mokelumne River below Camanche Dam, which is important for steelhead rearing, changes downstream because of flow releases from the dam.

The California Department of Fish and Game (DFG) (1993) recommended substantial increases in flow releases, with specific monthly flows in wet, normal, and dry years ranging from approximately 100 cfs to 450 cfs, along with temperature objectives during the summer steelhead rearing period. The U.S. Fish and Wildlife Service (USFWS 1997) recommended evaluation of spring flows to assist the outmigration of juveniles. USFWS (1997) also recommended improving fish passage at Woodbridge Dam and replenishing spawning gravels. However, neither flow recommendation was based on modeling results that considered water supply, water quality, and water temperatures.

EBMUD prepared a comprehensive management plan for the lower Mokelumne River in 1992 that includes additional instream flows and non-flow enhancement components. The Plan was implemented voluntarily by EBMUD in 1993 and the Plan was further improved by implementing components of the Joint Settlement Agreement among EBMUD, CDFG, and USFWS in 1998.

Unscreened or poorly screened diversions along the lower Mokelumne River contribute to the poor salmon and steelhead production on the river. Juvenile salmon and steelhead losses occur at the Woodbridge Irrigation District water diversion at Woodbridge Canal due to inadequate screening. The North San Joaquin Water Conservation District diversion, the second largest single diversion below Camanche Dam, is unscreened. There are also numerous unscreened small irrigation diversions on the lower Mokelumne River.

Woodbridge Dam also provides conditions for predators, such as birds, squawfish, and striped bass, to prey on juvenile salmonids that pass downstream over the dam or through the fish ladder. The dam also impedes upstream adult salmon and steelhead passage.

The amount and condition of spawning and rearing habitat below Camanche Dam may limit the chinook salmon and steelhead populations, although based upon the results of fisheries monitoring studies conducted since 1991, EBMUD has seen no evidence that rearing habitat is limiting in the lower Mokelumne River. Spawning habitat for chinook salmon and steelhead is limited below Camanche Dam, because gravel transport down the river has been disrupted by Camanche and Pardee Dams. Also, the stream channel has become armored in a few places, but the presence of salmon redds in the same locations year after year suggests that armoring is a minor problem. The river supported 3,892 chinook salmon spawners in 1996 and gravel restoration since 1990 has increased the carrying capacity by 300 spawning female salmon (Setka 1997). Rearing habitat suffers from a lack of riparian shade vegetation and cover. There has also been a significant loss of riparian and riverine aquatic vegetation along the lower river. In many years, including dry years, water temperatures are purposely increased by drawing water off the epilimnion to provide optimum salmonid rearing temperatures downstream of Camanche Dam. This is done to increase growth rates and speed smoltification so chinook salmon will move through the Delta before being affected by high late spring water temperatures in the Delta.

As mitigation for the loss of spawning habitat between Camanche and Pardee Dams, EBMUD constructed a hatchery below Camanche Dam. The river below the hatchery was expected to provide habitat for 5,000 chinook salmon and the hatchery would produce 100,000 steelhead. From 1964 through 1988, the hatchery received an average annual return of 490 adult salmon and 28 adult steelhead. This has improved in recent years with an average annual hatchery return of 1,528 chinook salmon during 1989-1996.

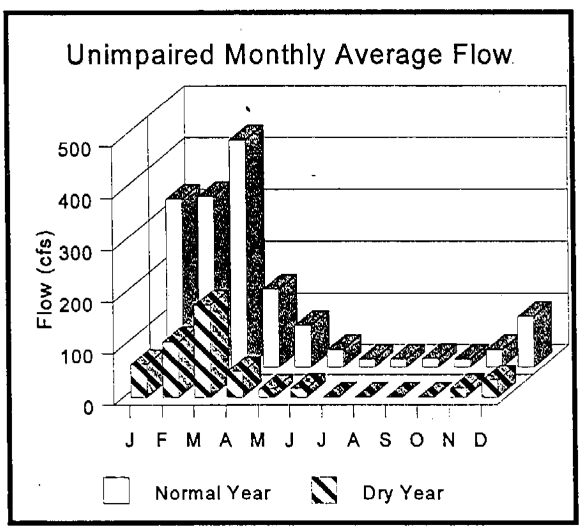
CALAVERAS RIVER ECOLOGICAL MANAGEMENT UNIT

The Calaveras River enters the San Joaquin River at Stockton, draining approximately 362 square miles in the foothills south of the Mokelumne River with an average annual runoff of 166,000 af. The river flows through Stockton and enters the San Joaquin River channel in the Delta. The ecological unit includes the lower Calaveras River from New Hogan Dam to the confluence with the lower San Joaquin River.

Flows on the Calaveras River are controlled by New Hogan Dam, constructed in 1964 by the U.S. Army Corps of Engineers (Corps) and operated by the U.S. Bureau of Reclamation (Reclamation). The conservation yield from the reservoir, with a gross pool capacity of approximately 325,000 af, is contracted for municipal and agricultural use to Calaveras County Water District and Stockton East Water District. The dam and reservoir are located in western Calaveras County near the town of Valley Springs.

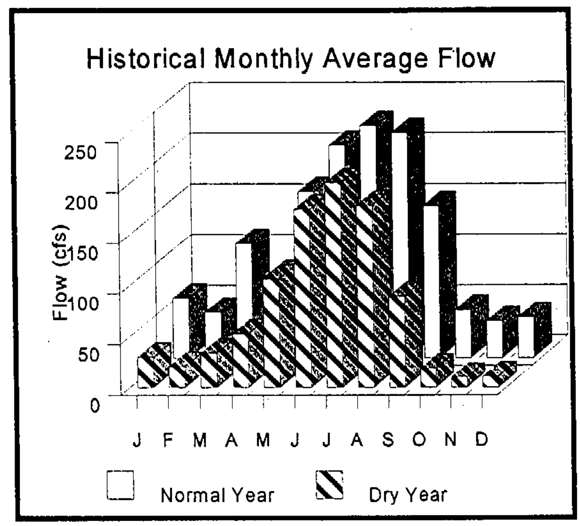
The Calaveras River drainage is almost entirely below the effective average snow level; therefore, the area receives runoff primarily as rainfall. About 93% of the runoff occurs from November to April. The valley portion of the river historically experienced frequent periods of low or no flow in late summer and early fall. However, deep pools in the approximately 6-mile reach from the dam to the town of Jenny Lind now provide suitable summer holding areas for salmon and resident trout in all but the driest years.

The monthly unimpaired flow pattern for the river is typical of Sierra foothill streams, with most rainfall coming in winter. Streamflow varies considerably from year to year with rainfall variations. The average annual streamflow is 240 cfs with the peak average monthly flows of 3,000 cfs in winter of wettest years. Summer and early fall flows are very low, and the channel is dry from July through October in low rainfall years.



Calaveras River Unimpaired Streamflow at Jenny Lind, 1970-1990 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Historical flow data below New Hogan Dam indicate a shift of the natural runoff pattern to irrigation season releases from May through September, with a slight decrease in the average flow (220 cfs) caused by evaporation and upstream diversions. Because of the relatively large capacity of New Hogan reservoir, non-irrigation releases (spills) are confined to wet years. In the highest rainfall years, average monthly flows range from 1,400 to 2,800 cfs from November through April. Irrigation season releases generally range from 150 to 250 cfs, except in the driest years, when releases only average 60 to 80 cfs from May through August. Non-irrigation season minimum flows are generally 30 to 90 cfs, except in drier years, when they average only 30 cfs or less.



Lower Calaveras River Streamflow below New Hogan Dam, 1970-1990 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Although winter-run chinook salmon were known to occur irregularly in the Calaveras River, this stock is not a focus of restoration in this ecological management zone. The Ecosystem Restoration Program (ERP) focuses on restoring or re-creating ecological processes that support sediment supply, stream channel meander, and riparian and riverine aquatic habitat and eliminating or reducing stressors. Together, the actions proposed for the Calaveras River Ecological Unit will benefit fall-run chinook salmon and other fish, wildlife, and plant resources. New Hogan Dam operations may have increased the frequency of salmon runs into the Calaveras River, despite no requirements for minimum flow releases. Since the completion of the New Hogan project, returns of winter-run chinook salmon to the river were documented in 1972, 1975, 1976 (tidewater only), 1978, 1982 (tidewater only), and 1984. Physical habitat conditions are adequate for salmon spawning and rearing, which includes abundant spawning gravel and a dense riparian canopy. Streamflow is the principal limiting factor.

Another limiting factor is loss of juvenile salmon into water diversions downstream of New Hogan Dam. Stockton East Water District's diversion is presently unscreened. There are several other unscreened diversions along the river.

Diversion channels that carry Calaveras River water and act as migratory routes for salmon below Bellota Dam include the original Calaveras River channel, Mormon Slough, and the Stockton Diverting Canal. In some years, typically in March, partial or complete blockage of adult salmon migration coincides with placing approximately 30 temporary irrigation dams in these channels. Adult salmon are prevented from reaching deep pools and spawning gravel above Bellota Dam and are subject to poaching below the flashboard dams. Two of the diversion structures, Clements Dam and Cherryland Dam, have been identified as barriers to salmon movement. The Bellota Dam (weir) blocks upstream salmon migrants at flows below approximately 200 cfs.

VISION FOR THE ECOLOGICAL MANAGEMENT ZONE

The vision for the Eastside Delta Tributaries Ecological Management Zone is to improve the values of the rivers and riparian zones as fish and wildlife corridors from the delta to the upland and upstream habitats; restore tidal wetlands; create and maintain permanent freshwater marshes, seasonal wetlands, floodplain habitat, spawning areas for splittail, and rearing, spawning, foraging habitat for fall-run chinook salmon and steelhead, habitat for the giant garter snake. Elements to reach this vision include improved streamflow patterns and water temperatures, reconnecting the river with its floodplain, restoring riparian and riverine aquatic habitat, reducing loss of salmon and steelhead and other young fish at unscreened diversions, and reducing fish passage problems at diversion dams. Ecological health will be attained when levees are modified to allow seasonal floodplain inundation; chinook salmon and steelhead populations reach target levels; habitat is improved for resident native fishes, sandhill cranes, and migratory waterfowl; migration corridors are improved for aquatic and terrestrial species; and riparian and stream channel habitats are restored.

The vision focuses on improving streamflows and stream channel and gravel recruitment processes needed to support habitat for anadromous salmonids and other fish species. It also focuses on restoring tidal wetlands, floodplains, seasonal floodplain inundation, and natural flood regimes. On the lower Mokelumne River, restoration will focus on habitat for fall-run chinook salmon and steelhead. On the Calaveras River, the emphasis will be on providing the opportunity for fall-run chinook salmon to spawn successfully and providing juveniles the opportunity to emigrate from the system successfully. On the Cosumnes River, the focus will be on restoring floodplain processes, seasonally flooded habitat, tidal wetlands, splittail and chinook salmon rearing habitat, sandhill crane habitat, and establishing an extensive riparian and riverine aquatic corridor. Throughout the basin, restoring and protecting a self-sustaining, diverse riparian community will be emphasized to maintain nutrient and woody debris input to the aquatic system, enhance bank stability and stream shading, and provide valuable habitat for a variety of wildlife species.

The ERP envisions that the fish, wildlife, and riparian needs of the East Delta Tributaries Ecological Management Zone will be met and an acceptable level of ecosystem health will be achieved when the following visions have been satisfactorily attained.

VISIONS FOR ECOLOGICAL MANAGEMENT UNITS

COSUMNES RIVER ECOLOGICAL MANAGEMENT UNIT

The vision for the Cosumnes River Ecological Unit is to restore floodplains, seasonally flooded habitat, tidal wetlands, splittail and chinook salmon rearing habitat, sandhill crane habitat, and a riparian plant community. The fall-run chinook salmon population can be sustained through improvements in streamflow, channel and floodplain morphology, spawning and rearing habitat, fish passage at diversion dams, and reducing losses to unscreened diversions and illegal harvest.

The vision for the Cosumnes River includes improved streamflow and riparian habitat, modified floodplain and channel conditions, reduced fish passage problems and unscreened diversions. These actions will improve habitat conditions for fall-run chinook salmon and other wildlife species. The flow regime is the primary factor affecting the size of the Cosumnes River salmon run. In drier years, the early portion of the run experiences difficulty negotiating the shallow bar and shoal areas.

Although there are only minor water storage reservoirs on the Cosumnes River, streamflows are reduced by numerous small water diversions and the lowering groundwater table. Most water is diverted from the first rains in the fall through early summer, coinciding with instream flow needs for fall-run chinook salmon. Minimum instream flow during the salmon spawning and rearing season may be needed. Additional streamflow is needed in dry and normal years to ensure survival of downstream migrating juvenile salmon.

Also important to restoration will be removing existing levees and constructing set back levees, implementing improved land management and livestock grazing practices along stream/riparian zones, fish passage improvements at small dams, screening water diversions, and improving gravel recruitment and riparian habitats.

Riparian and aquatic habitat quality and distribution will be improved by expanding the width of the river floodplain through a program of levee setbacks. In combination with other efforts to improve floodplain safety and levee management on the lower Cosumnes River, levee setbacks will allow natural river meanders to form and associated habitats to thrive. Greater floodplain width between levees reduces the need for channel straightening and bank armoring at the expense of aquatic and riparian habitat. Floodplain land could continue to be farmed within the levees, or conservation easements could be acquired to expand riparian forest and seasonal wetland habitats along the river.

Sandhill crane roosting and foraging habitat in the lower Cosumnes River will be protected by land acquisition through in-fee purchase or easement.

Mokelumne River Ecological Management Unit

The vision for the Mokelumne River Ecological Unit is to support self-sustaining fall-run chinook salmon and steelhead populations by improving streamflows, riparian and SRA habitat, natural sediment supply and gravel recruitment, and fish passage; reducing predation and illegal harvest; eliminating unscreened and poorly screened diversions; and improving and upgrading hatchery facilities and management strategies.

The vision for the Mokelumne River includes improved streamflow, gravel recruitment, floodplain configuration, fish passage, salmon spawning and rearing habitat, riparian habitat, screening of diversions, and enforcement of fishing regulations. Under this vision, the Mokelumne River would better support naturally spawning steelhead trout, fall-run chinook salmon, American shad, and resident native fishes. For the Mokelumne River, this means improving flows from spring through fall below Camanche and Woodbridge dams. Higher and more natural flows will help steelhead move upstream during the late fall and early winter. Higher flows will benefit downstream migrating juvenile fall-run chinook salmon and steelhead, as well as juvenile salmon and steelhead migrating out of the Sacramento and San Joaquin Rivers and their tributaries through the Delta. These flows will also benefit stream channel and riparian vegetation processes in the lower river, which in turn will benefit the fish.

Habitat improvements in the lower Mokelumne River will improve natural production of these same anadromous fish. Improved spawning habitat will increase young salmon and steelhead production. Improved stream channel and riparian vegetation will increase juvenile salmon and steelhead survival. Floodplain stream channel and habitat improvements will also benefit salmon and steelhead by providing valuable seasonal rearing habitat.

Calaveras River Ecological Management Unit

The vision for the Calaveras River Ecological Unit is to restore and maintain important ecological processes that support a sustainable migration corridor for fall-run chinook salmon and other terrestrial and aquatic species and their upstream habitat.

The vision for the Calaveras River includes improved streamflow, gravel recruitment, floodplain configuration, fish passage, riparian and stream channel habitat, screening of diversions, and enforcement of fishing regulations. Proper conditions will maintain more consistent fall-run chinook runs.

Restoring instream flows adequate to maintain anadromous fish habitat will be the focus element. Maintaining an adequate water temperature regime, improving fish passage at irrigation dams, and reducing entrainment at water diversions will also be important.

Physical habitat conditions are adequate for salmon spawning and rearing, including abundant spawning gravel and a dense riparian canopy. With appropriately timed flows and other improvements, fall-run chinook salmon could be maintained more consistently.

VISIONS FOR ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOWS: Instream flows are inadequate and need to be supplemented where possible, consistent with existing agreements. Increased flows would help restore ecological processes and functions that maintain habitats for important aquatic and terrestrial species. The vision is that instream flows will be at levels and mimic natural flow regimes that support restored ecological processes and functions that maintain important fish, wildlife, and plant communities and their habitats.

COARSE SEDIMENT SUPPLY: The input of sediments into the riverine systems below major dams is inadequate to maintain ecological health. The vision is that gravel recruitment, transport, and cleansing processes will be restored, reactivated, or supplemented to a level that supports habitat for anadromous and other native fish populations and sustains self-regenerating riparian and riverine plant communities.

NATURAL FLOODPLAIN AND FLOOD PROCESSES: Natural river-floodplain interaction has been impaired by the construction of dams and levees. This seasonal inundation is needed to promote ecological health and restoration of important species. The vision is that floodplains along the Cosumnes, Mokelumne, and Calaveras rivers will be expanded, reconnected to their channels, and seasonally inundated by increased stream flows. These actions will support natural riparian regeneration and nutrient input to the Delta and help create seasonal habitat for splittail spawning and the rearing and emigration of juvenile fish.

CENTRAL VALLEY STREAM TEMPERATURES: High stream temperatures limit or interrupt the natural life cycle of aquatic organisms. The vision is that water temperatures below major dams will be suitable for maintaining important aquatic organisms and biological functions, such as chinook salmon and steelhead spawning, egg development, and fry and juvenile rearing and emigration.

VISIONS FOR HABITATS

SEASONAL WETLAND HABITAT: The vision is that increased seasonal flooding of leveed lands, use of the Zones natural flood detention capacity, protection and enhancement of existing wetlands, and development of cooperative programs with local landowners will contribute to increased habitats for waterfowl and other wetland dependent fish and wildlife resources such as shorebird, wading birds, and the giant garter snake.

RIPARIAN AND RIVERINE AQUATIC HABITATS: Riparian plant communities are important to a healthy ecosystem and contribute in many ways to sustaining fish and wildlife populations. The vision is to restore diverse, self-sustaining riparian and shaded riverine aquatic habitat along the lower reaches of the Cosumnes, Mokelumne, and Calaveras rivers.

FRESHWATER FISH HABITAT: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native and anadromous fish species. The streams of the Eastside Delta Tributaries Ecological Management Zone are typical of a fall chinook salmon spawning stream (Moyle and Ellison 1991). The quality of freshwater fish habitat in these streams will be maintained through actions directed at streamflows, coarse sediment supply, stream meander, natural floodplain and flood processes, and maintaining and restoring riparian and riverine aquatic habitats.

ESSENTIAL FISH HABITAT: The Mokelumne, Cosumnes, and Calaveras rivers have been identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). Key features of EFH to maintain or restore in these streams include substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

VISION FOR REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS: The vision is to contribute to adult fish survival and return by reducing the loss of juvenile aquatic organisms into water diversions and lessen the impact of water diversion on the elevation of the water table.

DAMS AND OTHER STRUCTURES: The vision is to contribute to restoring chinook salmon and steelhead by improving up- and downstream fish passage at diversion structures.

INVASIVE RIPARIAN AND MARSH PLANTS: The vision is to support riparian regeneration by controlling invasive (non-native) plants so that they do not impair efforts to restore natural riparian and riverine plant communities.

PREDATION AND COMPETITION: The vision is to contribute to restoring naturally spawning chinook salmon and steelhead populations by modifying hatchery practices and instream structures to reduce rates at which juvenile salmonids fall prey to predators.

CONTAMINANTS: The vision is to reduce fish and wildlife losses due to pesticides, hydrocarbons, heavy metals, and other toxins and contaminants.

HARVEST OF FISH AND WILDLIFE: The vision is to contribute to restoring important resident, estuarine, and anadromous fish species by managing legal and illegal harvest to protect naturally spawning fish.

ARTIFICIAL PROPAGATION OF FISH: The vision is to improve and balance natural chinook salmon and steelhead production in the Mokelumne River with hatchery produced populations.

VISIONS FOR SPECIES

SPLITTAIL: The vision for splittail is to recover this federally listed threatened species. The vision is to contribute to splittail restoration by improving the riparian and stream meander corridors and natural floodplains along the Cosumnes and Mokelumne Rivers. The value of the seasonal habitat will be improved by late-winter and early-spring streamflows to provide attraction flows for spawning adults and increased spawning habitat.

CHINOOK SALMON: The vision for chinook salmon is to recover all stocks presently listed or proposed for listing under ESA or CESA, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that use fully existing and restored habitats. The vision is to assist in fall-run chinook salmon restoration by:

improving streamflows for passage, spawning, rearing, and emigration,

- improving gravel recruitment,
- providing water temperatures needed for successful egg incubation and rearing,
- increasing riparian and riverine aquatic habitat,
- reducing or eliminating unscreened diversions and sources of contaminants, and
- operating Mokelumne River Fish Facility to improve and protect naturally spawning fish.

STEELHEAD TROUT: The vision for steelhead trout is to recover this species listed as threatened under ESA and achieve naturally spawning populations of sufficient size to support inland recreational fishing and that use fully existing and restored habitats. The vision is to assist in of steelhead trout restoration by:

- improving streamflows for passage, spawning, rearing and emigration,
- improving gravel recruitment,
- providing water temperatures needed for successful egg incubation and rearing,
- increasing riparian and riverine aquatic habitat,

- reducing or eliminating unscreened diversions, sources of contaminants, and
- operating Mokelumne River Fish Facility to improve and protect naturally spawning fish.

NATIVE RESIDENT FISH SPECIES: The vision for resident fish species, including hitch and hardhead, is to increase their abundance and distribution by implementing actions to improve stream channel, floodplain, and riparian processes.

LAMPREY: The vision for Pacific and river lamprey is to maintain the diversity, distribution and abundance of these species.

WHITE STURGEON: The vision for white sturgeon is to maintain and restore population distribution and abundance to historical levels and support a sport fishery. Improved flows and stream channel and floodplain processes will benefit sturgeon populations through improved habitat and food supply. Higher peak late winter and spring flows will provide attraction for adult sturgeon moving upstream from the lower rivers, Delta, Bay, and ocean. Stream channel improvements will provide greater amounts and improved quality of spawning and early rearing habitat.

GIANT GARTER SNAKE: The vision for giant garter snake is to contribute to the recovery of this State and federally listed threatened species in order to contribute to the overall species richness and diversity. The vision for giant garter snake is to maintain or expand existing populations by improving stream channel, floodplain, riparian processes, and reducing predator species.

WESTERN POND TURTLE: The vision for the western pond turtle is to maintain and restore their abundance and distribution by maintaining or expanding existing populations by improving stream channel, floodplain riparian processes, and reducing predator species.

CALIFORNIA RED-LEGGED FROG: The vision for the California red-legged frog is to maintain populations of this federally listed threatened species. Protecting existing and restoring additional suitable aquatic, wetland, and riparian habitats and reducing mortality from non-native predators will be critical to achieving recovery of the California red-legged frog.

CALIFORNIA TIGER SALAMANDER: The vision for the California tiger salamander is to maintain existing populations of this Federal candidate species in the Bay-Delta. Protecting and restoring existing and additional suitable aquatic, wetland, and floodplain habitats and reducing the effect of other factors that can suppress breeding success will be critical to the recovery of the California tiger salamander.

WESTERN SPADEFOOT: The vision for the western spadefoot is to maintain this California species of special concern in the Bay-Delta. Protecting and restoring existing and additional suitable aquatic, wetland, and floodplain habitats and reducing the effect of other factors that can suppress breeding success will be critical to the recovery of the western spadefoot.

SWAINSON'S HAWK: The vision for Swainson's hawk is to contribute to the recovery of this State-listed threatened species. The vision for Swainson's hawk is that actions in the Eastside Delta Tributaries Ecological Management Zone to improve nesting and foraging habitat will contribute to overall species recovery.

GREATER SANDHILL CRANE: The vision for the greater sandhill crane is to contribute to the recovery of this California species of special concern. The vision includes contributing to their recovery by improving foraging and resting habitat.

WESTERN YELLOW-BILLED CUCKOO: The vision for the western yellow-billed cuckoo is to contribute to recovery of this State-listed endangered species. Improvements will result from efforts to protect, maintain, and restore riparian and riverine aquatic habitats throughout the Eastside Delta Tributaries Ecological Management Zone.

NEOTROPICAL MIGRATORY BIRDS: The vision for the neotropical migratory bird guild is to restore and maintain healthy populations of neotropical migratory birds through restoring habitats on which they depend. Protecting existing and restoring additional suitable wetland, riparian, and grassland habitats will be critical to maintaining healthy neotropical migrant bird populations in the Eastside Delta Tributaries Ecological Management Zone. Large-scale restoration of nesting habitats will help reduce nest parasitism and predation by creating habitat conditions that render neotropical birds less susceptible to these stressors.

WATERFOWL: The vision for waterfowl is to maintain and restore healthy populations at levels that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses. Many species of resident and migratory waterfowl will benefit from improved aquatic, wetland, riparian, and agricultural habitats. Increase use of the Eastside Tributaries Ecological Management Zone. Improved seasonal wetlands and floodplain/stream interactions will be beneficial not only to waterfowl but other fish and wildlife resources.

PLANT SPECIES AND COMMUNITIES: The vision for plant species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland and riparian and riverine aquatic habitats. This vision includes such key communities as floodplain dependent species such as California hibiscus, button-bush thickets, and native grasslands.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Attaining the vision for the Eastside Delta Tributaries Ecological Management Zone includes near-term funding and implementing actions to achieve the targets. This includes managing water project operations, purchasing in-title or land easements from willing sellers, cooperatively developing and implementing a phased fish screening program, acquiring and placing gravel in the stream channel, and the performing engineering feasibility and design studies to improve fish passage at diversion structures.

Along with the near-term actions, the vision includes cooperation and support of existing ecosystem and species restoration efforts and programs. Parallel efforts include developing and integrating local land use plans that embrace and foster the objectives of ERPP.

Long-term efforts that will enhance the vision for the Eastside Delta Tributaries Ecological Management Zone and provide durable ecosystem restoration involve developing and implementing watershed management plans by land use agencies and evaluating flood management options.

COSUMNES RIVER PROJECT

The Cosumnes River Project is a multi-agency effort to restore and protect the Cosumnes River ecosystem. The Cosumnes River Project encompasses 37,000 acres including Staten Island, the McCormack-Williamson Tract, and the lower Cosumnes floodplain, vernal pools, grasslands, and blue oak woodland. Partners in this effort include The Nature Conservancy, Bureau of Land Management, County of Sacramento, Department of Water Resources, Department of Fish and Game, State Lands Commission, Ducks Unlimited, Environmental Protection Agency, Wildlife Conservation Board, and the American Farmland Trust. Actions sponsored by the Cosumnes River Project will complement efforts undertaken by the ERPP to restore ecological health of the Cosumnes River Ecological Unit.

CENTRAL VALLEY PROJECT IMPROVEMENT ACT

Restoring and maintaining ecological processes and functions in the Eastside Delta Tributaries Ecological Management Zone will augment other important ongoing and future restoration efforts for the zone. The program proposed by the CVPIA will complement efforts of the USFWS' Anadromous Fish Restoration Program. The goal of the program is to double the average number of anadromous fish that was produced naturally in the system from 1967 through 1991.

CALFED BAY-DELTA PROGRAM

CALFED has funded eight ecosystem restoration projects in the Eastside Delta Tributaries Ecological Management Zone. One of the more significant projects is the design and construction of fish screens and ladders at the Woodbridge Irrigation District diversion on the Mokelumne River.

SALMON, STEELHEAD TROUT AND ANADROMOUS FISHERIES PROGRAM ACT (SB 2261)

The vision will also help the DFG reach its goal of doubling the number of anadromous fish that were produced in 1988.

JOINT SETTLEMENT AGREEMENT BETWEEN EAST BAY MUNICIPAL UTILITY DISTRICT, U.S. FISH AND WILDLIFE SERVICE, AND CALIFORNIA DEPARTMENT OF FISH AND GAME

This agreement protects and maintains the purpose of the EBMUD's Mokelumne River Project, protects the anadromous fishery and lower Mokelumne River ecosystem, and encourages cooperative action to achieve and maintain the objectives. The agreement contributes to the overall effort to improve the ecological health of the Mokelumne River Ecological Unit by establishing a $2 million partnership fund, encouraging voluntary participation of local interests, establishing a lower Mokelumne River stakeholders group, and recommending ecosystem protection and improvement priorities.

Efforts in the Eastside Delta Tributaries Ecological Management Zone will require cooperation from resource agencies, such as DFG, the California Department of Water Resources (DWR), California Department of Forestry and Fire Protection, State Water Resources Control Board, USFWS, USFS, U.S. Bureau of Land Management and the National Marine Fisheries Service (NMFS), as well as participation and support from the Corps, Reclamation, Natural Resource Conservation Service, other private organizations, water districts, and individual land owners. These groups are expected to work together to restore and maintain ecosystem health in this zone. This program may provide funding for the restoration measures included in the visions.

CENTRAL VALLEY HABITAT JOINT VENTURE

The Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan have developed objectives for wetlands in the Eastside Delta Tributaries Ecological Management Zone. These objectives are consistent with the ERPP targets developed for this ecological management zone.

LINKAGE TO OTHER ECOLOGICAL MANAGEMENT ZONES

The ecosystem health of the Eastside Delta Tributaries Ecological Management Zone depends on conditions in the Sacramento-San Joaquin Delta Ecological Management Zone. Because these tributaries are directly linked to the Delta, stressors there (entrainment, water quality) have a significant effect on resources, such as anadromous fish, in this zone. Conditions in San Francisco Bay and the Pacific Ocean can also have a significant effect on anadromous fish.

Reducing or eliminating stressors in the downstream ecological management zones will be important in restoring healthy fish and wildlife communities in the Eastside Delta Tributaries Ecological Management Zone.

RESTORATION TARGETS AND PROGRAMMATIC ACTIONS

ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOWS

TARGET 1: For the Cosumnes River, where a natural streamflow pattern presently exists with natural winter and spring streamflows, the target is to maintain or restore natural summer and fall base flows (◆◆).

PROGRAMMATIC ACTION 1A: Improve summer and fall base flows on the Cosumnes River by developing new water supplies along the river and by purchases from willing sellers.

PROGRAMMATIC ACTION 1B: Cooperatively develop a program to minimize or eliminate unpermitted water diversions on the Cosumnes River, and review water allocation for the entire basin.

PROGRAMMATIC ACTION 1C: Cooperatively develop a groundwater replenishment program to raise the water table in the Cosumnes River floodplain.

TARGET 2: The target for the Mokelumne River is to provide conditions to maintain the fishery and riparian resources in good condition by implementing and evaluating the flow regime in the Joint

Settlement Agreement (JSA) for Mokelumne River. The JSA provides increased flows below Camanche Dam beyond present requirements, which will benefit the fishery and riparian resources of the lower Mokelumne River (◆◆◆).

PROGRAMMATIC ACTION 2A: Provide target flows for Mokelumne River storage releases, but only if there are sufficient inflows into storage reservoirs and carryover storage to meet target levels. The additional water would be obtained by developing new water supplies within the Central Valley basin, water transfers, and from willing sellers.

PROGRAMMATIC ACTION 2B: Maintain or enhance summer and fall base flows on the Mokelumne River by developing new water supplies and by purchases from willing sellers.

TARGET 3: The target also is to provide enhanced streamflows below Woodbridge Dam by providing minimum flows recommended by DFG in dry years: 200 cfs from November 1 through April 14; 250 cfs from April 15 through April 30; 300 cfs in May; and 20 cfs from June 1 through October 31. In normal years, minimum flows should be 250 cfs from October 1 through October 14; 300 cfs from October 15 through February 29; 350 cfs during March; 400 cfs during April; 450 cfs during May; 400 cfs during June; 150 cfs during July; and 100 cfs during August and September. In wet years, minimum flows should be 300 cfs from June 1 through October 14; 350 cfs from October 15 through February 29; 400 cfs in March; and 450 cfs during April and May (◆).

PROGRAMMATIC ACTION 3A: Cooperatively evaluate the potential for minimizing water supply impacts by replacing the diversions at Woodbridge with other Delta diversions.

PROGRAMMATIC ACTION 3B: Cooperatively develop a program to minimize or eliminate unpermitted water diversions on the Mokelumne River.

TARGET 4: A flow event should be provided on the Mokelumne River in late April or early May, averaging 500 to 1,000 cfs in dry years, 1,000 to 2,000 cfs in normal years, and 2,000 to 2,500 cfs in wet years (◆).

PROGRAMMATIC ACTION 4A: Develop a cooperative feasibility study of opportunities to provide spring flow events.

TARGET 5: For the Calaveras River, where the natural streamflow has been greatly altered, streamflows should be enhanced below New Hogan Dam by the minimum flows recommended by DFG (◆).

PROGRAMMATIC ACTION 5A: Provide target flows for the Calaveras River from storage releases, but only if there are sufficient inflows into storage reservoirs and carryover storage to meet target levels. The additional water would be obtained by developing new water supplies within the Central Valley basin, water transfers, and from willing sellers.

PROGRAMMATIC ACTION 5B: Cooperatively develop a program to minimize or eliminate unpermitted water diversions on the Calaveras River.

PROGRAMMATIC ACTION 5C: Cooperatively evaluate the potential for resizing criteria at New Hogan Reservoir on the Calaveras River to yield additional water for instream flow needs while maintaining or improving flood control requirements.

PROGRAMMATIC ACTION 5D: A flow event should be provided in late February or early March, averaging 100 to 200 cfs in dry years, 300 to 400 cfs in normal years, and 600 to 800 cfs in wet years. Such flows would be provided only when inflows to New Hogan Reservoir are at these levels

RATIONALE: *The proposed supplemental flows were selected as a representative value for impact analysis in the Programmatic EIS/EIR. Throughout the ERP, the need to determine optimal streamflow for ecological processes, habitats, and species is repeated. The issues of supplemental flows are complex in term of ecosystem improvements. The frequency, magnitude, duration, timing and rate of change of streamflows that form channels, create and maintain riparian habitat (including all species of vegetation), and promote all life stages of the various aquatic species dependent on a particular stream will never occur within a single year. An optimal flow regime will have to vary, perhaps significantly, from year to year. The supplemental flow recommendations will be an intensive exercise in adaptive management and must be based on credible scientific underpinnings.*

Inadequate instream flows have been identified as a limiting factor for anadromous fish and other aquatic resources in the eastside Delta tributary streams. For example, the Cosumnes River receives most of its water from rainfall due to the low elevation of its headwaters and the lower reaches of the river are often dry until the fall rains occur. As a result, adult fish must await the runoff following rains in late October and November before ascending to the spawning areas between Michigan Bar and Sloughhouse. Although there are no water storage reservoirs on the Cosumnes River, there are 157 registered appropriative water rights (U.S. Fish and Wildlife Service 1995). Most water is diverted from the first rains in the fall through early summer, coinciding with instream flow needs for fall-run chinook salmon. USFWS recommended an evaluation of instream flow requirement to ensure adequate flows for all life stages of all salmonids.

DFG (1993) recommended revised minimum flow schedules for the lower Mokelumne River. A Joint Settlement Agreement was signed in 1998 by EBMUD, CDFG, and USFWS that provides improved fish flows for the Mokelumne River, higher minimum flows below Camanche Dam, and gainsharing of additional flows between EBMUD and the Environment. It incorporates a broader ecosystem approach for managing the Mokelumne River resources.

The JSA flows for the Mokelumne River follow.

- *In normal and above normal water years, the agreed upon flows at Camanche Dam are 325 cfs from October 1 to June 30, 100 cfs in July, August, and September.*
- *In below normal years, the agreed upon flows at Camanche Dam are 250 cfs from October 1 through June 30, and 100 cfs in July, august and September.*
- *In dry years the agreed upon flows at Camanche Dam are 220 cfs from October 1 through May 31, and 100 cfs in June, July, August, and September.*
- *In critically dry years the recommended flows at Camanche Dam are 100 cfs from October 1 through 15, 130 cfs from October 16 through April 30, and 100 cfs in May, June, July, August, and September.*

Although the 1993 DFG flows for the Mokelumne River are presented as enhancement targets to be achieved when possible, these target levels need further review and should be a subject of adaptive management and focused research. The DFG flows were not developed with full consideration of upstream water quality, reservoir storage, and water temperatures, which need to be addressed for a finer assessment of water availability. The target flows, however, provide a possible target for further enhancement of the Mokelumne resource.

The Calaveras River drainage is almost entirely below the effective average snow level and thus receives runoff primarily as rainfall. Historically, the valley portion of the river commonly experienced periods of low or even no flow for many days or weeks in the late summer and early fall (California Department of Fish and Game 1993). Chinook salmon runs into the river were known to occur irregularly. There are currently no requirements to maintain flow releases for fishery purposes.

A preliminary instream flow study (U.S. Fish and Wildlife Service 1993) indicated that between 50 and 225 cfs, depending on time of year and water year type, is needed to provide spawning and rearing habitat for chinook salmon. A complete instream flow incremental methodology study is needed, however, to further define flow needs. Since the Calaveras River water supply is already over-allocated, the means of providing additional instream flows also need to be considered. The resizing of flood control criteria at New Hogan Reservoir has the potential to yield additional water to meet instream flow needs.

COARSE SEDIMENT SUPPLY

TARGET 1: On the Mokelumne River below Camanche Dam, provide average annual supplementation of 1,200 to 2,500 cubic yards of gravel into the active stream channel to maintain quality spawning areas and to replace gravel that is transported downstream (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate, implement, and monitor sediment supplementation on the Mokelumne River, consistent with adaptive management.

TARGET 2: On the Calaveras River, provide for the annual recruitment of 500 to 1,000 cubic yards of gravel into the active stream channel (◆◆).

PROGRAMMATIC ACTION 2A: Cooperatively develop a program to protect all existing gravel recruitment sources to the rivers.

PROGRAMMATIC ACTION 2B: Develop a cooperative program to supplement gravel with artificial introductions.

PROGRAMMATIC ACTION 2C: Develop a cooperative program with the aggregate (sand and gravel) resource industry to improve extraction activities within the Mokelumne River floodplain.

TARGET 3: Restore gravel transport and cleaning processes to attain sufficient high quality salmon spawning habitat in each of the three streams for target population levels (◆).

PROGRAMMATIC ACTION 3A: Develop a cooperative program to provide late winter or early spring flow events, as needed, to establish appropriate flushing/channel maintenance flows.

PROGRAMMATIC ACTION 3B: Facilitate fine sediment transport by restoring, as necessary, the river channel configuration so that it is consistent with planned flow regime and available sediment supply.

PROGRAMMATIC ACTION 3C: Develop a cooperative program to improve the flexibility of upstream reservoir management to minimize fine sediment inputs to the lower Mokelumne and Calaveras Rivers.

PROGRAMMATIC ACTION 3D: Develop a cooperative evaluation of mechanically cleaning spawning gravel at selected sites in lower Mokelumne and Calaveras rivers.

PROGRAMMATIC ACTION 3E: Develop a cooperative program on the Cosumnes River to relocate sand and gravel extraction activities to areas beyond the natural stream meander corridor.

TARGET 4: Restore channel gradient and stream profile in the Cosumnes River between Twin Cities Road and Highway 16 (◆◆).

PROGRAMMATIC ACTION 4A: Develop a cooperative program to assess the feasibility of reversing head cutting and stream channel incision in the Cosumnes River.

RATIONALE: *Recruitment of suitable salmonid spawning gravel below Camanche Dam on the Mokelumne River is minimal. Most gravel present is in the small range of the preferred sizes used by spawning chinook salmon. Targeted levels are to maintain processes linked to sediment supply, stream channel meander, and riparian and riverine aquatic habitat. This program will be subject to adaptive management, focused research, and monitoring, and thus is considered short-term until a more detailed evaluation is completed.*

Flood stage for the lower Mokelumne River is 5,000 cfs. Preliminary data suggest that spawning-sized gravel for adult salmonids (DFG 1991, Bjorn and Reiser 1991) do not begin moving in the lower Mokelumne River until flows of 3,000 cfs or more are reached (Envirosphere 1988). Even at 5,000 cfs (flood stage), the larger gravel does not move. Significant impacts occur to property along the lower Mokelumne River at flows above 2,500 cfs. It would not be practical to place supplemental gravel along the entire reach of the lower Mokelumne River because numerous roads would have to be constructed for access. The environmental impact of these roads would negate any benefit from the addition of spawning gravel. Therefore, a gravel supplementation program on the Mokelumne River would have to be long-term and gravel injected at the upper end. Lower gravel enhancement sites were established below Highway 88 at Mackville Road on the lower Mokelumne River in 1997 and 1998. These sites are approximately 5 miles below Camanche Dam.

Flow regulation has reduced the frequency and magnitude of high flow events in the lower Mokelumne River. Due to the reduction in high flows and excessive input of fine sediments, sediments accumulate in salmonid spawning gravel and degrade habitat. BioSystems (1992) reported that over 70% of the substrate samples taken in 1991 and 1992 from chinook salmon redds contained amounts of fine sediment less than 0.48 mm in diameter, which is detrimental to egg survival (Chapman 1988). The need for salmonid spawning gravel restoration is also identified by DFG (1993) and USFWS (1997).

Gravel supplementation programs should be subject to adaptive management, monitoring, and focused research. The frequency and amount of supplemental gravel will vary greatly from year to year. Physical monitoring can record observable changes in the size and distribution of gravel, while biological monitoring can record use of new gravel by anadromous fish and invertebrates. Focused research is needed to calculate annual bedload movement, gravel quality, infiltration, and intragravel water quality.

Mechanical means to clean gravel should be evaluated. This could be a focused research project. Due to water quality constraints and the presence of juvenile anadromous and other fish species, the window for gravel cleansing may be short. This concern should be included in the feasibility analysis.

NATURAL FLOODPLAIN AND FLOOD PROCESSES

TARGET 1: Restore and improve opportunities for rivers to inundate their floodplain seasonally (◆◆◆).

PROGRAMMATIC ACTION 1A: Conduct a feasibility study to construct setback levees in the Mokelumne River floodplain in the area from Elliot Road to Woodbridge and from Woodbridge to the mouth, including the Mokelumne forks below the river's mouth.

PROGRAMMATIC ACTION 1B: Restore, as needed, stream channel and overflow basin configurations within the floodplain.

PROGRAMMATIC ACTION 1C: Minimize effects of permanent structures, such as bridges and diversion dams, on floodplain processes.

PROGRAMMATIC ACTION 1D: Develop a floodplain management plan for the Mokelumne River.

PROGRAMMATIC ACTION 1E: Develop a floodplain management plan for the Calaveras River.

PROGRAMMATIC ACTION 1F: Develop and implement a cooperative program to evaluate the feasibility of reconnecting the Cosumnes River to its historical floodplain in areas where the river has become entrenched.

PROGRAMMATIC ACTION 1G: Cooperatively develop and implement a feasibility study on the Cosumnes River to identify opportunities to improve sediment transport, stream meander, and maintain the natural flow pattern.

RATIONALE: *Setback levees will provide greater floodplain inundation, room for stream meander, and greater amounts of riparian forest and seasonal wetland habitats along the lower rivers. Channel configuration adjustments may be necessary to accelerate restoration of natural floodplain habitats and to restore and maintain configurations that may not occur naturally due to remaining constraints from new setback levees. Permanent structures, such as bridges and diversions dams, can interrupt and impair natural floodplain processes and habitat development and succession, thus requiring removal of the structures, rebuilding, or some continuing maintenance or mitigative efforts to minimize their effects. Some reaches of the Cosumnes River upstream of Twin Cities Road have become entrenched and even setback levees will not raise the level of the river bed to the point where the historical floodplain is again functional. This requires a feasibility analysis to identify causes of the stream channel degradation and identification of potential remedial measures.*

The value of floodplain inundation to native fish species is extremely high. Recent studies have provided more insight to the value of the Cosumnes River floodplain to splittail spawning and rearing and chinook rearing.

CENTRAL VALLEY STREAM TEMPERATURES

TARGET 1: Maintain mean daily water temperatures at or below levels suitable for all life stages of fall-run chinook salmon and steelhead (◆◆).

PROGRAMMATIC ACTION 1A: Cooperatively evaluate the feasibility of releasing sufficient instream flows to improve temperature conditions for key resources in the Mokelumne and Calaveras Rivers.

PROGRAMMATIC ACTION 1B: Establish minimum pool size at New Hogan Reservoir to ensure cold-water releases into the Calaveras River.

PROGRAMMATIC ACTION 1C: Cooperatively develop reservoir and stream temperature models for the Calaveras River to identify potential for water temperature improvement.

PROGRAMMATIC ACTION 1D: Manage Pardee and Camanche Reservoirs through October to maintain a cold water volume of 28,000 af when Pardee Reservoir volume exceeds 100,000 af.

RATIONALE: *Water temperatures in the lower Mokelumne, Calaveras, and Cosumnes Rivers are often at stressfully high levels for fall-run chinook salmon early in the spawning run, and again in the spring when young salmon are migrating downstream to the Delta. The problem is especially acute downstream of Camanche Dam, where water temperature depends on release temperature, prevailing weather conditions, and flow rate. From April to mid-October, the closure of Woodbridge Dam and subsequent filling of Lake Lodi results in the slowing of flow, allowing the water to warm. Differences in water temperature between Camanche and Woodbridge Dams have been measured up to 16.2°F during dry years (Walsh et al. 1992). Higher flow, colder water, and riparian woodlands may reduce this water heating during the fall upstream spawning run and spring downstream migration of young to the Delta.*

Releases of Pardee Reservoir water into Camanche Reservoir should coordinated to maximize the effectiveness of the Camanche coldwater pool. Timely releases of cold water from Pardee Reservoir can extend the period and increase the value of coldwater releases from Camanche Reservoir.

Water temperatures in the Calaveras River are closely associated with instream flows, reservoir release schedules, and pool size at New Hogan Reservoir (U.S. Fish and Wildlife Service 1993). Temperatures often exceed stressful or lethal levels for chinook salmon migration, spawning, egg incubation, and rearing. An improved temperature regime could be achieved by maintaining a minimum pool at New Hogan Reservoir and adequate instream flow releases (U.S. Fish and Wildlife Service 1993). The appropriate minimum pool size needs to be determined. Reservoir and stream temperature computer models are also needed to identify the potential for maintaining suitable water temperatures for chinook salmon and to weigh the conflict between coldwater releases and loss of carryover storage necessary to provide coldwater releases later in the season or the following year(s).

Riparian woodlands along all three rivers are essential for shade to minimize heating of the rivers. This is especially important along the Cosumnes River, because there is no source of cold reservoir bottom water as there is below Camanche and New Hogan Reservoirs.

HABITATS

GENERAL HABITAT RATIONALE

Restoring seasonal wetland habitats along with other aquatic, permanent wetland, and riparian habitats is an essential element of the restoration strategy for the Eastside Tributaries Ecological Management Zone. The ecological units in this zone are closely linked to the Sacramento/San Joaquin Delta Ecological Management Zone, particularly the East Delta Ecological Unit. The lower sections of the Eastside ecological units overlap the East Delta Ecological Unit so it is important to consider habitat restoration recommendations in the Delta when evaluating needs in the Eastside Tributaries. For example, the following programmatic actions apply to the East Delta Ecological Unit:

- *restore 1,000 acres of shallow-water habitat (tidal perennial aquatic habitat) at the eastern edge of the East Delta Ecological Unit,*
- *develop 200 acres of open-water areas (nontidal perennial aquatic habitat) in the East Delta Ecological Unit,*
- *develop 300 acres of shallow, open-water areas (nontidal perennial aquatic habitat) within restored fresh emergent wetland habitat in the East Delta Ecological Unit,*
- *in the short-term, restore 10 miles of slough habitat and 30 miles in the long-term in the East Delta Ecological Unit,*
- *restore tidal action to portions of islands and tracts in the East Delta Ecological Unit with appropriate elevations, topography, and water-landform conditions,*
- *develop tidal freshwater marshes (fresh emergent wetland habitat) along the upper ends of dead-end slough in the East Delta Ecological Unit,*

- *restore 1,000 acres of nontidal freshwater marshes (fresh emergent wetland habitat) in leveed lands designated for floodplain overflow adjacent to the dead-end sloughs in the East Delta Ecological Unit,*
- *restore and manage at least 6,000 acres of additional seasonal wetland habitat and improve management of 1,000 acres of existing, degraded seasonal wetland habitat in the East Delta Ecological Unit,*
- *restore 8 to 15 miles of riparian and riverine aquatic habitat in the East Delta Ecological Unit of which 40% is more that 75 feet wide and 20% over 300 feet wide,*
- *develop a cooperative program to restore 1,000 acres of perennial grassland in the East Delta Ecological Unit through either conservation easements of purchase from willing sellers, and*
- *generally, cooperatively manage agricultural lands in a wildlife friendly manner.*

SEASONAL WETLANDS

TARGET 1: Protect existing seasonal wetland habitat (◆◆).

PROGRAMMATIC ACTION 1A: Develop and implement a cooperative program to improve management of existing, degraded seasonal wetland habitat.

PROGRAMMATIC ACTION 1B: Identify and acquire seasonal wetland habitat from willing sellers through acquisition or easement.

RATIONALE: *Restoring these habitats will also reduce the amount and concentrations of contaminants that could interfere with restoring the ecological health of the aquatic ecosystem. Seasonal wetlands support a high production rate of primary and secondary food species and large blooms (dense populations) of aquatic invertebrates.*

Wetlands that are dry in summer are also efficient sinks for the transformation of nutrients and the breakdown of pesticides and other contaminants. The roughness of seasonal wetland vegetation filters and traps sediment and organic particulates. Water flowing out from seasonal wetlands is typically high in foodweb prey species concentrations and fine particulate organic matter that feed many Delta aquatic and semiaquatic fish and wildlife. To capitalize on these functions, most of the seasonal wetlands of the Eastside Delta Tributaries Ecological Management Zone should be subject to periodic flooding and overland flow from river floodplains

RIPARIAN AND RIVERINE AQUATIC HABITATS

TARGET 1: Restore a minimum of 1,240 acres of self-sustaining or managed diverse natural riparian habitat along the Mokelumne River, and protect existing riparian habitat (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to restrict further riparian vegetation removal, and establish riparian corridor protection zones.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to implement riparian restoration activities.

PROGRAMMATIC ACTION 1C: Encourage improved land management and livestock grazing practices along stream riparian zones.

PROGRAMMATIC ACTION 1D: Purchase streambank conservation easements from willing sellers to widen riparian corridors.

PROGRAMMATIC ACTION 1E: Develop a cooperative program to restore riparian woodlands along the entire Mokelumne River.

TARGET 2: Restore a minimum of 1,240 acres of self-sustaining or managed diverse, natural riparian habitat along the Calaveras River, and protect existing riparian habitat (◆◆◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to restrict further riparian vegetation removal. Establish riparian corridor protection zones along all three rivers.

PROGRAMMATIC ACTION 2B: Develop a cooperative program to implement riparian restoration activities.

PROGRAMMATIC ACTION 2C: Encourage improved land management and livestock grazing practices along stream riparian zones.

PROGRAMMATIC ACTION 2D: Purchase streambank conservation easements from willing sellers to widen riparian corridors.

PROGRAMMATIC ACTION 2E: Develop a cooperative program to restore riparian woodlands along the entire Calaveras River.

TARGET 3: Restore a minimum of 1,240 acres of self-sustaining or managed diverse, natural riparian habitat along the Cosumnes River, and protect existing riparian habitat (◆◆◆).

PROGRAMMATIC ACTION 3A: Develop a cooperative program to restrict further riparian vegetation removal, and establish riparian corridor protection zones.

PROGRAMMATIC ACTION 3B: Develop a cooperative program to implement riparian restoration activities.

PROGRAMMATIC ACTION 3C: Encourage improved land management and livestock grazing practices along stream riparian zones.

PROGRAMMATIC ACTION 3D: Purchase streambank conservation easements from willing sellers to widen riparian corridors.

PROGRAMMATIC ACTION 3E: Develop a cooperative program to restore riparian woodlands along the entire Cosumnes River.

RATIONALE: *The DFG is developing a strategy to establish a stream corridor protection zone on the Cosumnes River to prevent incompatible land use from affecting existing salmonid habitat. In addition, The Nature Conservancy is targeting the restoration of more than 7,000 acres. The 1,240 acres recommended for restoration under Target 3 are to be compatible with ongoing restoration efforts. Generally, the 1,240 acres represents a 100 foot-wide riparian corridor along 10 miles of stream. The site specific refinement of this target will likely occur in collaboration with the partners of the Cosumnes River Project.*

Riparian vegetation along the lower Mokelumne River is diminishing (U.S. Fish and Wildlife Service 1993), however, EBMUD and the Natural Resources Conservation Service are developing a strategy for establishing a stream corridor protection zone on the lower Mokelumne River. In many areas, there is no regeneration along the relatively thin riparian corridor (California Department of Fish and Game 1991). Riprapping long sections of streambank has reduced tree growth and decreased stream shading, resulting in increased stream temperatures (East Bay Municipal Utility District 1994). Bankside erosion has potentially affected salmonid production in several areas where livestock grazing is permitted.

FRESHWATER FISH HABITAT AND ESSENTIAL FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination (◆◆).

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for Eastside Delta Tributaries Ecological Management Zone ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitats. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of streams in this zone and their floodplains, and in maintaining and restoring riparian and riverine aquatic habitats.*

STRESSORS

WATER DIVERSION

TARGET 1: Install fish screens representing the best available technology and operational constraints, as necessary, to minimize losses in diversions that limit the recovery of fish populations (◆◆◆).

PROGRAMMATIC ACTION 1A: Consolidate diversions, seek alternative water sources, and install a permanent fish screen at North San Joaquin Conservation District diversion on the lower Mokelumne River.

PROGRAMMATIC ACTION 1B: Improve fish screens and the fish bypass system at Woodbridge Dam on the lower Mokelumne River.

PROGRAMMATIC ACTION 1C: Evaluate the feasibility of installing state-of-the-art screens on small pump diversions.

PROGRAMMATIC ACTION 1D: Develop a cooperative program to operate temporary screens at diversions where juvenile salmon rear or during seasons when they pass the diversion site.

PROGRAMMATIC ACTION 1E: Consolidate and install screens on diversions in the Cosumnes River.

RATIONALE: *On the lower Calaveras River, most of the existing diversions are not screened or are inadequately screened (California Department of Fish and Game 1993). Nearly all water in the river is diverted, especially in the summer and fall of drier years. During the winter and spring, unscreened diversions between the spawning areas and the river mouth are a potential threat to juvenile salmon.*

Stockton East Water District has an appropriative water right to divert up to 100 cfs from the Calaveras River. This diversion is currently unscreened. There are several other unscreened diversions along the river. It is probable that juvenile salmon losses occur during years when chinook salmon enter and spawn in the Calaveras River (California Department of Fish and Game 1993).

On the lower Mokelumne River, more than 90 pumps withdraw water from the river between Camanche Dam and the Delta. Few, if any, are screened to prevent fish entrainment (BioSystems 1992). The Woodbridge Irrigation District (WID) diversion at Woodbridge Canal allows juvenile chinook salmon and steelhead losses, because the screen does not meet present DFG criteria for approach velocity and mesh size, nor does it effectively screen the opening of the diversion (California Department of Fish and Game 1993). North San Joaquin Water Conservation District is the second largest diversion below Camanche Dam; temporary fish screens were installed in 1993 (U.S. Fish and Wildlife Service 1995).

Most Cosumnes River diversions are unscreened and likely entrain juvenile salmonids (U.S. Fish and Wildlife Service 1995).

Screening or eliminating diversions from areas where juvenile salmon are rearing or actively migrating will increase production of naturally produced juvenile salmon from these three streams.

DAMS AND OTHER STRUCTURES

TARGET 1: Improve anadromous fish passage at dams and diversion structures (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate the need for passage improvements at small dams on the lower Cosumnes River.

PROGRAMMATIC ACTION 1B: Cooperatively improve fish passage at WID diversions and Lake Lodi on the lower Mokelumne River.

PROGRAMMATIC ACTION 1C: Cooperatively isolate the City of Lodi's Recreational Lake Lodi on the lower Mokelumne River to improve adult salmon and steelhead passage and juvenile fish survival.

PROGRAMMATIC ACTION 1D: Develop a cooperative program to provide fish passage at temporary irrigation dams in the Calaveras River, Mormon Slough, and the Stockton Diverting Canal.

PROGRAMMATIC ACTION 1E: Develop a cooperative program to install fish passage facilities at Bellota Weir, Clements Dam, and Cherryland Dam on the Calaveras River, and provide passage flows.

RATIONALE: *Small flashboard dams and some illegal dirt and gravel dams exist on the lower portions of the three rivers (U.S. Fish and Wildlife Service 1997). These dams may impede up- and downstream chinook salmon migration. On the lower Mokelumne River, Woodbridge Dam and the WID diversion may kill fish or delay downstream migrating juvenile salmonids and upstream passage of adult salmonids. DFG (1993) and USFWS (1997) recommended evaluating improvements to the existing fishway on Woodbridge Dam.*

An informal inspection of Granlees Diversion Dam by DFG in 1998 suggested that the ladder design is deficient. In addition to this dam, there are three concrete summer dams/low flow crossings in the lower Cosumnes River, well below the chinook salmon spawning area. The Fisheries Foundation of California and the DFG identified these to be low flow barriers to upstream migration. Minimum estimated flows needed for passage in this area is approximately 150 cfs.

The channels that carry Calaveras River water, and are migratory routes for salmon below Bellota Dam, *include the original Calaveras River stream channel, Mormon Slough, and the Stockton Diverting Canal (into which drains Mormon Slough) (California Department of Fish and Game 1993). In some years, typically in March, partial or complete blockage of the adult salmon migration coincides with the annual placement of approximately 30 temporary irrigation dams in these channels. Fish are prevented from reaching the deep holding pools and spawning gravel above Bellota and are subjected to poaching below the flashboard dams. Reclamation Board Permit No. 7594 (August 27, 1971) requires that some of the flashboards and slide gates be removed from the channel prior to November 1 of each year and not replaced before April 15. Two of the diversion structures, Clements Dam and Cherryland Dam, have been identified as barriers to salmon movement and require fish passage facilities. The Bellota Dam (weir) has also been known to block upstream salmon migrants at flows below approximately 200 cfs (California Department of Fish and Game 1982). In some years, salmon have been observed in the tidewater reach, apparently unable to move upstream at lower flows. Juvenile salmon have trouble finding the downstream outlets to the dam and fish ladder.*

INVASIVE RIPARIAN AND MARSH PLANTS

TARGET 1: Reduce the adverse effects of invasive riparian plants on native species and ecosystem processes, water quality and conveyance systems, and major rivers and their tributaries (◆◆).

PROGRAMMATIC ACTION 1A: Develop and implement a coordinated control program to reduce or eliminate invasive plant species from the riparian corridor along the Cosumnes, Mokelumne, and Calaveras Rivers.

RATIONALE: *Non-native plant species, such as Arundo, also known as giant reed or false bamboo, can be highly invasive, fast-growing plants that outcompete and displace native riparian vegetation. These plants restrict water flow, increase sedimentation, and form large debris piles in streams and rivers. Arundo has been introduced into the watersheds of the Eastside Delta Tributary Ecological Management Zone. Its presence is impairing existing riparian communities and will likely hinder riparian corridor restoration. Riparian regeneration programs will require a coordinated approach to controlling invasive or non-native species through public education and chemical, biological, and mechanical methods.*

PREDATION AND COMPETITION

TARGET 1: Reduce predation level on juvenile salmonids below Woodbridge Dam on the lower Mokelumne River (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to modify the stream channel and rebuild the Woodbridge Dam fish passage and diversion screening facilities. This will help minimize losses of downstream migrating salmon and steelhead, while maintaining other important functions.

PROGRAMMATIC ACTION 1B: Modify and improve the fish bypass discharge at Woodbridge Dam.

RATIONALE: *High spring flows attract striped bass, American shad, and squawfish to the base of Woodbridge Dam on the lower Mokelumne River. Studies suggest that a significant proportion of the juvenile salmon smolt production in the Mokelumne River basin may be lost to predation (Boyd 1994, East Bay Municipal Utility District 1994). Juvenile salmon must first pass the reservoir, then the dam, and then the predators concentrated immediately below the dam (striped bass and American shad are unable to ascend the ladder and move upstream; therefore, they tend to gather in large numbers below the dam).*

CONTAMINANTS

TARGET 1: Restore and maintain water quality in Camanche Reservoir on the Mokelumne River (◆).

PROGRAMMATIC ACTION 1A: Support EBMUD in developing operating procedures at Pardee and Camanche Reservoirs that optimize water quality below Camanche Dam.

PROGRAMMATIC ACTION 1B: Support implementation of the cooperative agreement for the long-term remediation of Penn Mine contamination.

TARGET 2: Reduce the input of nonpoint source contaminants into the Mokelumne River (◆◆).

PROGRAMMATIC ACTION 2A: Develop an integrated program to coordinate and minimize agricultural pesticide and herbicide use in areas that drain into the Mokelumne River.

RATIONALE: *Poor water quality has been identified by USFWS (1997) as a limiting factor affecting fall-run chinook salmon and steelhead in the Mokelumne River. USFWS (1995) stated that managing Camanche Reservoir elevations and Pardee Reservoir inflows have not consistently provided suitable water quality to the Mokelumne River Fish Facility and to the lower river. Occurrences of low dissolved oxygen, elevated hydrogen sulfide, and elevated heavy metal levels have been documented, occasionally resulting in fish kills. Presently, reservoir operations have successfully maintained the Camanche release water quality to the lower Mokelumne River. Recently, EBMUD and others have adopted a long-term plan to remediate Penn Mine contamination. The final EIR/EIS has been completed and a Restoration Plan adopted by EBMUD, CVRWQCB, CSM, and federal ESA.*

HARVEST OF FISH AND WILDLIFE

TARGET 1: Develop harvest management strategies that allow the spawning population of wild, naturally produced fish to attain levels that fully utilize existing and restored habitat and allow harvest to focus on hatchery-produced fish (◆◆◆).

PROGRAMMATIC ACTION 1A: Reduce or eliminate the illegal salmon and steelhead harvest by increasing enforcement efforts.

PROGRAMMATIC ACTION 1B: Develop harvest management plans with commercial and recreational fishery organizations, resource management agencies, and other stakeholders that support ecosystem restoration and protect important species.

PROGRAMMATIC ACTION 1C: Evaluate a marking and selective fishery program for chinook salmon.

RATIONALE: *Restoring and maintaining chinook salmon and steelhead populations to levels that take full advantage of habitat may require harvest restrictions during, and even after, the recovery period. Involvement of the various stakeholder organizations should help provide a balanced and fair allocation of available harvest. Target population levels may preclude existing harvest levels of wild, naturally produced fish. For populations supplemented with hatchery fish, selective fisheries may be necessary to limit wild fish harvest, while harvesting hatchery fish to reduce their potential to disrupt the genetic integrity of wild populations.*

ARTIFICIAL PROPAGATION OF FISH

TARGET 1: Minimize the likelihood that hatchery-produced salmon and steelhead could stray into adjacent non-natal rivers and streams to protect naturally produced salmon and steelhead (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate the benefits of limiting stocking in the Mokelumne River with salmon and steelhead produced at the Mokelumne River Hatchery.

TARGET 2: Employ methods to limit straying and reduced genetic integrity of wild and hatchery supported stocks (◆◆◆).

PROGRAMMATIC ACTION 2A: Rear hatchery salmon and steelhead in hatcheries on natal streams to limit straying.

PROGRAMMATIC ACTION 2B: Limit stocking of salmon and steelhead fry and smolts to natal watersheds to minimize straying that may compromise the genetic integrity of naturally producing populations.

PROGRAMMATIC ACTION 2C: Develop a plan to stop importing egg or fry chinook salmon and steelhead to the Mokelumne River.

RATIONALE: *In watersheds like the eastside tributaries to the Delta, where dams and habitat degradation have limited natural spawning, some hatchery supplementation may be necessary. This would help to sustain fishery harvest at former levels and to maintain a wild or natural spawning population during adverse conditions, such as droughts. However, hatchery augmentation should be limited in extent and to levels that do not inhibit recovery and maintenance of wild populations. Hatchery-produced salmon and steelhead might directly compete with and prey on wild salmon and steelhead. Straying of adult hatchery fish into non-natal watersheds might also threaten the genetics of wild stocks. Hatchery fish might also threaten the genetic makeup of stocks in natal rivers. Further research and experimentation are necessary to determine how this issue is addressed. Long-term* *hatchery augmentation of healthy wild stocks may genetically undermine those stocks and threaten the genetic integrity of other stocks.*

Straying of adults into non-natal streams may result in interbreeding with a wild population specifically adapted to that watershed, and thus lead to the loss of genetic integrity in the wild population. Release of hatchery-produced fish into the San Joaquin River and its tributaries, other than the Mokelumne River, could lead to a loss in the genetic integrity of wild salmon and steelhead populations.

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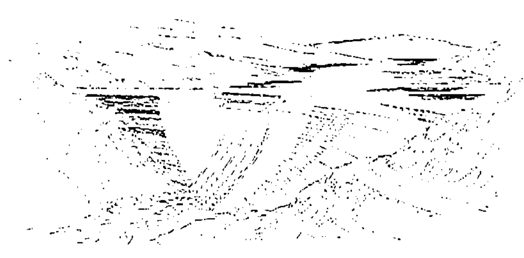
◆ San Joaquin River Ecological Management Zone



Introduction

The health of the Sacramento-San Joaquin Delta is dependent on its tributaries for inflows of water along with their sediments and nutrients. The tributaries also provide spawning, rearing, and migration habitats for aquatic species. The Delta also depends on quality riparian corridors that connect it with the upper watershed habitats needed by many terrestrial species. The ecological integrity of the San Joaquin River below Friant Dam is critical to the ecological health of the Bay-Delta system. The ecological quality of the mainstem San Joaquin River below the mouth of the Friant Dam is particularly important for the anadromous fish that annually migrate into and out of the Stanislaus, Tuolumne, and Merced rivers.

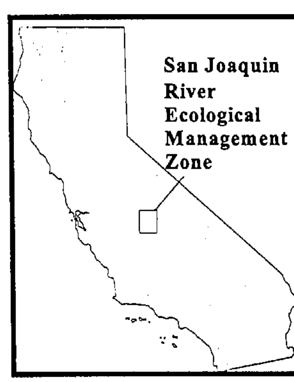
The San Joaquin Ecological Management Zone encompasses four Ecological Management Units:

- Vernalis to Merced Ecological Management Unit,
- Merced to Mendota Pool Ecological Management Unit,
- Mendota Pool to Gravelly Ford Ecological Management Unit, and
- Gravelly Ford to Friant Ecological Management Unit.

Description of the Management Zone

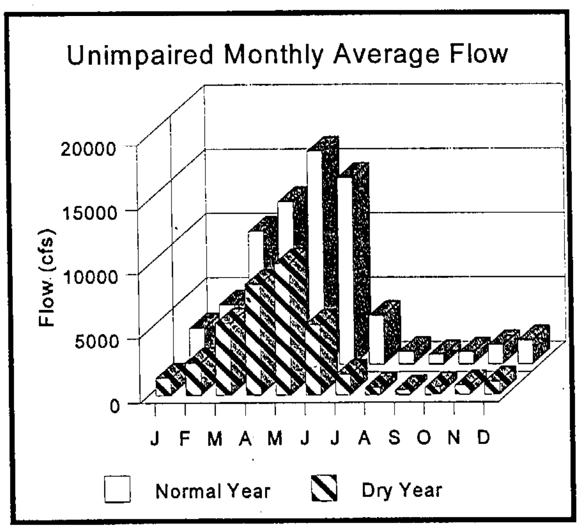
The 290-mile-long San Joaquin Valley occupies the southern half of the Central Valley and has an average width of 130 miles. The Tulare Lake basin to the south is normally considered a separate drainage basin but, during wet years, has contributed occasional floodflows and subsurface flows to the San Joaquin River. The San Joaquin River basin is bounded on the west by the Coast Ranges and on the east by the Sierra Nevada. The San Joaquin River flows west from the Sierra Nevada, turns sharply north at the center of the valley floor, and flows north through the valley into the Sacramento-San Joaquin River Delta.

On the arid west side of the basin, relatively small intermittent streams drain the eastern slopes of the Coast Ranges but rarely reach the San Joaquin River. Natural runoff from westside sloughs is augmented by contaminated agricultural drainage and spill flows. On the east side, many streams and three major rivers drain the west slope of the Sierra Nevada and flow into the San Joaquin River. The major eastside tributaries south of the Delta are the Stanislaus, Tuolumne, and Merced rivers. Secondary streams south of the Merced River include Bear Creek and the Chowchilla and Fresno rivers and the upper San Joaquin River.



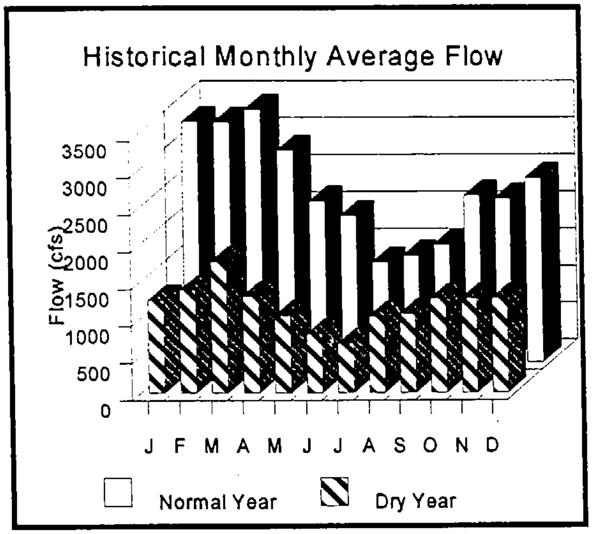
Precipitation in the San Joaquin River basin averages about 27.3 inches per year. Snowmelt runoff is the major source of water to the upper San Joaquin River and the larger eastside tributaries. Historically, peak flows were in May and June, and natural overbank flooding took place in most years along all the major rivers. When floodflows reached the valley floor, they spread out over the lowlands, creating several hundred thousand acres of permanent tule marshes and more than 1.5 million acres of seasonally flooded wetlands and native grasslands. The rich alluvial soils of natural levees once supported large, diverse riparian (waterside) forests. As much as 2 million acres of riparian vegetation are estimated to have grown on levees, on floodplains, and along small stream courses. Above the lower floodplain, the riparian zone graded into higher floodplains supporting valley oak, savanna, and native grasslands interspersed with vernal pools. Less than 10% of the historic wetland acreage and less than 2% of the historic riparian acreage exist as remnant vestiges.

Agricultural development in the basin, which began in the 1850s, brought dramatic changes in the hydrologic system. The upper San Joaquin River drainage (1,650 square miles) now has seven power-generation reservoirs, which alter flows in the upper basin. Friant Dam near Fresno is the major storage reservoir there. Completed in 1949, the dam is operated by the U.S. Bureau of Reclamation (Reclamation) to provide flood control, irrigation, and power generation. Millerton Lake, formed by Friant Dam, has a gross storage capacity of 520,000 acre-feet (af) and provides for deliveries into the Friant-Kern Canal, the Madera Canal, and other Central Valley Project (CVP) facilities. Mean annual runoff of the San Joaquin River into Millerton Lake totals 1.9 million af, with 2.2 million af per year committed in water contracts.



Unimpaired Streamflow on the San Joaquin River at Vernalis, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Water development caused a great change in the natural streamflow pattern of the river. The high flows of spring are now captured in storage reservoirs in the basin except for the years of highest rainfall. Summer and fall flows are higher than before to provide water for irrigation and urban water supply.



Historical Streamflow on the San Joaquin River at Vernalis, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Historically, the upper San Joaquin River supported spawning and rearing habitat for the southernmost stocks of spring- and fall-run chinook salmon and for steelhead. Early dams along the river restricted passage of adult salmon. By the early 1940s, large runs of salmon in the upper San Joaquin River near Fresno were mostly spring-run fish. This spring run, ranging from 2,000 to 56,000 fish between 1943 and 1948, was extirpated after 1949 when the Friant Dam closed the channel. The fall run, averaging about 1,000 spawning adults in the 1940s, was also eliminated by the dam. Streamflow releases to the San Joaquin River below the dam are now insufficient to support salmon passage, spawning, or rearing. No water passes through the Gravelly Ford to Mendota Pool reach except during extremely high runoff periods.

There is historical documentation of steelhead in the San Joaquin river system, south to and including the Kings River and Tulare Lake (Yoshiyama et al. 1996). The widespread distribution of chinook salmon in this system provides further indication of the extent of steelhead distribution. In the Klamath River drainage, for instance, all streams that contain a chinook salmon population have steelhead as well and, in nearly all cases, steelhead go higher into the drainage and utilize more of the stream system than do chinook salmon. This indicates that if chinook salmon were able to access and utilize habitat of a particular stream, steelhead could as well. Because steelhead utilize smaller tributaries for spawning and rearing, they were probably more widely distributed in the San Joaquin River system (and the rest of the Central Valley) than were chinook salmon (Yoshiyama et al. 1996).

Friant Dam's closure of the channel and reduction of total basin outflow damaged anadromous fish runs in other tributaries as well. Reducing fall attraction flows and spring outflows on the mainstem San Joaquin River reduced adult returns, production, and survival of salmon throughout the system. When spring outflow at Vernalis on the mainstem San Joaquin River is high, the total adult salmon escapement (fish that survive migration to spawn) in the San Joaquin River basin increases 2.5 years later. Since Friant Dam began operating, low spring outflows from the basin in most years have contributed substantially to low salmon production.

The three major eastside tributaries to the San Joaquin River—the Stanislaus, Tuolumne, and Merced rivers—support spawning and rearing habitat for fall-run chinook salmon, steelhead, rainbow trout, and perhaps late-fall-run chinook salmon. Substantial evidence exists to show that there is an extant self-sustaining steelhead run in the San Joaquin Basin. Since 1995, a small, but consistent, number of juvenile steelhead that exhibit smolt characteristics have been captured in rotary screw traps at two chinook salmon monitoring sites on the lower Stanislaus River (Demko and Cramer 1997; 1998). The presence, over multiple years, of juvenile steelhead that have undergone smoltification and are actively migrating to the ocean is sufficient evidence to conclude that natural production is occurring and a self-sustaining population exists. This is also the opinion of the Department of Fish and Game (CDFG 1997), the Steelhead Project Workteam of the Interagency Ecological Program (IEP Steelhead Project Workteam 1999) and apparently the Department of Water Resources and the U.S. Bureau of Reclamation (DWR and USBR 1999). It is the opinion of the Department of Fish and Game that small runs of steelhead still exist in the Tuolumne and Merced rivers as well (CDFG 1997).

Recent genetic analysis by the National Marine Fisheries Service of Stanislaus River rainbow trout/steelhead collected from the anadromous reach below Goodwin Dam show that this population has close genetic affinities to upper Sacramento River steelhead (NMFS 1997). Further, this Central Valley group forms a genetic group that is distinct from all other samples of steelhead analyzed (132 samples from Washington, Oregon, Idaho, and California) (Busby et al. 1996), hence may be representative of native Central Valley steelhead. In most years, a few salmon are observed spawning in late January and February on the lower Stanislaus River. Whether these fish are a remnant of a distinct late fall run in the San Joaquin River basin or whether they are strays or fall-run fish spawning later than usual is not known.

In recent years, fall-run chinook spawning escapements in the San Joaquin River basin have declined to alarmingly low levels. In fall 1991, an estimated 658 fish returned to the basin to spawn, compared to 135,000 in 1944, 80,500 in 1953, 53,400 in 1960, and 70,000 in 1985.

A streamflow of 35 to 230 cubic feet per second (cfs) is required in the river between Friant Dam and Gravelly Ford to support riparian water diversions. Major reaches of the river between Gravelly Ford and the confluence with the Merced River are essentially dry for much of the year. The stream channel has been affected by inchannel gravel mining and by vegetative encroachment resulting from the absence of frequent scouring flows. The mainstem San Joaquin River downstream from the confluences with the major eastside tributaries provides the migration corridor for anadromous fish to the Delta and the Pacific Ocean.

In recent years, drainage practices in western Merced County have increased agricultural return flows from Salt and Mud Sloughs into the mainstem San Joaquin River. These flows attracted significant numbers of adult salmon into the sloughs and, subsequently, into irrigation canals with no suitable spawning habitat. As spawning runs have declined, the proportion of the San Joaquin drainage salmon straying into the westside area has increased. In fall 1991, 31% of the salmon in the basin was estimated to have strayed into westside canals.

Fish screens were installed on the El Solyo, West Stanislaus, and Patterson Irrigation District diversions in the late 1970s. Because of the low number of returning adult salmon and juveniles the inappropriate design and inefficiency of the screens, and the high cost of maintenance; the screens were abandoned within a few years. The El Soyo diversion has the capacity to withdraw as much as 80 cfs; each of the other diversions has a capacity of 249 cfs. Together, these diversions can withdraw a significant proportion of the mainstem river flow, particularly in dry years.

Many small and medium-size irrigation diversions on the mainstem San Joaquin River entrain juvenile salmon in addition to those at the El Soyo, West Stanislaus, and Patterson Irrigation District diversions. Cumulative losses at these other sites may be significant.

San Joaquin River basin outflow standards should be established to protect adults migrating upstream in the fall and emigrating smolts in the spring.

High water temperatures during emigration probably reduce smolt survival in the mainstem river. California Department of Fish and Game (DFG) Exhibit 15 to the California State Water Resources Control Board (SWRCB) for Phase I of the Bay-Delta hearings showed that, in years when the flow at Vernalis was 5,000 cfs or less in May, water temperatures were at levels of chronic stress for these fish. Temperature stress is additive and increases with successive exposures to diversions, predation, handling in the Delta fish salvage process, and migration delays.

List of Species to Benefit from Restoration Actions in the San Joaquin River Ecological Management Zone

- chinook salmon
- steelhead trout
- splittail
- white sturgeon
- American shad
- giant garter snake
- Swainson's hawk
- greater sandhill crane
- western yellow-billed cuckoo
- shorebirds
- wading birds
- waterfowl
- neotropical migratory birds
- San Joaquin Valley woodrat
- riparian brush rabbit
- native resident fishes
- plants and plant communities.

Restoring and maintaining important ecological processes and functions in the San Joaquin River Ecological Management Zone depend on conditions in both the main tributaries to the river (the East San Joaquin Basin Ecological Management Zone) and the downstream Sacramento-San Joaquin Delta Ecological Management Zone. Water flow, channel incision, levee construction, gravel mining, sediment and nutrient supply, and input of contaminants from the tributary streams all influence habitat conditions in the mainstem San Joaquin River. Changes of these factors in the tributaries from historical conditions have degraded habitat on the mainstem river. Conditions in the Delta have a significant effect on anadromous fish production in the basin because, in most years, a significant proportion of inflow from the San Joaquin River is diverted at the Delta.

Descriptions of Ecological Management Units

Vernalis to Merced Ecological Management Unit

The Vernalis to Merced Ecological Management Unit (43 miles, from river mile [RM] 75 to RM 118) is the nontidal reach of the river that includes the confluences with the Merced, Tuolumne, and Stanislaus rivers. These major tributaries drain the west slope of the Sierra Nevada and provide most of the flow to this reach. On the arid west side of the basin, relatively small intermittent streams drain the eastern slopes of the Coast Ranges but their waters rarely reach the river, which flows in this reach through a broad alluvial channel and floodplain. Levees set close to the main channel confine the floodplain throughout most of its length, including along the lower tributaries.

Merced to Mendota Pool Ecological Management Unit

The Merced to Mendota Pool Ecological Management Unit (87 miles, from RM 118 to RM 205) includes the mouth of Salt Slough and the Chowchilla and Fresno rivers. Flows in this reach have been significantly reduced from historical conditions by the Friant Dam project upstream and by the Eastside Bypass and levee system. The reach receives inflow from the Delta-Mendota Canal into Mendota

Pool. Irrigation deliveries in the local area use this reach as a conduit. Agricultural drainage practices in western Merced County result in significant return flows from Salt and Mud Sloughs into this reach.

MENDOTA POOL TO GRAVELLY FORD ECOLOGICAL MANAGEMENT UNIT

The vision for the Mendota Pool to Gravelly Ford Ecological Management Unit (24 miles, from RM 205 to RM 229) includes no significant tributary inflow. Because of the Friant Dam project upstream, most of this reach is dry for much of the year. The stream channel has been altered by inchannel gravel mining, floodplain confinement by levees and incision, and vegetation encroachment into the abandoned channel and floodplain.

GRAVELLY FORD TO FRIANT ECOLOGICAL MANAGEMENT UNIT

The Gravelly Ford to Friant Dam Ecological Management Unit (31 miles, from RM 229 to RM 260) includes no significant tributary inflow. At Friant Dam, almost all the mainstem riverflow is diverted into the Friant-Kern Canal. Except during spill conditions at Friant Dam, the reach from the dam to Gravelly Ford receives a flow release of 35-230 cfs to support riparian water diversions; any streamflow reaching Gravelly Ford sinks into the channel bed because of the highly permeable substrate (bottom material) in that area. The stream channel has been altered by inchannel gravel mining, incision, and vegetation encroachment into the channel and floodplain.

Significant stressors of ecological functions, habitats, and species on the San Joaquin River are:

- artificial confinement of the river channel within levees
- dams the block access to historical habitat
- poor land use and livestock grazing practices on riparian lands,
- lack of floodflows, which alters the natural sediment balance and reduces riparian vegetation growth, and
- reservoir management and diversions on the mainstem and tributary streams that significantly reduce streamflow and alter stream temperature.

Additional stressors are:

- direct removal and fragmentation of riparian habitat for agricultural and urban development and floodway maintenance,
- entrainment of fish and other aquatic organisms in water diversions, and
- inchannel and floodplain gravel extraction, which alters channel forms.

Channel instability and floodplain disturbance have caused bank and floodplain deposits to erode and release too much fine sediment into the river. This sediment damages spawning habitat and bars fish passage. Construction of levees close to channels, as well as flood bypasses and weirs, has fragmented and degraded floodplain habitats (e.g., by causing unnaturally high salt concentration in surface soils). Levees have also caused excessive scour of the channel and instability of riparian and aquatic habitats within the leveed channel. In some reaches, native vegetation is being replaced by non-native invasive plants, such as giant reed. This reduces the quality of fish and wildlife habitat, increases sediment deposits, and decreases floodway capacity.

Important habitats provided by the San Joaquin River and its ecological processes include riparian and riverine aquatic habitats; riparian forest; valley oak woodland; perennial grassland; various cropland habitats (e.g., agricultural wetlands and uplands); and migration, holding, spawning, nursery, and emigration habitats for anadromous and resident fish populations.

Important fish, wildlife, and plant species occupying the San Joaquin River Ecological Management Zone and its habitats include steelhead, fall-run chinook salmon, splittail, white sturgeon, green sturgeon, and American shad.

VISION FOR THE ECOLOGICAL MANAGEMENT ZONE

The vision for the San Joaquin River Ecological Management Zone includes restoring important fishery, wildlife, and plant communities and ecological processes to healthy conditions and reducing stressors that inhibit health and limit restoration. This will require reactivating natural ecological processes, including streamflow and natural stream meander, to accomplish most of the restoration. In addition, stressors such as unscreened diversions and levee confinement of the floodplain must be reduced. The vision includes significant improvements in floodplain and stream-channel habitats consistent with flood control, urban, and agricultural development plans in the San Joaquin Valley floodplain.

Throughout the San Joaquin River, restoring a healthy riparian zone and improving stream meander corridor will increase the shaded riverine aquatic (SRA) habitat, the woody debris, and the natural sediment regime (pattern) in the aquatic system.

In the lower part of the zone from the Merced River to Vernalis, restoring the stream meander corridor will benefit upstream and downstream migration of fall-run chinook salmon and steelhead and restore spawning and rearing habitat for American shad, striped bass, white and green sturgeon, and splittail. Reducing losses of fish to water diversions, improving streamflows at critical times of year, reestablishing a functional floodplain and a balanced sediment budget, and improving water quality by reducing input of contaminants to the river will also benefit fish and wildlife.

In the reach from the Merced River confluence to Mendota Pool, emphasis will be on reducing the input of contaminants from westside drainage and reducing straying of fall-run chinook salmon upstream of the confluence with the Merced River.

In the reach from Friant Dam to Gravelly Ford, the vision focuses on maintaining native resident fishes and waterfowl and wildlife habitat by restoring minimum streamflows, stream-channel configuration, and the riparian corridor.

VISIONS FOR ECOLOGICAL MANAGEMENT UNITS

VERNALIS TO MERCED RIVER ECOLOGICAL MANAGEMENT UNIT

The vision for the Vernalis to Merced River Ecological Management Unit would:

- restore the ecological processes needed to support spawning and rearing habitat for American shad, white and green sturgeon, and splittail and the migratory corridor for upstream and downstream migration of fall-run and late-fall-run chinook salmon, steelhead, and resident rainbow trout.
- restore and maintain streamflows that provide habitat and adequate temperature levels for migrating salmon and steelhead and resident native fishes,
- maintain a diverse, self-sustaining riparian zone,
- reestablish a functional floodplain,
- restore a balanced sediment regime,
- reduce entrainment of aquatic resources at water diversions, and
- reduce the input of salt and other contaminants.

Restoring fall-run chinook salmon and steelhead runs in the San Joaquin River basin could contribute significantly to recovery of Central Valley stocks. In the past, natural fall-run spawning escapements in the basin have accounted for as much as 27% of the total natural escapement of fall-run chinook salmon in the Central Valley.

Floodway capacity should be expanded by a combination of:

- levee setbacks,
- levee abandonment where new land use and public ownership justify restoring the floodplain,
- widening and extending the bypass system throughout this reach, and
- establishing a new design floodflow capacity that includes a firm commitment to natural vegetation not subject to maintenance or removal.

These measures are environmentally superior alternatives to rebuilding and riprapping existing banks and levees without modifying the undersized flood-control infrastructure damaged by the 1997 floods.

The vision sets a high priority on connecting fragmented riparian and seasonal floodplain habitat corridors and restoring ecological structures and processes, such as natural channel meanders and unconfined lower floodplains, that promote self-sustaining riparian succession and creation of aquatic habitat. Wildlife refuges and undeveloped historical floodplains that support seasonal wetlands and other natural habitats, but that have inadequate water supplies and high surface salt concentrations, will be flooded by the restored flood cycles from modified flood control system described above.

Instream sand and gravel mining on the major tributaries in this reach should be phased out and replaced by off-channel, high-terrace mines and relocation to other sources. Such sources may include reservoir delta deposits or abandoned floodplain terraces where the channel is unnaturally confined by recent downcutting. Abandoned inchannel pits that cause channel instability and trap fish should be filled, where this is feasible, or modified and restored to create stable habitats and landforms. Revegetation programs and levee and grade modifications should be implemented at abandoned mine pits to provide greater bank cohesion and channel stability and to route low flows away from potential fish entrapments.

Merced River to Mendota Pool Ecological Management Unit

The vision for the Merced River to Mendota Pool Ecological Management Unit would reduce the input of contaminants, which will improve aquatic habitat quality in this unit and downstream in the Vernalis to Merced River Ecological Management Unit and in the Sacramento-San Joaquin Delta Ecological Management Zone. Other parts of the vision are to restore ecological processes that create and sustain the habitats of a diverse, self-sustaining riparian corridor linked with upstream and downstream Ecological Management Units; to reduce the straying of adult fall-run chinook salmon into areas with no suitable spawning habitat; and to improve land management and livestock grazing practices along streams and riparian zones.

Other requirements are to maintain a diverse, self-sustaining riparian habitat zone, to reestablish a functional floodplain, to restore a balanced sediment regime, to reduce entrainment of aquatic resources at water diversions, and to reduce the input of salt and other contaminants.

Floodway capacity should be expanded by a combination of:

- levee setbacks,
- levee abandonment where new land use and public ownership justify restoring the floodplain,
- widening and extension of the bypass system throughout this reach, and
- establishment of new design floodflow capacity that includes a firm commitment to natural vegetation not subject to maintenance or removal.

These measures are environmentally superior alternatives to rebuilding and riprapping existing banks and levees without modifying the undersized flood-control infrastructure damaged by the 1997 floods.

The vision sets a high priority on reconnecting fragmented riparian and seasonal floodplain habitat corridors and restoring ecological structures and processes, such as natural channel meanders and unconfined lower floodplains, that promote self-sustaining riparian succession and the creation of aquatic habitat. Wildlife refuges and undeveloped historical floodplains that support seasonal wetlands and other natural habitats, but that have inadequate water supplies and high surface salt concentrations, will be flooded frequently by the restored flood cycles from the modified flood control system described above.

Mendota Pool to Gravelly Ford Ecological Management Unit

The vision for the Mendota Pool to Gravelly Ford Ecological Management Unit would restore the ecological processes needed to support a diverse, self-sustaining riparian corridor linked with upstream and downstream Ecological Management Units and that does not encroach on the stream channel. The vision would also improve land management and livestock grazing practices along streams and riparian zones.

Instream sand and gravel mining should be phased out and replaced with off-channel, high-terrace mines and relocation to other sources. Such sources may include reservoir delta deposits or abandoned floodplain terraces where the channel is unnaturally confined by recent downcutting. Abandoned inchannel pits that cause channel instability and trap fish should be filled, where feasible, or modified and restored to create stable habitats and landforms. Revegetation programs and levee modifications should be implemented at abandoned mine pits to provide greater bank cohesion and channel stability and to route flows away from potential fish entrapments.

GRAVELLY FORD TO FRIANT DAM ECOLOGICAL MANAGEMENT UNIT

The vision for the Gravelly Ford to Friant Dam Ecological Management Unit would restore a diverse, self-sustaining riparian corridor linked with upstream and downstream Ecological Management Units. The vision would also maintain streamflows for resident native fishes and improve livestock grazing practices along streams and riparian zones.

Instream sand and gravel mining should be phased out and replaced with off-channel, high-terrace mines and relocation to other sources. Such sources may include reservoir delta deposits or abandoned floodplain terraces where the channel is unnaturally confined by recent downcutting. Abandoned inchannel pits that cause channel instability and trap fish should be filled, where feasible, or modified and restored to create stable habitats and landforms. Revegetation programs and levee modifications should be implemented at abandoned mine pits to provide greater bank cohesion and channel stability and to route flows away from potential fish entrapments.

VISIONS FOR ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOWS: Instream flows are inadequate and need to be supplemented where possible, consistent with existing agreements. The vision is that instream flows will be high enough to support the restoration of ecological processes and functions that maintain important fish, wildlife, and plants along with their habitats.

COARSE SEDIMENT SUPPLY: The vision is that existing sources of coarse sediments will be protected and cooperative programs or conservation easements will be developed to reduce the amount of coarse sediments harvested from the active stream channel.

NATURAL FLOODPLAINS AND FLOOD PROCESSES: Natural river-floodplain interaction has been impaired by the construction of dams and levees. Seasonal flooding is needed to promote ecological health and restoration of important species. The vision is that floodplains along the San Joaquin River will be expanded, reconnected to their channels, and seasonally flooded by increased stream flows that will regenerate natural riparian habitat, carry nutrients to the Delta, and create seasonal habitat for splittail spawning and the rearing and emigration of juvenile fish.

STREAM MEANDER: Natural stream meander in the San Joaquin River is constrained by dams, flood-control levees, and altered flow patterns. The vision is to create and maintain any possible meander to sustain habitats similar to those that occurred naturally to provide sediment for the Delta and rearing habitats for chinook salmon and steelhead.

CENTRAL VALLEY STREAM TEMPERATURES: High stream temperatures limit or interrupt the natural life cycle of aquatic organisms. The vision is that water temperatures below major dams will be suitable for maintenance of important aquatic organisms and biological functions such as steelhead rearing and chinook salmon spawning, egg development, and fry and juvenile rearing and emigration.

VISIONS FOR HABITATS

SEASONAL WETLAND HABITAT: The vision is that increased seasonal flooding and enhancement of existing wetlands, and development of cooperative programs with local landowners will contribute to increased habitats for waterfowl and other wetland dependent fish and wildlife resources such as shorebird, wading birds, and the giant garter snake.

RIPARIAN AND RIVERINE AQUATIC HABITATS: Riparian plant communities are important components of a healthy ecosystem and contribute in many ways to sustaining fish and wildlife populations. The vision is to restore diverse self-sustaining riparian and riverine aquatic habitat along the San Joaquin River which will serve as an important migratory corridor to upstream habitats for terrestrial and aquatic species.

FRESHWATER FISH HABITAT: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native fish species. The San Joaquin River is a low elevation, valley floor river (Moyle and Ellison 1991). The quality of freshwater fish habitat in the San Joaquin River will be maintained through actions directed at streamflows, sediment supply, stream meander, natural floodplain and flood processes, maintaining and restoring riparian and riverine aquatic habitats, and reducing the adverse effects of stressors such as contaminants.

AGRICULTURAL LANDS: Improving habitats on and adjacent to agricultural lands in the Butte Basin Ecological Management Zone will benefit native waterfowl and wildlife species. Emphasizing certain agricultural practices (e.g., winter flooding and harvesting methods that leave some grain in the fields) will also benefit many wildlife that seasonally use these important habitats.

VISIONS FOR REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS: The vision for water diversions is that the diversion of water from the lower San Joaquin River will not adversely influence efforts to rebuild fish populations and maintain riparian and riverine aquatic habitats.

LEVEES, BRIDGES, AND BANK PROTECTION: Levees, bridges, and bank protection measures along the San Joaquin River have inhibited overland flow and erosion and depositional processes that develop and maintain the floodplain. The vision is to modify, remove, or reoperate structures in a manner that greatly lessens adverse affects on ecological processes and aquatic organisms.

CONTAMINANTS: The vision is to reduce losses of fish and wildlife due to pesticide, hydrocarbon, heavy metal, and other pollutants.

VISIONS FOR SPECIES

CHINOOK SALMON: The vision for chinook salmon is to recover all stocks presently listed or proposed for listing under ESA or CESA, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that use fully existing and restored habitats. The vision is that improved habitats and flows in the San Joaquin River below the mouth of the Merced River will contribute to the survival of adult and juvenile chinook salmon.

STEELHEAD: The vision for steelhead trout is to recover this species listed as threatened under the ESA and achieve naturally spawning populations of sufficient size to support inland recreational fishing and that use fully existing and restored habitat.

SPLITTAIL: The vision for splittail is to achieve recovery of this federally listed threatened species. The vision is that splittail will have access to seasonally flooded spawning habitat and that their offspring will have unimpaired access to rearing and foraging areas.

WHITE STURGEON: The vision for white sturgeon is to maintain and restore population distribution and abundance to historical levels. Improved flows in late winter and early spring will benefit sturgeon spawning. Improved stream meander corridors should also benefit sturgeon. The vision is that restoration of ecological processes and habitats along with a reduction of stressors will contribute to stable and larger sturgeon populations.

AMERICAN SHAD: The vision for American shad is to maintain a naturally spawning population, consistent with restoring native species, that supports a sport fishery similar to the fishery that existed in the 1960s and 1970s.

LAMPREY: The vision for river lamprey is to maintain the diversity, distribution and abundance of this species.

WESTERN POND TURTLE: The vision for the western pond turtle is to maintain and restore their abundance and distribution by maintaining or expanding existing populations by improving stream channel, floodplain riparian processes, and reducing predator species.

GIANT GARTER SNAKE: The vision for the giant garter snake is to contribute to the recovery of this State and federally listed threatened species in order to contribute to the overall species richness and diversity. Achieving this vision will reduce the conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. Protecting existing and restoring additional suitable wetland and upland habitats will be critical to achieving recovery of the giant garter snake. The proposed restoration of aquatic, wetland, and riparian habitats in the East San Joaquin Ecological

Management Zone will help in the recovery of these species by increasing habitat quality and area.

SWAINSON'S HAWK: The vision for Swainson's hawk is to contribute to the recovery of this State-listed threatened species. Improvements in riparian and agricultural wildlife habitats will aid in the recovery of the Swainson's hawk. Increased abundance and possibly some nesting would be expected as a result of improved habitat.

GREATER SANDHILL CRANE: The vision for the greater sandhill crane is to contribute to the recovery of this California species of special concern. Improvements in pasture lands and seasonally flooded agricultural habitats, such as flooded corn fields, should help toward recovery of the greater sandhill crane population. The population should remain stable or increase with improvements in habitat.

WESTERN YELLOW-BILLED CUCKOO: The vision for the western yellow-billed cuckoo is to contribute to the recovery of this State-listed endangered species. The yellow-billed cuckoo along the San Joaquin River and its tributaries is not a species for which specific restoration projects are proposed. Potential habitat for the cuckoo will be expanded by improvements in riparian habitat areas. These improvements will result from efforts to protect, maintain, and restore riparian and riverine aquatic habitats throughout the San Joaquin River and East San Joaquin Ecological Management Zones, thus sustaining the river meander belt, and increasing the natural sediment supply to support meander and riparian regeneration.

SHOREBIRDS AND WADING BIRDS: The vision for the shorebird and wading bird guilds is to maintain and restore healthy populations through habitat protection and restoration. Shorebirds and wading birds will benefit from restoration of wetland, riparian, aquatic, and agricultural habitats. The extent of seasonal use of the East San Joaquin Ecological Management Zone by these birds should increase.

WATERFOWL: The vision for waterfowl is to maintain and restore healthy populations at levels that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses. Many species of resident and migratory waterfowl will benefit from improved aquatic, wetland, riparian, and agricultural habitats. Increase use of the East San Joaquin Ecological Management Zone and possibly increases in some populations would be expected.

NEOTROPICAL MIGRATORY BIRDS: The vision for the neotropical migratory bird guild is to restore and maintain healthy populations of neotropical migratory birds through restoring habitats on which they depend. Protecting existing and restoring additional suitable wetland, riparian, and grassland habitats will be critical to maintaining healthy neotropical migrant bird populations in the Bay-Delta.

RIPARIAN BRUSH RABBIT: The vision for the riparian brush rabbit is to contribute to the recovery of this federally and State-listed endangered species through improvements in riparian habitat and reintroduction to former habitat.

SAN JOAQUIN VALLEY WOODRAT: The vision for the San Joaquin Valley woodrat is to contribute to the recovery of this federally listed endangered species through improvement in its habitat.

NATIVE RESIDENT FISHES: The vision for native resident fish species is to maintain and restore the distribution and abundance.

PLANT SPECIES AND COMMUNITIES: The vision for plan species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland and riparian and riverine aquatic habitats.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

The Ecosystem Restoration Program (ERP) proposes targets and actions for the San Joaquin River Ecological Management Zone to augment other current and future restoration efforts for the zone.

SAN JOAQUIN RIVER MANAGEMENT PROGRAM

The San Joaquin River Management Program was established through State legislation (Chapter 1068/90) to develop comprehensive and compatible solutions to water supply, water quality, flood control, fisheries, wildlife habitat, and recreational needs in the San Joaquin River basin.

Central Valley Project Improvement Act

Section 3406(c) of the Central Valley Project Improvement Act directed the Secretary of the Interior to develop a comprehensive plan to address fish, wildlife, and habitat concerns on the San Joaquin River. The vision for the San Joaquin River Ecological Management Zone will also complement efforts of the U.S. Fish and Wildlife Service (USFWS) Anadromous Fish Restoration Program. The goal of the program is to double the natural production of anadromous fish in the system over average production during 1967 through 1991.

CALFED Bay-Delta Program

CALFED has funded eight ecosystem restoration projects in the San Joaquin River Ecological Management Zone. One project acquires and restores 6,169 acres of land along the San Joaquin River to be incorporated into the San Joaquin River National Wildlife Refuge. Another project studies the use of bacteria to reduce selenium in agricultural drain water.

Salmon, Steelhead Trout and Anadromous Fisheries Program Act

Established in 1988 by Senate Bill 2261, this Act directs the California DFG to implement measures to double the numbers of salmon and steelhead present in the Central Valley (DFG 1993, 1996). The DFG's salmon and steelhead restoration program includes cooperative efforts with local governments and private landowners to identify problem areas and to assist in obtaining funding for feasibility studies, environmental permitting, and project construction. The ERP vision for this Ecological Management Zone will also assist DFG as it progresses toward its goal of doubling the number of anadromous fish over 1988 population levels.

Sacramento-San Joaquin River Basins Comprehensive Study

This study proposes coordination between the U.S. Army Corps of Engineers (Corps), USFWS, California Department of Water Resources (DWR), and other participating agencies to review and reevaluate the San Joaquin River flood control system in light of the inadequate capacity demonstrated by the 1997 floods, and consistent with floodplain habitat recommendations contained in the 1995 San Joaquin River Management Plan. Emphasis will be placed on managing the floodplain and detaining floodflows to meet safety, infrastructure reliability, and habitat objectives, along with reconstructing and upgrading existing levees.

Agreement on San Joaquin River Protection

In an effort to resolve issues brought forth in the State Water Resources Control Board's 1995 Water Quality Control Plan for the Bay/Delta, the San Joaquin River Tributaries Association, San Joaquin River Exchange Contractors Water Authority, Friant Water Users Authority, and the San Francisco Public Utilities Commission collaborated to identify feasible, voluntary actions to protect the San Joaquin River's fish resources. In spring 1996, these parties agreed on a "Letter of Intent to Resolve San Joaquin River Issues." This agreement, when finalized, has the potential of providing the following:

- higher minimum base flows,
- significantly increased pulse flows,
- installation and operation of a new fish barrier on the mainstem San Joaquin River,
- set up a new biological monitoring program, and
- set aside federal restoration funds to cover costs associated with these measures.

One of the important components of the Agreement is the development of the Vernalis Adaptive Management Program (VAMP) to improve environmental conditions on the San Joaquin River. Elements of this potential adaptive management program include a range of flow and non-flow habitat improvement actions throughout the watershed, and an experimental program designed to collect data needed to develop scientifically sound fishery management options for the future.

The future of the Agreement is unknown at this time. However, several actions by the San Joaquin River Stakeholders Policy Group and other parties have been or are presently being implemented throughout the watershed. These actions include:

- Increased flow from the Tuolumne River, and implementation of non-flow programs through a settlement between the Federal Energy Regulatory Commission and numerous other parties;
- An interim operating plan for the New Melones Project to provide additional flows on the Stanislaus River;
- New fishery response test programs on the Merced River;
- Actions by water users on the Stanislaus and Merced rivers to sell water purchase options that would help meet Central Valley Project Improvement Act objectives;
- Salmon smolt out-migration studies conducted by Oakdale Irrigation District, South San Joaquin Irrigation District, USFS, and DFG on the Stanislaus River;
- A two-year water purchase by USBR from Oakdale Irrigation District and South San Joaquin Irrigation Districts of up to 50,000 acre-feet to help implement fish-doubling objectives of the Central Valley Project Improvement Act; and
- Seasonal installation of a fish barrier at the head of Old River for a five-year period.

SAN JOAQUIN RIVER RIPARIAN HABITAT RESTORATION PROJECT

The San Joaquin River Riparian Habitat Restoration Project is a collaborative effort of the Friant Water Users Authority, the Natural Resources Defense Council, the Pacific Coast Federation of Fishermen's Associations, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, with participation by other local and state interests, who share a strong interest in the mainstem of the San Joaquin River. The group agreed to pursue mutually acceptable restoration activities and initially will focus on riparian habitat restoration along the San Joaquin River from Friant Dam to the confluence with the Merced River. There are many benefits to developing and implementing a riparian restoration plan, including improved flood control, groundwater recharge, and fish and wildlife enhancement. Other projects may be pursued as consensus is reached.

Riparian restoration may take a variety of forms and the project will be developed to ensure that it is consistent with other goals and objectives established for the San Joaquin River. This is a stakeholder driven project that will need the assistance of all the interested parties and the public.

In October 1998, the Program reported an analysis of the affects of physical processes on the potential for riparian habitat on the San Joaquin River from Friant Dam to the confluence of the Merced River. They reported that natural physical processes affecting the river and riparian vegetation included surface and groundwater hydrology, bank and bed erosion and deposition, channel and floodplain hydraulics and sediment transport, and other channel-forming processes. The timing, pattern, and magnitude of these natural physical processes have been altered by local and state flood control projects, operation of reservoir dams and weirs, reclamation of the river floodplain and basin lands for agricultural and urban uses, and mining of sand and gravel from channel deposits.

CENTRAL VALLEY HABITAT JOINT VENTURE

The Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan have developed objectives for wetlands in the San Joaquin River Ecological Management Zone. These objectives are consistent with the ERP targets developed for this Ecological Management Zone.

LINKAGE TO OTHER ECOLOGICAL MANAGEMENT ZONES

Restoring and maintaining important ecological processes and functions in the San Joaquin River Ecological Management Zone depends on conditions in both the main tributaries to the river (the East San Joaquin Basin Ecological Management Zone) and the downstream Sacramento-San Joaquin Delta Ecological Management Zone. Water, sediment, nutrient supply, and input of contaminants from tributary streams all influence habitat conditions in the mainstem San Joaquin River. Changes in these factors from historical conditions have degraded habitat on the mainstem river. Maintaining a healthy riparian zone and balanced sediment budget in the mainstem San Joaquin River will depend on an appropriate input of nutrients, water, and sediment from the major tributaries. Water supply from the tributaries is critical to maintaining aquatic habitat in the mainstem river between the Merced River confluence and Vernalis because Friant Dam diverts almost all the flow from the upper San Joaquin River watershed.

The Sacramento-San Joaquin Delta Ecological Management Zone provides habitat for upstream migration of adult anadromous fish and downstream migration and rearing of juvenile anadromous fish from the San Joaquin River basin. Conditions in the Delta have a significant effect on anadromous fish production in the San Joaquin River basin because, in most years, a significant proportion of inflow from the basin is diverted at the Delta and entrainment losses of juveniles are high. In turn, the volume of inflow and the input of nutrients, contaminants, and sediments from the San Joaquin River significantly affect the health of the Delta ecosystem. Restoring and maintaining a healthy ecosystem in this zone will be critical to ecosystem restoration in the Delta.

Although delta smelt (federally listed as threatened) do not inhabit the San Joaquin River Ecological Management Zone, flows from this zone have significant effects on habitat for the species in the Delta. Delta smelt spawn in different locations in the Delta each year. Some always spawn on the San Joaquin side of the Delta; however, and sometimes hydrologic conditions cause larvae and juveniles to move from the Sacramento to the San Joaquin side. In the 1995 USFWS biological opinion for delta smelt, year-round base flows and April and May flows from the San Joaquin River are specified to protect delta smelt. The biological opinion also states that contaminants entering the Delta from the San Joaquin River likely affect delta smelt and its food organisms, as well as juvenile chinook salmon and striped bass.

Additionally, stressors affecting fish and wildlife species that use the San Joaquin River during at least part of their life cycle occur outside the identified Ecological Management Zones. For example, ocean recreational and commercial fisheries have a significant effect on the numbers of anadromous fish returning to spawn and rear in the San Joaquin River basin. New harvest management strategies for ocean fisheries may be needed in addition to restoration work inland.

RESTORATION TARGETS AND PROGRAMMATIC ACTIONS

ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOWS

TARGET 1: Manage flow releases from tributary streams to provide adequate upstream and downstream passage of fall-run and late-fall-run chinook salmon, resident rainbow trout, and steelhead and spawning and rearing habitat for American shad, splittail, and sturgeon from the Merced River confluence to Vernalis (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to purchase water from willing sellers or develop alternative sources of water.

TARGET 2: Manage flow releases from Friant Dam to Gravelly Ford to maintain sustainable populations of resident native fish (◆◆).

PROGRAMMATIC ACTION 2A: Evaluate the feasibility of increasing flows below Friant to restore terrestrial and aquatic habitats for fish and wildlife including anadromous salmonids.

TARGET 3: Optimize the ecological value of wet year flood releases below Friant Dam (◆◆).

PROGRAMMATIC ACTION 3A: Evaluate the feasibility of modifying flood operation guidelines and schedules in wet years to include more variable hydrographs with higher peak flows of shorter duration and more overall flow variability.

RATIONALE: *Flows in the major eastside tributaries to the San Joaquin River (Stanislaus, Tuolumne, and Merced rivers) are controlled by releases from foothill storage reservoirs (New Melones, New Don Pedro, and New Exchequer reservoirs, respectively). Flows from the mainstem San Joaquin River are controlled by Friant Dam. The significant reduction in outflow from the San Joaquin River caused by water development in the basin has significantly reduced production of chinook salmon in the basin. Increasing base-flow releases from the tributary reservoirs would increase habitat in the mainstem San Joaquin River for rearing and for upstream and downstream migration of fall-run and late-fall-run chinook* *salmon, rainbow trout, and steelhead and for spawning and rearing habitat of American shad, white and green sturgeon, and splittail from the Merced River confluence to Vernalis.*

Escapement of chinook salmon in the San Joaquin River basin appears to be strongly improved by high April through June flows at Vernalis and low exports during the year of outmigration (California Department of Fish and Game 1992, 1993; Carl Mesick Consultants 1994). Based on this relationship, the USFWS (1995) recommended base flows for Vernalis by water-year type to meet the goals of the Anadromous Fish Restoration Program.

Flows from Friant Dam to Gravelly Ford should be managed to maintain native resident fish populations until an evaluation of the potential to restore anadromous salmonids is completed.

Natural stream-meander belts in alluvial systems transport and deposit sediments and provide transient habitats important to algae, aquatic invertebrates, and fish, as well as substrates (surfaces on which plants and animals can live) for colonization by riparian vegetation.

Present flood operations below Friant Dam typically result in uniform flows for long durations during the winter and spring months. Providing a more variable hydrograph which emulated natural inflow patterns to Millerton Lake would increase habitat complexity and diversity, mobilize bar material, and create better seed dispersal and more favorable sites for colonization by riparian species. A particular emphasis should be placed on flow peaks during at least portions of the early spring months when seed of cottonwood and sycamore trees is being dispersed in the river. The purchase of easements or fee title on lands that become subject to greater flood frequency from peak overbank flows could be used to expand the area of low floodplain along the river to be colonized naturally or planted with riparian vegetation (San Joaquin River Riparian Habitat Restoration Program 1998).

COARSE SEDIMENT SUPPLY

TARGET 1: Conserve existing natural sources of coarse sediments below Friant Dam (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative incentive program to relocate gravel mining operations from the active floodplain.

RATIONALE: *Dry Creek enters the river below Friant Dam and is the only remaining tributary that supplies a significant source of coarse sediments with high flows. Bedload entering the river from Dry Creek during high flows reduces the tendency of the channel to incise and forms shifting river deposits on bars that are needed for riparian colonization and succession to occur.*

STREAM MEANDER

TARGET 1: Restore and maintain a defined stream-meander zone on the San Joaquin River between Vernalis and the mouth of the Merced River (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative strategy to acquire or obtain easements on floodplain and riparian land.

PROGRAMMATIC ACTION 1B: Establish a river meander corridor between the Chowchilla Bypass and Mendota Pool.

RATIONALE: *Preserving and improving the stream meander belt below the mouth of the Merced River will ensure that this important natural process is maintained in the San Joaquin River. This reach is important for migrating and rearing salmon and steelhead and other anadromous and resident fish species. A natural meander process will provide excellent habitat for spawning (through gravel recruitment), rearing (channel form, cover, and foodweb), and migration. The stream channel meander program must be consistent with flood control requirements and, in the longer term, should reduce the need for future flood control efforts by using natural system resilience and flood control characteristics.*

The river between Chowchilla Bypass and Mendota Pool has the highest sinuosity and a greater tendency for bank migration, bendway cutoffs, and overbank flow across meander bends. The suggested approach to restoring meander in this section allows river bends to migrate within a designated meander corridor and allows high flows to overtop the large point bars. These alluvial processes will promote the regeneration of riparian vegetation and overall habitat complexity.

NATURAL FLOODPLAIN AND FLOOD PROCESSES

TARGET 1: Restore floodplain-river interactions in the San Joaquin River between Vernalis and the mouth of the Merced River (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate the potential for levee deauthorization, levee removal, or levee setbacks.

PROGRAMMATIC ACTION 1B: Develop a cooperative strategy to acquire or obtain easements or ownership of floodplain along the lower San Joaquin River.

PROGRAMMATIC ACTION 1C: Conserve remaining natural floodplain topography and sloughs.

RATIONALE: *Setback levees will provide more floodplain flooding, room for stream meander, and more riparian forest and seasonal wetland habitats along the lower San Joaquin River. Channel form adjustments may be necessary to accelerate restoration of natural floodplain habitats and to restore and maintain configurations that may not occur naturally due to remaining constraints from the new setback levees. Permanent structures such as bridges and diversions dams can interrupt and impair natural floodplain processes and habitat development and succession, thus requiring removal of the structures, rebuilding, or some continuing maintenance or mitigation to minimize their effects.*

Major flood flows along the San Joaquin River periodically exceed flow capacity within the river levees, causing local and regional flooding. Even lesser flows can result in seepage damage to levees and lands adjacent to the floodway. The U.S. Army Corps of Engineers investigated the potential for a demonstration project for distributing peak flood flows over land on wildlife refuges adjacent to the river. A previous analysis of the West Bear Creek Floodplain Restoration Project was a joint effort by the U.S. Fish and Wildlife Service and the California Department of Water Resources using the San Joaquin Basin Action Plan interagency agreement and the San Joaquin River Management Program funding. Recently, the CALFED Category III restoration program provided funding to the USFWS to conduct a feasibility study for this floodplain restoration program.

Large areas of the historic floodplain still support natural topography and sloughs on both sides of the levee network, while other areas have been laser leveled for irrigated agriculture or managed wetlands. The potential for rewetting the floodplain varies by reach, based on the changes in bankfull channel capacity and the magnitude of the reduction of flow under present hydrology. Many areas would derive ecological benefits from the reintroduction of managed or natural overbank flows, generally within a range of average annual to 10-year frequency inundation (San Joaquin River Riparian Habitat Restoration Program 1998).

CENTRAL VALLEY STREAM TEMPERATURES

TARGET 1: Manage reservoir releases and other factors to provide suitable water temperatures for important resources from the Merced River confluence to Vernalis (◆◆).

PROGRAMMATIC ACTION 1A: Evaluate the feasibility of releasing sufficient instream flows to improve the temperature regime for important resources.

PROGRAMMATIC ACTION 1B: Evaluate the use of upstream temperature control devices and reservoir management options to reduce water temperatures during critical periods.

PROGRAMMATIC ACTION 1C: Develop a cooperative program to evaluate the potential for restoring riparian vegetation to reduce water temperatures.

PROGRAMMATIC ACTION 1D: Develop a cooperative program to evaluate the impact of discharge returns on stream temperature.

RATIONALE: *Water temperatures in the mainstem San Joaquin River between the Merced River confluence and Vernalis in the fall and spring often exceed stressful or lethal levels for upstream and downstream migrating fall-run chinook salmon. High temperatures are thought to delay migration in the fall (DFG 1992) and increase mortality of rearing and outmigrating juveniles in the spring (DFG 1993). When the Vernalis flow is 5,000 cfs or less in May, water temperatures are at levels of chronic* *stress. Maintenance of improved base flows in the fall and spring will increase survival of up and downstream migrating chinook salmon.*

HABITATS

SEASONAL WETLANDS

TARGET 1: Assist in protecting 52,500 acres of existing seasonal wetland habitat through fee acquisition or perpetual easements consistent with the goals of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan (◆◆).

PROGRAMMATIC ACTION 1A: Develop and implement a cooperative program to improve management of 52,500 acres of existing, degraded seasonal wetland habitat.

TARGET 2: Develop and implement a cooperative program to enhance 120,300 acres of existing public and private seasonal wetland habitat consistent with the goals of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan (◆◆).

PROGRAMMATIC ACTION 2A: Improve and manage seasonal wetland habitat throughout the Ecological Management Zone.

RATIONALE: *Restoring seasonal wetland habitats along with aquatic, permanent wetland, and riparian habitats is an essential element of the restoration strategy for the Joaquin Ecological Management Zone. Restoring these habitats will also reduce the amount and concentrations of contaminants that could interfere with restoring the ecological health of the aquatic ecosystem. Seasonal wetlands support a high production rate of primary and secondary food species and large blooms (dense populations) of aquatic invertebrates.*

Wetlands that are dry in summer are also efficient sinks for the transformation of nutrients and the breakdown of pesticides and other contaminants. The roughness of seasonal wetland vegetation filters and traps sediment and organic particulates. Water flowing out from seasonal wetlands is typically high in foodweb prey species concentrations and fine particulate organic matter that feed many Delta aquatic and semiaquatic fish and wildlife. To capitalize on these functions, most of the seasonal wetlands of the San Joaquin Ecological Management Zone should be subject to periodic flooding and overland flow from river floodplains.

RIPARIAN AND RIVERINE AQUATIC HABITATS

TARGET 1: Restore 50 stream miles (1,212 acres) of diverse, self-sustaining riparian community (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to protect large remnant stands of old growth riparian woodlands.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to restore riparian habitat.

PROGRAMMATIC ACTION 1C: Improve land management and livestock grazing practices along streams and riparian zones.

TARGET 2: Revegetate low floodplains formerly cleared for agricultural purposes or during past floodway clearing projects (◆◆).

PROGRAMMATIC ACTION 2A: Identify potential revegetation sites that are subject to inundation at least every 5-10 years.

RATIONALE: *Because of high-flow-event reduction, stream channelization, livestock grazing, gravel extraction, and direct loss of habitat to agriculture and urban development; the extent of riparian vegetation along the mainstem San Joaquin River has been significantly reduced. Before they were disturbed, riparian forests were an important component of the mosaic of habitats in the San Joaquin Valley, providing habitat for a variety of native wildlife species. The riparian community provides nutrients and woody debris to the aquatic system, along with shade and increased bank stability. The importance of restoring riparian habitat has been identified by DFG (1993) and USFWS (1997).*

Old-growth stands of cottonwood forest, sycamore and valley oak woodlands, and wooded grassland savanna are scattered throughout the area. Some of these stands occur within State and federal refuges or parks, while others are found on private lands. Landowners at these sites should be contacted to determine if the old growth sites are secure under existing land management practices or if special conservation easements or management plans are *needed to ensure the long-term survival of these unique relict-age classes and their wildlife habitat and aesthetic values (San Joaquin River Riparian Habitat Restoration Program 1998).*

There are also many sites along the San Joaquin River where low floodplains along the channel are subject to infrequent inundation every 5-10 years. The Corp's comprehensive new hydraulic model of the entire river and bypass system may reveal segments of designated floodways where actual capacity exceed design capacity and can therefore safely convey large flood events, even with an increase in channel roughness. In other instances, forest may have been cleared within a meander corridor for agricultural use, though many sites on agricultural fields appeared in aerial photos to be abandoned. Planted species mixes should conform to the vertical range of cohorts in the general vicinity of the river corridor (San Joaquin River Riparian Habitat Restoration Program 1998).

FRESHWATER FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination (◆◆).

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat is evaluated in terms of its quality and quantity. Actions described for San Joaquin River ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitats. For example, maintaining freshwater fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of the San Joaquin River and its floodplain, and in maintaining and restoring riparian and riverine aquatic habitats.*

AGRICULTURAL LANDS

TARGET 1: Cooperatively enhance 15,290 acres of private agricultural land to support nesting and wintering waterfowl consistent with the objectives of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan (◆◆).

PROGRAMMATIC ACTION 1A: Increase the area of rice fields and other crop lands flooded in winter and spring to provide high-quality foraging habitat for wintering and migrating waterfowl and shorebirds and associated wildlife.

RATIONALE: *Following the extensive loss of native wetland habitats in the Central Valley, some wetland wildlife species have adapted to the artificial wetlands of some agricultural practices and have become dependent on these wetlands to sustain their populations. Agriculturally created wetlands include rice lands; fields flooded for weed and pest control; stubble management; and tailwater circulation ponds.*

Managing agricultural lands to increase forage for waterfowl and other wildlife will increase the survival rates of overwintering wildlife and strengthen them for migration, thus improving breeding success.

Creating small ponds on farms with nearby waterfowl nesting habitat but little brood habitat will increase production of resident waterfowl species when brood ponds are developed and managed properly. Researchers and wetland managers with the DFG, U.S. Fish and Wildlife Service and the California Waterfowl Association have found that well managed brood ponds produce the high levels of invertebrates needed to support brooding waterfowl. Other wildlife such as the giant garter snake will also benefit. Restoring suitable nesting habitat near brood ponds will increase the production of resident waterfowl species.

REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS

TARGET 1: Reduce entrainment of fish and other aquatic organisms into diversions by 50%, by volume, from the Merced River confluence to Vernalis (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative approach to install state-of-the-art fish screens at El Solyo, Patterson, and West Stanislaus Irrigation District diversions.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to evaluate the feasibility of installing state-of-the-art screens on small and medium-sized diversions.

TARGET 2: Eliminate the loss of adult fall-run chinook salmon straying into the San Joaquin River upstream of the Merced River confluence (◆◆◆).

PROGRAMMATIC ACTION 2A: Continue annually installing a temporary weir on the San Joaquin River immediately upstream from the confluence with the Merced River to block adult salmon migration.

RATIONALE: *Three large water diversions are between the Merced River confluence and Vernalis on the mainstem San Joaquin River: El Solyo, West Stanislaus, and Patterson Irrigation District diversions. Fish screens were installed at these diversions in the late 1970s; however, because of the scarcity of returning salmon, the inappropriate design and inefficiency of the screens, and the high cost of maintenance; the screens were abandoned within a few years. Together, these diversions can withdraw a significant portion of the mainstem riverflow, particularly during dry water years. Irrigation diversions take place during the juvenile salmon outmigration. In addition, many, small or medium-sized diversions are on this reach of the San Joaquin River.*

In recent years, drainage practices in western Merced County have increased agricultural return flows from Salt and Mud Sloughs into the mainstem San Joaquin River. These flows attract significant numbers of adult salmon into the sloughs and, subsequently, into irrigation canals where no spawning habitat is available (DFG 1993). In fall 1991, 31% of the run in the San Joaquin River basin is estimated to have strayed into westside canals. In the late 1980s, DFG established an adult trapping station at Los Banos Wildlife Refuge at which eggs were taken for rearing at the Merced River Fish Facility. In fall 1992, DFG installed a temporary electrical barrier across the mainstem San Joaquin River immediately upstream from the confluence with the Merced River; this was extremely effective in blocking fish passage into the westside irrigation canals. Since then, a temporary weir has been installed at the site annually, and this has also been effective in blocking passage.

LEVEES, BRIDGES, AND BANK PROTECTION

TARGET 1: Set back 10 miles of levees along the San Joaquin River between the Merced River confluence and Vernalis where feasible to reestablish the hydrologic connectivity between these channels and natural floodplains (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative strategy to evaluate the potential for levee deauthorization or relocation.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to acquire or obtain easements on floodplain and riparian land needed to meet restoration goals.

RATIONALE: *Natural stream meander belts in alluvial systems function to transport and deposit sediments and provide transient habitats important to algae, aquatic invertebrates, and fish, as well as providing substrates for colonization by riparian vegetation. Setting back levees along the San Joaquin River encourages natural stream meander and flooding processes.*

This measure includes removing site-specific local levees or deauthorizing unneeded segments of state levees to expand the area of flood basin and floodplain inundation. Additional information is needed to make these determinations. Each site-specific project will require a subreach hydraulic model and sediment transport analysis to evaluate the feasibility of breaching or removing levees or constructing controlled release weirs to restore periodic inundation of the flood basin and rewater formerly abandoned channels outside existing levees (San Joaquin River Riparian Habitat Restoration Program 1998).

INVASIVE RIPARIAN PLANTS

TARGET 1: Eradicate or suppress populations of exotic, invasive trees and shrubs (◆◆).

PROGRAMMATIC ACTION 1A: Evaluate and implement effective new techniques to control invasive plant species that combine low-impact, mechanical removal or prescribed fire with low concentrations of selective herbicides.

RATIONALE: *Expansions of giant reed (Arundo), tamarisk, and eucalyptus in some river segments threatens riparian habitat diversity and quality. Because of their growth characteristics, expansion of these invasive, non-native species will reduce channel floodway capacity and increase bank stability. The recommended action would involve a program to map and monitor the distribution of these harmful* *species. In vulnerable subreaches of the San Joaquin River with small, developing populations immediate eradication by be a cost effective strategy (San Joaquin River Riparian Habitat Restoration Program 1998).*

CONTAMINANTS

TARGET 1: Reduce losses of fish and wildlife from use of pesticides, hydrocarbons, heavy metals, and other pollutants in the basin (◆◆).

PROGRAMMATIC ACTION 1A: Provide additional funding to enforce State laws regarding point- and nonpoint-source pollution.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to strengthen water quality standards as needed.

PROGRAMMATIC ACTION 1C: Work with local landowners and State and federal agencies to improve land management practices to reduce contaminant input.

PROGRAMMATIC ACTION 1D: Evaluate the use of real-time releases from tile drainage.

TARGET 2: Reduce sediment sources entering the river and bypass system (◆◆).

PROGRAMMATIC ACTION 2A: Conduct an hydraulic analysis of the stability of bypasses.

PROGRAMMATIC ACTION 2B: Cooperatively develop streambed and bank protection and erosion control management alternatives to reduce sources of sediment.

RATIONALE: *Poor water quality resulting from point- and nonpoint-source discharge of toxic chemicals and other pollutants may affect anadromous fish survival in the San Joaquin River basin. Drainage practices in western Merced County result in highly saline and pollution-laden agricultural return flows from Salt and Mud Sloughs into the mainstem San Joaquin River above the confluence with the Merced River. Contaminant input from this area also affects water quality in the downstream Sacramento-San Joaquin Delta Ecological Management Zone.*

Sediment deposition within the mainstem San Joaquin River and its bypasses is a recognized problem. The potential for aggradation of sand in the river bed is a serious constraint to revegetation of riparian habitat in some river segments. Much of the problem sediments appears to originate from erosive processes within the bypasses and some of the eastside tributaries. Therefore the reduction of the sediment problem requires solution of the erosion occurring within the bypasses and eastside tributaries (San Joaquin River Riparian Restoration Program 1998).

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◆ EAST SAN JOAQUIN BASIN ECOLOGICAL MANAGEMENT ZONE

INTRODUCTION

The East San Joaquin Basin Ecological Management Zone includes the lower Stanislaus, Tuolumne, and Merced rivers. These rivers support Sacramento-San Joaquin Delta health by supplying freshwater inflow, sediments, nutrients, and seasonal habitats for Delta species, especially fall-run chinook salmon, steelhead, waterfowl (including the endangered Aleutian Canada goose), riparian brush rabbit, Swainson's hawk, giant garter snake, and western pond turtle. The overall health of the Delta depends on habitat quality and quantity in this zone and the health of its fish, wildlife, and plant populations.

Important ecological processes that would maintain or increase the health of the East San Joaquin Basin Ecological Management Zone are:

- streamflow,
- stream meander,
- floodplain processes,
- coarse sediment supply including gravel recruitment, transport, and cleansing, and
- water temperature.

Riparian and riverine aquatic is an important habitat within zone and has close links to wetlands areas. Caswell Memorial State Park is the best example of remaining Great Valley riparian habitat in the San Joaquin Valley (with the exception of the Cosumnes River Preserve in the Eastside Delta Tributaries Ecological Management Zone). Seasonally flooded wetlands are common through the lower portions of the basin and are important habitats for waterfowl, shorebird, and wading bird guilds. Important aquatic habitat designations include freshwater fish habitat and essential fish habitat.

Important species include fall-run chinook salmon, steelhead trout, native resident fishes, waterfowl guilds, shorebird and wading bird guilds, and riparian wildlife guilds.

Stressors include:

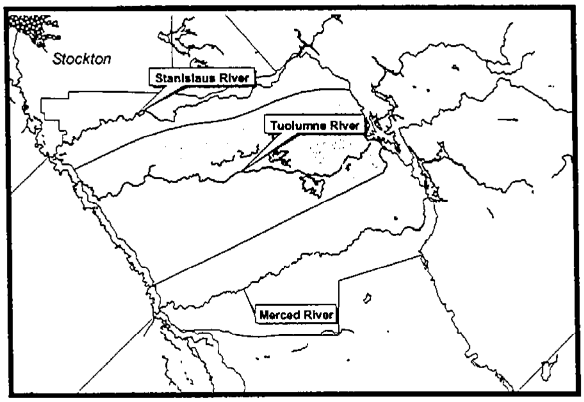
- dams that hinder or block fish migration,
- legal and illegal fish harvest,
- water diversions that result in insufficient flow in the lower portions of most streams,
- high water temperature during salmon and steelhead spawning and rearing,
- poor water quality,
- hatchery stocking of salmon and steelhead,
- gravel mining in the stream channel,
- poor livestock grazing practices,
- high predation levels on juvenile salmon by non-native fish,
- salmon and steelhead harvest,
- and unscreened or poorly screened water diversions.

These stressors have reduced the health of fish wildlife, and plant populations in the zone. Fall-run chinook salmon populations are generally unhealthy because of poor habitat conditions within the zone, entrainment at the Delta pumping plants, and potentially high ocean harvest rates. The status of steelhead in the zone is unknown and will require more focused research to determine specific restoration actions that need to be implemented to improve conditions for its recovery. Wildlife populations are adversely affected by loss of riparian and wetland habitats and the ecological functions that maintain them.

Description of the Management Zone

The East San Joaquin Basin Ecological Management Zone includes the three major eastside tributaries to the San Joaquin River and consists of the following Ecological Management Units:

- Stanislaus River Ecological Management Unit,
- Tuolumne River Ecological Management Unit, and
- Merced River Ecological Management Unit.



Location Map of the East San Joaquin Ecological Management Zone and Unit.

The Stanislaus, Tuolumne, and Merced rivers flow through extensive and biologically valuable grassland/vernal pool complexes located in eastern Stanislaus and Merced counties. Two important National Wildlife Refuges are located in this zone: Merced NWR and San Joaquin NWR. In addition to the larger ecological values, these units also provide habitat for many fish, wildlife, and plant species. They are particularly important as spawning and rearing areas for chinook salmon.

List of Species to Benefit from Restoration Actions in the East San Joaquin Ecological Management Zone

- chinook salmon
- steelhead trout
- giant garter snake
- Swainson's hawk
- greater sandhill crane
- western yellow-billed cuckoo
- riparian brush rabbit
- San Joaquin Valley woodrat
- shorebirds
- wading birds
- waterfowl
- neotropical migratory birds
- native resident fishes
- lamprey
- plants and plant communities.

Description of Ecological Management Units

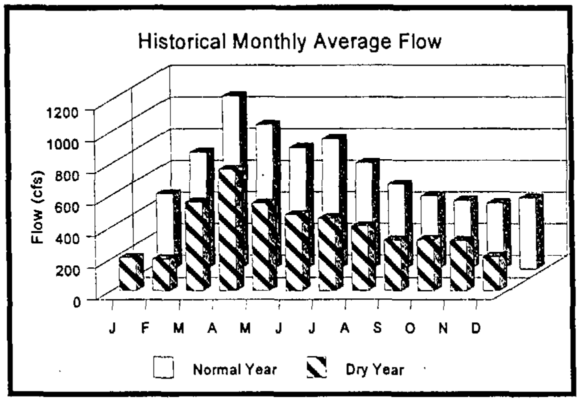
Stanislaus River Ecological Management Unit

The Stanislaus River is the northernmost major tributary in the San Joaquin River basin. The river flows westward into the Central Valley, draining approximately 1,100 square miles in the Sierra Nevada. The average unimpaired runoff in the basin is about 1.2 million acre-feet (af).

Significant changes have been made in the hydrological conditions of the basin since agricultural development began in the 1850s. New Melones Dam, completed by the U.S. Army Corps of Engineers (Corps) in 1978 and approved for filling in 1981, is now the largest storage reservoir in the Stanislaus basin, with a gross capacity of 2.4 million af. The project is operated by the U.S. Bureau of Reclamation (Reclamation) as part of the federal Central Valley Project (CVP). Downstream of the New Melones Dam, Tulloch Reservoir, with a gross storage capacity of 68,400 af, regulates water releases from the New Melones Dam. Goodwin Dam, downstream, regulates releases from Tulloch Reservoir and diverts water for power and irrigation to South San Joaquin Irrigation District and Oakdale Irrigation District.

Monthly unimpaired flows at New Melones (900-square-mile watershed) average approximately 1,600 cubic feet per second (cfs), with highest runoff in the rainfall months of December through March and in the snowmelt months of April, May, and June. This pattern is typical of San Joaquin basin streams originating from the high Sierra. During dry years, inflows are 500 to 1,800 cfs from February through June, whereas summer inflows are less than 50 cfs from August through October. In driest years, inflows are less than 50 cfs from July through February but still reach peaks near 1,500 cfs in April and May. In highest rainfall years, average monthly inflows are 6,000 to 11,000 cfs from February through June, and 600 to 1,400 cfs from August through October.

Monthly historical average flow at Ripon (near the mouth of the Stanislaus River) is approximately 950 cfs and is more uniformly distributed throughout the year than unimpaired flow at New Melones Dam. In dry years, monthly average flows vary between 200 cfs and 500 cfs, except for a small increase to 750 cfs in April. Normal year flows range from 400 cfs to 1,100 cfs, with a peak in April and lowest flows from September through January. In driest years, flows vary from 200 cfs to 400 cfs. In highest precipitation years, flows are similar to unimpaired flows, ranging from monthly averages of 2,000 to 5,000 cfs, with peaks in March and April.



Stanislaus River Streamflow at Ripon (Highway 99), 1981-1991 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Although considerable flow is diverted for irrigation upstream of Ripon, much of the water released from New Melones is used for water quality control in the San Joaquin River at Vernalis during the irrigation season and is diverted at south Delta pumping plants. Fall minimum flows and spring flow pulses are prescribed to sustain fall-run salmon.

Interim flow releases for fishery purposes in the lower Stanislaus River were designated in a 1987 agreement between Reclamation and the California Department of Fish and Game (DFG). This agreement, enacted under a DFG protest of Reclamation's water right applications to redivert water from New Melones Dam, specified interim annual flow allocations for fisheries between 98,300 af and 302,100 af, depending primarily on the carryover storage at New Melones and inflow. Under the agreement, a 7-year cooperative study program was established to evaluate flows in the lower Stanislaus River.

In addition to flow allocations for fisheries, 70,000 af is a minimum annual allocation for water quality purposes. To meet Delta water quality standards, Reclamation commonly releases additional water over the 70,000-acre-foot requirement. In recent years, coordinating fishery and water quality flow releases and releases for water sales and transfers have resulted in schedules that significantly benefit anadromous fish.

Flows needed for fall-run chinook salmon smolt (the life stage at which salmon are ready for saltwater), emigration, in particular, can be adequately met in drier years with the present annual flow allocations. The results of IFIM and water temperature model for the Stanislaus River indicates that about 99,000 acre-feet can provide suitable conditions between October 16 and June 7 for chinook salmon. There is a positive relationship between spring outflow at Vernalis on the San Joaquin River and at Ripon on the Stanislaus River to the number of adults reaching the river 2½ years later. Smolt survival studies have not been completed for the Stanislaus River and the existing data do not indicate that higher flows would improve smolt survival. Three survival tests have conducted at a range of flow releases between 800 and 1,200 cfs in the Stanislaus River and no obvious relationship between flow and smolt survival resulted from these tests. On the other hand, flow releases made since the 1987 Reclamation and DFG agreement have been substantially greater than those made during the 1967-1991 and yet the chinook salmon population did not rebound.

DFG has developed flow recommendations for the Stanislaus River (California Department of Fish and Game 1993). Recommended flows for the October 1 through March 31 period were based on results of the instream flow study for salmon spawning, egg incubation, and rearing. Flows during April 1 through May 31 for late rearing and smolt emigration were based on results of the smolt survival studies. These flows for the lower Stanislaus River are consistent with spring outflow objectives proposed for the basin at Vernalis on the San Joaquin River. Summer flow recommendations incorporate the needs of oversummering yearling salmon and steelhead. The recommended flows represent the minimum needed for salmon spawning, rearing, and emigration on the lower Stanislaus River. These flows would represent a significant improvement over existing required stream releases but are not optimum flows, particularly in drier water years. The U.S. Fish and Wildlife Service (USFWS 1995) recommended similar flows to double anadromous fish production in the basin.

Water temperature in the Stanislaus River is influenced by ambient air temperatures, late summer storage levels and thermocline development at New Melones Reservoir, the depth of diversions from New Melones Reservoir, and Tulloch Reservoir temperatures and operations.

Fall flow releases to the lower Stanislaus River sometimes exceed critical temperatures for salmon spawning and egg incubation when storage levels at New Melones Reservoir are low. Elevated water temperatures are a problem in critically dry water years, a problem exacerbated by low reservoir storage and the presence of the Old Melones Dam in the reservoir which restricts access to the remaining cold water pool. During the 1987 through 1992 drought, the first fish entering the river to spawn did not arrive until early November, rather than in October, because of low water and high water temperatures. Elevated water temperatures were the major cause of the delay. With such a delay in spawning, juvenile fish are not ready to emigrate until later in spring when high water temperatures again occur in the river and in the mainstem San Joaquin River.

Delayed spawning also reduces survival of eggs in gravel, the number of fry rearing in the river, and the number of young salmon traveling to and through the Delta to San Francisco Bay and the Pacific Ocean. Egg mortality has been shown to increase when temperatures exceed 56°F. When storage levels at New Melones are low, water temperature exceeds 56°F in much of the salmon spawning reach until ambient air temperatures cool the river during November. Water temperatures above 65°F are stressful to juvenile salmon.

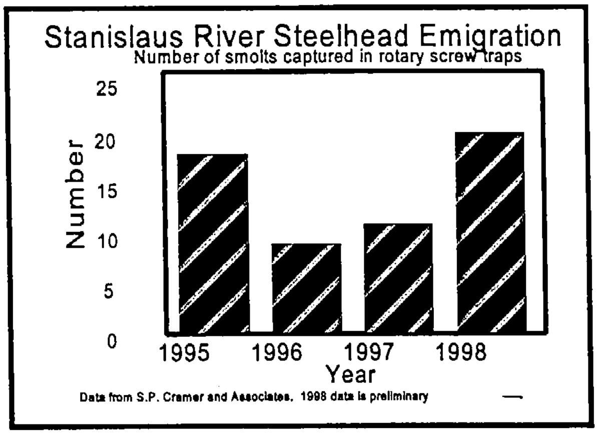
Forty-four small pump diversions have been identified on the lower Stanislaus River, none of which are adequately screened to prevent entrainment (carrying into the diversion) of juvenile salmon and other aquatic organisms. Although losses at these diversions are unknown, the diversions are considered a serious threat to these populations.

Goodwin Dam, located approximately 15 miles downstream of New Melones Dam, is the upstream barrier for steelhead and salmon migration. Spawning occurs in the 23-mile reach downstream of Goodwin Dam (California Department of Fish and Game 1993) and juvenile chinook salmon and steelhead rear in the entire lower river. Historically, the river supported steelhead and spring- and fall-run chinook salmon. The river now supports fall-run chinook salmon and steelhead and perhaps late-fall-run chinook.

Substantial evidence exists to show that there is an extant self-sustaining steelhead run in the Stanislaus River. Since 1995, a small, but consistent, number of juvenile steelhead that exhibit smolt characteristics have been captured in rotary screw traps at two chinook salmon monitoring sites on the lower river (Demko and Cramer 1997; 1998). These fish do not appear to be the result of straying of juvenile hatchery steelhead planted in the Mokelumne River because none of the smolts captured in the screw traps in 1988 were adipose-fin clipped (1997 was the first year of 100% marking of hatchery steelhead at Mokelumne River Hatchery). The presence, over multiple years, of juvenile steelhead that have undergone smoltification and are actively migrating to the ocean is sufficient evidence to conclude that natural production is occurring and a self-sustaining population exists. We note that this is the opinion of the Department of Fish and Game (CDFG 1997) and the Steelhead Project Workteam of the Interagency Ecological Program (IEP Steelhead Project Workteam 1999) as well. Other evidence that a self-sustaining run exists includes:

- CDFG fishery biologists have documented successful reproduction (in the form of juvenile emigrants) in the lower San Joaquin River since 1987 (CDFG 1997).
- Anglers in the Oakdale area report occasional steelhead from 2 to 10 pounds and CDFG creel census information documents the catch of rainbow trout greater than 20 inches (CDFG unpublished data). Examination of scale samples from these larger trout by CDFG biologists show an accelerated growth period typical of estuary or ocean residence (CDFG unpublished data).

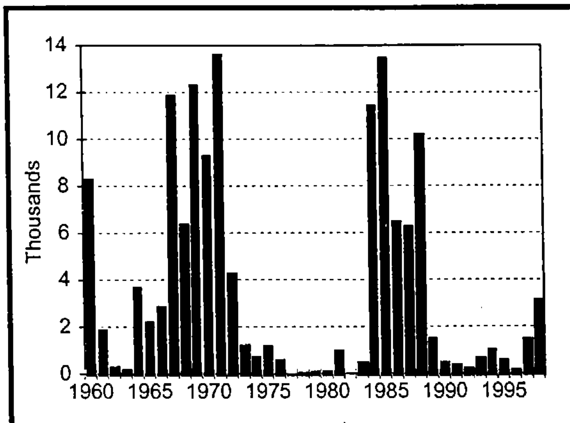
- A 28-inch steelhead illegally harvested from the Stanislaus River was confiscated by CDFG wardens in 1995.



Recent genetic analysis by the National Marine Fisheries Service of Stanislaus River rainbow trout/steelhead collected from the anadromous reach below Goodwin Dam show that this population has close genetic affinities to upper Sacramento River steelhead (NMFS 1997). Further, this Central Valley group forms a genetic group that is distinct from all other samples of steelhead analyzed (132 samples from Washington, Oregon, Idaho, and California) (Busby et al. 1996), hence may be representative of native Central Valley steelhead.

This analysis also provides further evidence that Stanislaus River steelhead are not derived from adults straying from Mokelumne River Hatchery. The analysis showed that steelhead from Nimbus Hatchery on the American River are more closely related to coastal steelhead, which accurately reflects the founding history of Nimbus Hatchery steelhead (Nimbus broodstock was founded from Eel River steelhead eggs). Mokelumne River Hatchery, which rears steelhead from eggs obtained every year from Nimbus Hatchery, is the nearest steelhead hatchery population in proximity to the Stanislaus River, therefore if the Stanislaus River steelhead population is derived from Mokelumne River Hatchery strays, then this population would show close genetic affinities to Nimbus Hatchery steelhead and other coastal steelhead populations.

As in other tributaries in the basin, fall-run chinook spawning escapements (fish that survive migration and spawn) in the lower Stanislaus River have varied considerably since surveys were initiated in 1939. In recent years, spawning escapements have declined to very low levels. In the falls of 1991 and 1992, fewer than 300 salmon returned to spawn in the lower Stanislaus, compared to a recent historic high of 35,000 fish in 1953. Peak runs in the past 30 years have generally followed a series of high rainfall years. Poor runs occur during and following droughts.



Fall-run Chinook Salmon Returns to the Stanislaus River, 1960-1999 (CDFG 1999).

Physical habitat for salmon and steelhead spawning and rearing on the lower Stanislaus River has been lost or degraded because of low instream flow releases. A variety of factors, including low flows, have cumulatively resulted in degradation of spawning gravel, loss of side channels and channel diversity, and reduced spawning gravel recruitment to the active stream channel. Siltation of spawning gravel is primarily caused by watershed disturbance. Existing fine sediments in the lower system may be a result of the intensive hydraulic mining that occurred in the mid-1800s, particularly near the town of Columbia. This problem can best be corrected by minimizing erosion in the watershed and by routinely adding clean gravel to the active channel. The loss of side channels and channel diversity was probably caused by road construction, instream gravel mining, armoring of streambanks by landowners, and by the current practice of removing woody debris from the active channel to protect rafters. Upstream dams and the practice of in-channel gravel mining have removed spawning gravel, altered the migration corridor, and created salmon predator habitat.

Habitat improvement opportunities for chinook salmon in the San Joaquin basin, including the lower Stanislaus River, have been assessed through a DFG-funded study. Projects identified include gravel renovation projects, channel modifications to create new spawning riffles, channel modifications to isolate existing excavated areas from the active river channel to reduce predation and improve the migration corridor, and riparian vegetation restoration.

Recovery options for steelhead in the Stanislaus River have not been assessed, but, as with other regulated rivers in the Central Valley, recovery measures will focus on providing access to historical habitats and/or maintaining adequate water temperatures below dams for oversummer rearing of juveniles. These issues will need to be addressed. The canyon reach between Knights Ferry and Goodwin Dam contains the highest quality habitat for steelhead, and there is a substantial, self-sustaining "wild trout" population in this reach. Juvenile steelhead probably utilize the entire reach between Goodwin Dam and Riverbank for rearing. Water temperatures of 60° F or less should be maintained during the summer months in this reach to provide the necessary conditions for rearing.

The remnant population of riparian brush rabbit is restricted to 198 acres of native riparian forest along the Stanislaus River in Caswell Memorial State Park. A population census following the January 1997 flood indicates that this species is close to extinction.

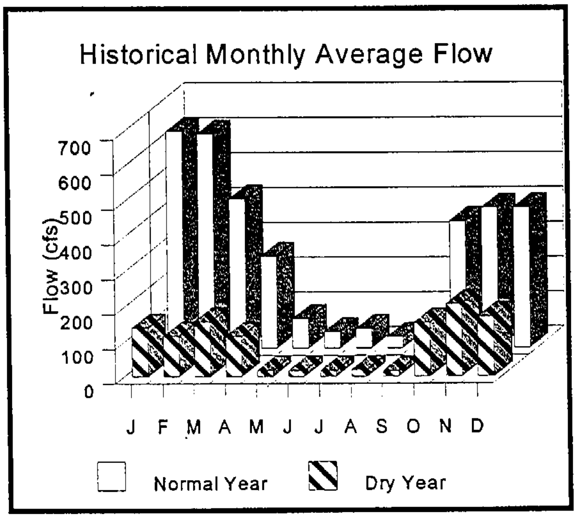
TUOLUMNE RIVER ECOLOGICAL MANAGEMENT UNIT

The Tuolumne River is the largest tributary in the San Joaquin River basin, with an average annual runoff of 1.95 million af and a drainage area of approximately 1,900 square miles, including the northern half of Yosemite National Park. The lower Tuolumne River below La Grange Dam is divided into two geomorphic zones based largely on channel slope and bedload material (McBain & Trush 1998). The lowermost area, the sand-bedded zone, extends from the mouth upstream for 24 miles. The upper area, the gravel-bedded zone, extends from river miles 24 to 52.

Hetch Hetchy Reservoir (located in Yosemite) was constructed by the City and County of San Francisco in 1923 for drinking water supply, with a capacity of approximately 360,000 af. Cherry Lake (capacity 260,000 af) was completed in 1953 to increase the aqueduct yield to the maximum of approximately 300 cfs (220,000 af per year) currently exported in the Hetch-Hetchy aqueduct to San Francisco. The Modesto and Turlock Irrigation Districts jointly regulate the flow to the lower river from New Don Pedro Reservoir, with a gross storage capacity of 2.03 million af. The reservoir, completed in 1970, provides power, irrigation, and flood control protection. LaGrange Dam, located downstream from New Don Pedro Dam, diverts approximately 900,000 af per year for power, irrigation, and domestic purposes.

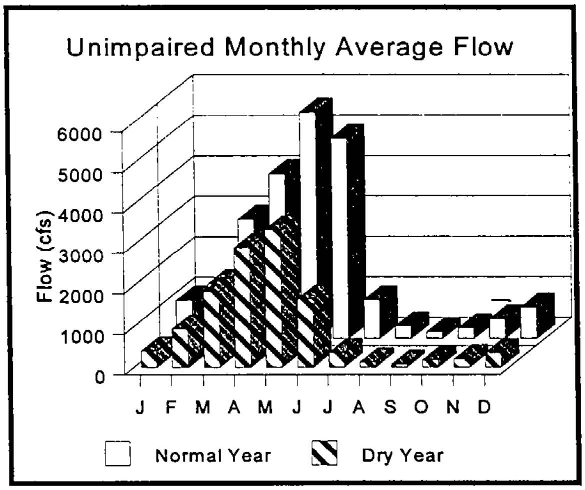
Streamflow in the Tuolumne River is typical of southern Sierra streams originating from the high mountains. Monthly unimpaired flows at New Don Pedro Dam average approximately 2,500 cfs, with peak runoff as snowmelt from April through July. Rainfall can cause substantial runoff from November through March. In highest rainfall years, average monthly inflows range from 10,000 to 18,000 cfs from February through July, 5,000 to 9,000 cfs from November through January, and 1,500 to 3,500 cfs from August through October. In driest years, April and May average monthly inflows peak at only 1,500 cfs, with August through October flows of only 15-30 cfs.

The average historical flow at La Grange near the river mouth is approximately 880 cfs, with most of this flow occurring during winter periods when storms cause reservoir flood control releases in all but low rainfall years. In highest rainfall years, monthly average flows peak in April and May at 8,000 to 10,000 cfs, with summer and fall flows of 900 to 4,000 cfs. Summer flows range from less than 10 cfs



Tuolumne River Streamflow at LaGrange, 1972-1992
(Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

to 50 cfs in all but wet years. Irrigation return flows along the lower Tuolumne increase summer flows near Modesto to approximately 100 cfs. Flows in dry and normal years generally peak in January to March at 150 to 600 cfs and are minimum in June to September at 10 to 50 cfs.



Tuolumne River Unimpaired Streamflow at Don Pedro Reservoir, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th or median percentile year.)

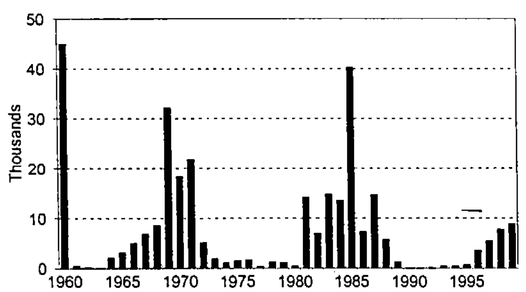
Streamflow strongly influences chinook salmon production in the Tuolumne River. Flow requirements for the lower Tuolumne River are specified in the New Don Pedro Proceeding Settlement Agreement (February 1996) and the Federal Energy Regulatory Commission (FERC) Order Amending License for the New Don Pedro Project (July 1996). USFWS (1995) recommended an alternative flow schedule to achieve the goals of the Anadromous Fish Restoration Program (AFRP).

Low flows can lead to poor water quality, which can delay spawning, decrease egg survival, and cause high juvenile mortality during the spring emigration period. Results of the stream temperature modeling study on the lower Tuolumne River indicate that in recent years, temperature limits for salmon spawning were commonly exceeded in a portion of the spawning reach in October. This contributed to delayed upstream migration and spawning. In recent drought years, the first fish have returned to spawn in the lower Tuolumne River in early November, rather than in October as in previous years, because high water temperatures blocked their upstream migration. As with the other San Joaquin basin tributaries, high water temperatures on the lower Tuolumne River during the spring emigration period may be a significant factor affecting smolt survival. Results of the stream temperature modeling study indicate that in May, and at times in late April, smolts emigrating from the Tuolumne River encounter stressful or lethal water temperatures. Temperature was a consideration in formulating the FERC and AFRP revised flow schedules. However, these new schedules will not ease temperature problems under all ambient conditions, especially in the lower portion of the river during low flows.

LaGrange Dam is the upstream barrier to salmon and steelhead migration. Salmon spawn in the 25-mile reach between LaGrange Dam and the town of Waterford and rear in the entire lower river. Historically, the river supported spring- and fall-run chinook salmon and steelhead trout. A total of 66 adult steelhead was counted at Dennett Dam near the City of Modesto in 1940. Other historical information and the presence of spring-run chinook salmon also provide ample evidence of a steelhead run in the Tuolumne River (Yoshiyama et al. 1996; CDFG 1997)

The river now supports fall-run chinook salmon and steelhead and perhaps late-fall-run chinook salmon. The presence of distinct anadromous runs of late-fall-run chinook salmon is not confirmed. Evidence of natural production (observations of young-of-the-year rainbow trout), creel census information, and anecdotal observations of adult steelhead by anglers, provides some evidence that a steelhead population persists in the Tuolumne River (CDFG 1997). Because there has been no focused effort to assess the steelhead population in the Tuolumne River, and there is essentially no indirect or bycatch information from other monitoring programs on which to estimate a probability of extinction, there is no information available to conclude that steelhead are extirpated from the Tuolumne River. This fact, and the anecdotal information and observations cited above, have led CDFG to conclude that a remnant steelhead population still exists in the Tuolumne River (CDFG 1997).

As in the other basin tributaries, fall-run spawning escapements in the lower Tuolumne River have varied substantially. Population fluctuations are the result of extreme variations in environmental conditions in the river, Bay-Delta, and ocean. Since surveys were initiated, the Tuolumne River, on average, has supported the highest spawning escapements (fish that survive migration and spawn) among the San Joaquin basin tributaries. During the 1987 through 1992 drought, chinook salmon spawning runs in the lower Tuolumne River declined drastically. In the falls of 1991 and 1992, fewer than 300 adults returned to spawn, as compared to a recent peak of 40,000 in 1985 and an earlier estimate of 130,000 in 1944.



Fall-run Chinook Salmon Returns to the Tuolumne River, 1960-1999 (CDFG 1999).

The San Joaquin NWR (780 acres) is located at the confluence of the San Joaquin and Tuolumne rivers. This refuge provides important riparian and seasonal wetland habitats for Aleutian Canada goose, greater sandhill crane, western yellow-billed cuckoo, waterfowl, shorebirds, and neotropical migrant birds.

Chinook salmon smolt survival studies completed thus far on the lower Tuolumne River indicate that adequate spring flows improve smolt survival. Smolt appears to be the critical bottleneck in the life cycle, because smolt production determines adult run size. Unnaturally high summer flows in the salmon spawning and rearing areas below the dams from storage releases for irrigation sustains large populations of predatory fish. These predators are then present in other months and can cause significant young salmon losses.

Steelhead and chinook salmon spawning and rearing habitat has been degraded because of low instream flow releases, which resulted in siltation of spawning gravel, and lack of spawning gravel recruitment. EA Engineering (1992) examined the distribution and abundance of chinook spawning habitat and concluded that spawning habitat was a significant factor limiting salmon production in the Tuolumne River. In addition, the study suggested that lack of gravel supply, combined with Tuolumne fall-run chinook's preference to spawn in the upper reach, led to substantial superimposition of redds, with this being a major cause of chinook mortality.

In major portions of the spawning reach and below, riparian vegetation has been removed because of agricultural development, cattle grazing, urban development, and gravel mining. Gravel mining in the active stream channel has removed gravel from long stretches of the spawning reach. In roughly half of the spawning reach, extensive mining has left long, deep pools and a widened channel. These pools provide habitat for salmon predators, such as largemouth and smallmouth bass, and contribute to warming the river. The 1992 EA Engineering study also revealed that these introduced bass species may be a dominant cause of juvenile chinook mortality, especially under low flow conditions in the Tuolumne River. The highest densities of predatory fish were observed in former in-channel gravel extraction pits.

Thirty-six small irrigation pump diversions have been identified on the lower Tuolumne River; none are screened. Juvenile salmon losses at these sites are unknown, but cumulatively, they may cause a measurable loss of young salmon and steelhead.

Illegal harvest of upstream migrating chinook salmon has been identified as a factor limiting production in the basin. With many miles of migratory habitat that are often under low-flow conditions, salmon are particularly vulnerable to poaching.

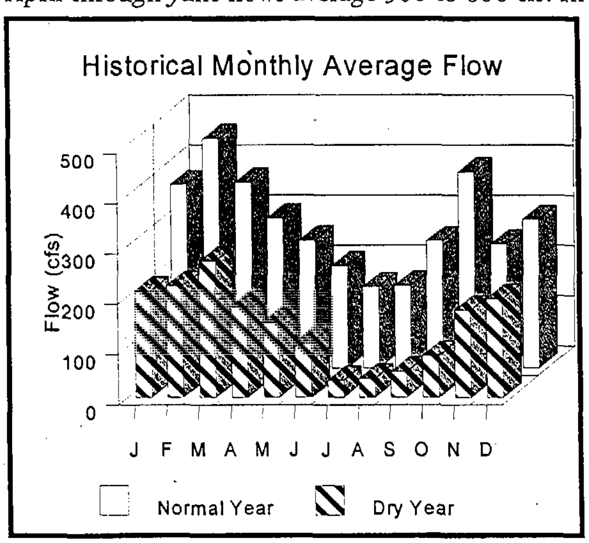
Steelhead recovery options for the Tuolumne River have not been addressed by the management agencies. However, the ESA listing of steelhead populations in the San Joaquin tributaries will necessitate that options be identified and implemented. As with other regulated rivers in the Central Valley, recovery measures will need to focus on providing access to historical habitats and/or maintaining adequate water temperatures below dams for oversummer rearing of juveniles. These issues will need to be addressed in future recovery planning.

MERCED RIVER ECOLOGICAL MANAGEMENT UNIT

The Merced River is the southernmost stream used by chinook salmon in the San Joaquin River basin and in California. The river flows westward into the valley, draining approximately 1,275 square miles in the Sierra Nevada mountains and foothills, including the southern half of Yosemite National Park The average unimpaired runoff in the basin is approximately 1.02 million af, similar to the Stanislaus River drainage.

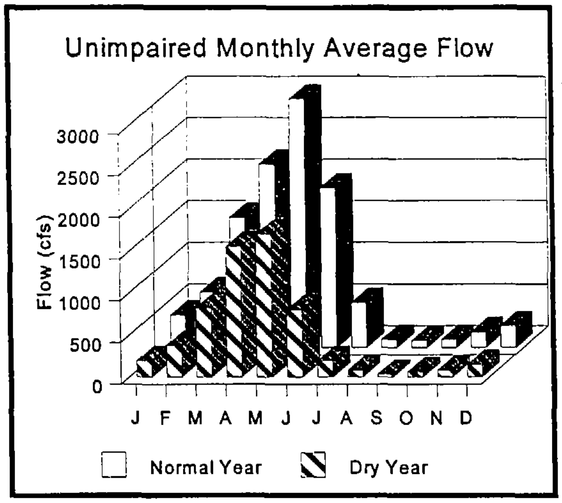
Agricultural development began in the 1850s, and significant changes have been made to the hydrologic (water circulation) system since that time. The enlarged New Exchequer Dam, forming Lake McClure with a gross storage capacity of 1,024,000 af, was constructed in 1967 and now regulates releases to the lower Merced River. The dam is operated by Merced Irrigation District (MID) for power production, irrigation, and flood control. The river is also regulated by McSwain Dam (an afterbay for New Exchequer Dam) and Merced Falls and Crocker-Huffman diversion dams located downstream. Approximately 500,000 af of water is diverted each year at Merced Falls and Crocker-Huffman Dams.

Merced River unimpaired inflows to its watershed are typical of southern Sierra streams with headwaters in the high mountains. Monthly unimpaired flows at Lake McClure average approximately 1,325 cfs, with peak runoff as snowmelt from April through June. Rainfall can cause substantial runoff from December through March. Unimpaired flows in late summer and early fall are generally less than 100 cfs in all but wet years. In highest rainfall years, average monthly inflows range from 6,000 cfs to 12,000 cfs from February through July. In driest years, flows are less than 20 cfs from August through December, whereas April through June flows average 300 to 600 cfs. In



Merced River Streamflow at Stevinson, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

dry and normal years, spring inflows average 800 to 1,700 cfs and 2,000 to 3,000 cfs, respectively, whereas August through October flows range from 30 to 100 cfs.



Unimpaired Merced River Streamflow at Lake McClure, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Monthly historic flow data near the mouth of the Merced River at Stevinson indicate that the water storage and delivery systems are extremely efficient on the Merced River. The historical average flow is approximately 650 cfs (50% of unimpaired), with most of this flow occurring during winter rainfall periods or in fall during reservoir flood control releases. Summer flows are less than 50 cfs in driest years. In highest rainfall years, flows in February through June average 4,000 to 5,500 cfs, whereas flows in August and September average 1,000 to 2,000 cfs. In dry and normal years November to April flows range from 150 to 450 cfs, while July to September flows range from 30 to 200 cfs.

In addition to streamflow, available natural spawning habitat also limits salmon production in the Merced River. Physical habitat for salmon spawning and rearing has been lost or degraded because of channel changes caused by many years of low-flow releases. These changes include siltation of spawning gravel; lack of spawning gravel recruitment below the reservoirs; removal of bankside riparian vegetation, reducing stream shading and bank stability; and in-channel mining, which has removed spawning gravel, altered the migration corridor, and created excellent salmon predator habitat.

Spawning and rearing habitat in the Merced River is the most degraded among the San Joaquin basin tributaries. Legally required summer flow releases are low (15 to 25 cfs) and are usually depleted before they reach the river mouth because of small water diversions throughout the lower river. In portions of the spawning reach and below, riparian (waterside) vegetation has been removed for agricultural development, cattle grazing, urban development, and gravel mining.

Gold dredging in the early 1900s removed significant quantities of spawning gravel from the Merced River. Large tailing piles remain along the spawning reach, and there is a lack of recruitment of new spawning gravel due to the dams, gravel mining, bank protection, and levee construction. In many riffles, significant armoring has also occurred, with only large cobbles remaining. In-channel gravel mining was extensive along the Merced River. Downstream from the State Route 59 bridge, the river flows through large mined-out pits in the channel. Some pit areas have been isolated from the active channel by levees; however, most of these levees were poorly designed and have been breached during flood flows. The ponds and small lakes resulting from these pits create excellent salmon predator habitat, disrupt salmon migration, trap juvenile salmon when water recedes, and raise stream temperatures.

Juvenile salmon are lost in water diverted at the six medium-sized irrigation diversions in the salmon spawning portion of the Merced River. The Davis-Grunsky contract between the California Department of Water Resources (DWR) and MID requires the district to install and maintain fish screening devices at these diversions. Rock screens, consisting of perforated conduit buried in cobble-filled gabions, have been installed at four of the diversions. These structures are only moderately effective at preventing juvenile salmon loss in diverted water. The screens quickly become clogged with vegetation, and the bypass gates, which allow diversion without water passing through the screens, are often opened when the screens become clogged.

DFG surveys on the lower Merced River have identified 68 small pump irrigation diversions; none is adequately screened to prevent entrainment of juvenile salmon. Cumulative losses at these sites are unknown.

Flow releases are not sufficient to accommodate salmon migration, spawning, egg incubation, juvenile rearing, and smolt emigration on the Merced River. Flows in the spawning reach during the spawning and early rearing period are further depleted by water diversions. Spring flows for smolt emigration are particularly inadequate.

Streamflow for fishery purposes in the lower Merced River is mandated in FERC License No. 2179 for the New Exchequer Project, issued in April 1964, and Davis-Grunsky Contract No. D-GG417 (DWR Contract No. 160282) between DWR and MID, executed in October 1967. The Davis-Grunsky contract requires MID to maintain a continuous flow of between 180 cfs and 220 cfs from November 1 through April 1 throughout the reach from Crocker-Huffman Dam to Shaffer Bridge.

Adequate releases for upstream attraction of adults and spawning begin on November 1, but upstream migration typically begins in October. The present spawning and rearing flow requirements were not established by scientific studies and are too low to meet spawning and rearing needs. In addition, six major riparian diversions in the spawning reach from Crocker-Huffman Dam to below Snelling deplete these flows. At times, significant portions of the spawning reach receive flows less than the legally required amounts. Required streamflows are measured at the Shaffer Bridge gage, which is downstream from several irrigation returns.

The most significant deficiencies in the present flow requirements for chinook salmon occur in the spring emigration period. April and May flows required in the FERC license are 75 cfs in a normal year and 60 cfs in a dry year. Smolt survival studies conducted in the other tributary streams in the San Joaquin drainage indicate that significantly higher spring flows are needed in the lower Merced River.

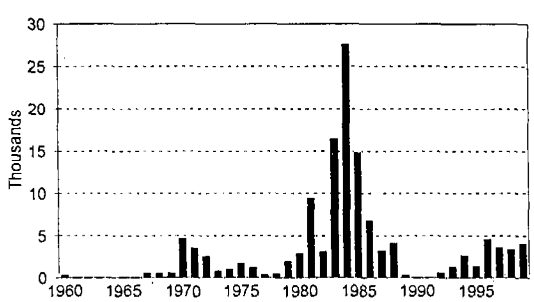
A revised flow schedule for the lower Merced River was formulated by DFG (1993) based on instream flow study and smolt survival data from similar drainages. DFG concluded that, although the recommended flows are a significant improvement over the presently required releases, they are not optimal for salmon spawning, rearing, or emigration, particularly in drier years. USFWS (1995) recommended flows that would contribute to its Central Valley Project Improvement Act (CVPIA) goal of doubling anadromous fish production in the basin, but did not include any measures to recover steelhead. The most significant deficiencies for steelhead are unsuitable water temperatures for summer rearing.

Poor water quality delays spawning, decreases egg survival, and causes high juvenile mortality. Stream temperature on the river often exceeds temperature tolerances for salmon spawning and egg incubation in October and early November in at least a portion of the spawning reach. High water temperature delays upstream migration and spawning. In recent drought years, salmon have not spawned in the river until after the first week of November, when water temperature has dropped to tolerable levels._

In late April and May, stream temperature often exceeds stressful levels for emigrating smolts. Elevated spring temperatures are a more significant problem in the lower Merced River than in the other San Joaquin tributaries because of higher ambient air temperatures and lower flows.

Crocker-Huffman Dam, near the town of Snelling, is the upstream barrier for salmon and steelhead migration. Salmon spawn in the 24-mile reach between Crocker-Huffman Dam and the Town of Cressey. Rearing habitat extends downstream of the designated spawning reach to the mouth.

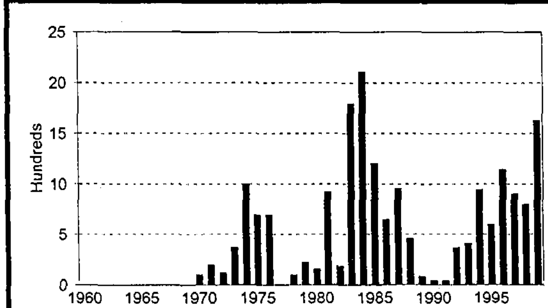
Historically, the river supported spring- and fall-run chinook salmon and steelhead. Historical information and the presence of spring-run chinook salmon provide ample evidence that a steelhead run was present historically in the Merced River (Yoshiyama et al. 1996; CDFG 1997), and there is some evidence that they were able to migrate as far upstream as Yosemite Valley (Hubbs and Wallis 1948; Snyder 1993). The river now supports fall-run chinook salmon and perhaps steelhead and late-fall-run chinook salmon.



Fall-run Chinook Salmon Returns to the Merced River excluding returns to Merced River Hatchery, 1960-1999 (CDFG 1999).

As with the Stanislaus and Tuolumne Rivers, the number of late-fall-run chinook salmon and steelhead in the Merced River is unknown. Each year, a few large rainbow trout, possibly steelhead, enter the Merced River Hatchery (MRH). Also, an adult steelhead was captured immediately above the Hills Ferry Salmon Barrier just upstream of the Merced River confluence in November, 1996 (Mayott 1997). Because there has been no focused effort to assess the steelhead population in the Merced River, and there is essentially no indirect or bycatch information from other monitoring programs on which to estimate a probability of extinction, there is no information available to conclude that steelhead are extirpated from the Merced River. This fact, and the anecdotal information and observations cited above, have led CDFG to conclude that a remnant steelhead population still exists in the Merced River (CDFG 1997).

As with other tributaries in the basin, fall-run chinook salmon spawning escapements in the lower Merced River have varied significantly since surveys were initiated. Construction and operation of MRH, in combination with increases in instream flows related to the 1967 Davis-Grunsky Contract, have increased the Merced River salmon run. Before 1970, spawning escapements were generally less than 500 fish annually; since that time, annual runs have averaged 5,800 fish. During the 1987 through 1992 droughts, spawning escapements in the lower Merced River declined to seriously low levels. In fall 1991, fewer than 100 fish returned to spawn, compared to a recent high of 23,000 fish in 1985. Extremely low returns to MRH in late 1980s and early 1990s



Fall-run Chinook Salmon Returns to Merced River Hatchery, 1970-1999 (CDFG 1999).

severely limited the hatchery's ability to sustain San Joaquin basin salmon through droughts.

MRH, located below Crocker-Huffman Dam, is presently the only salmon hatchery in the San Joaquin River drainage south of the Delta. Operated by the DFG, MRH was constructed in 1970 and operated for 10 years with funding provided in the Davis-Grunsky Agreement. The hatchery has been valuable in augmenting and sustaining salmon runs in the lower Merced River and in the Stanislaus and Tuolumne Rivers and providing fish for study purposes throughout the San Joaquin basin. The facility was recently modernized using funding from the Salmon Stamp Program and the DWR Four Pumps Agreement.

Merced NWR is located in the southern portion of this Ecological Management Zone. The refuge encompasses 2,561 acres and provides about 700 acres of seasonally flooded marsh and 600 acres of corn, alfalfa, irrigated pasture, and winter habitat. The marshes are flooded from October through April and attract thousands of migrating and wintering birds, especially ducks, geese, cranes, and shorebirds. The agricultural land provides forage for lesser sandhill cranes and four species of geese.

Preliminary surveys on the Merced River indicate that the major needs for salmon habitat improvement include rehabilitating riffle areas, constructing or repairing levees and channels to isolate mining pit areas from the active stream channel, and modifying diversion structures. The existing abandoned gravel pits also serve as predator habitat and trap sediments transported from upstream areas.

Steelhead recovery options for the Merced River have not been addressed by the management agencies. However, the ESA listing of steelhead populations in the San Joaquin tributaries will necessitate that options be identified and implemented. As with other regulated rivers in the Central Valley, recovery measures will need to focus on providing access to historical habitats and/or maintaining adequate water temperatures below dams for oversummer rearing of juveniles. These issues will need to be addressed in future recovery planning.

Illegal harvest of upstream-migrating adult salmon has also been identified as a factor limiting salmon production in the Merced River. Low water flows during the fall salmon migration make salmon easy prey for poachers.

VISION FOR THE ECOLOGICAL MANAGEMENT ZONE

The vision for the East San Joaquin Basin Ecological Management Zone includes improved streamflow, greater sediment supplies, lower spring through fall stream temperatures, improved upper watershed health, improved foodweb productivity, and improved habitats, including riparian, wetland, and seasonally flooded aquatic habitats. In addition, actions to reduce stressors, such as screening unscreened diversions, reducing the effects of gravel mining, reducing wild salmon and steelhead harvest, and limiting the adverse effects of introducing hatchery fish, will help restore salmon and steelhead populations in zone rivers.

The vision focuses on restoring important fish, wildlife, and plan communities and their habitats by restoring ecological processes and reducing stressors. Primary focus will be on restoring or reactivating the ecological processes that create and maintain habitats for anadromous salmonids and riparian vegetation. In each of the zone rivers, focus will be on restoring and protecting a self-sustaining stream meander corridor and an associated diverse riparian community that provide shade, nutrients, and woody debris to the rivers, as well as habitat for plants and wildlife communities. Because dams on each of the rivers interrupt the natural sediment supply on which natural stream meander depends, it will be necessary to sustain some natural sediment supply artificially, including silt, sand, and gravel.

In addition to restoring a natural stream channel process, it will also be necessary to restore natural floodplain processes needed to enhance foodweb productivity. These processes provide habitat for juvenile salmon and steelhead and spawning habitat for splittail and other native resident (non-migratory) fish, and habitat for migratory waterfowl and shorebirds. Natural floodplain processes occur in areas that receive seasonal flooding overflows adjacent to the stream channel, such as riparian forests, oxbows, and seasonal wetlands. These habitats depend on seasonal flooding, and the rivers and Delta depend on floodplain recruitment. Gravel is needed to maintain stream channel configuration (structure) and spawning habitat for salmon and steelhead.

Throughout the basin, restoring and/or protecting a self-sustaining, diverse riparian community will be emphasized to maintain nutrient and woody debris input to the aquatic system, enhance bank stability and stream shading, and provide valuable habitat for a variety of species.

In the lower Stanislaus, Tuolumne, and Merced rivers, emphasis will be on restoring fall-run chinook salmon and steelhead populations. Because spawning and rearing habitats are degraded, and poor streamflows and stressors have depressed the populations, it may be necessary to continue or expand hatchery rearing of salmon and steelhead, at least in the short term, to maintain sufficient production in these rivers to support sport and commercial fisheries. However, hatcheries will be operated to preserve the genetic identity of endemic (native to a particular locality), naturally spawning stocks of chinook salmon and steelhead trout. Hatchery-produced fish will be used to support sustainable ocean recreational and commercial fisheries and directed fisheries in the rivers. Marking techniques will enable sport and commercial anglers to distinguish between hatchery-produced and naturally produced fish to minimize wild fish harvest.

The Ecosystem Restoration Program (ERP) envisions that the fish, wildlife, and riparian needs of the East San Joaquin Basin Ecological Management Zone will be met and acceptable ecosystem health will be achieved when the following visions have been satisfactorily attained.

VISIONS FOR ECOLOGICAL MANAGEMENT UNITS

STANISLAUS RIVER ECOLOGICAL MANAGEMENT UNIT

The vision for the Stanislaus River Ecological Management Unit is to improve natural fall-run chinook salmon and steelhead populations by providing suitable water temperatures for rearing juveniles and improving spring flows below New Melones Dam in dry and normal water years, summer through winter base flows, and spawning and rearing habitat.

The vision for the Stanislaus River Ecological Management Unit includes improving streamflow, gravel recruitment, stream channel and riparian habitat, and screening diversions to increase the survival of chinook salmon, steelhead, and native resident fish and wildlife. Managing flow releases to provide suitable habitat and water temperatures for key resources is critical to ecosystem restoration. Also important will be restoring natural channel configurations and gravel recruitment, transport, and cleansing processes. Improved land use and livestock grazing practices will contribute to improved riparian habitat. Reducing non-native fish populations, entrainment of aquatic resources at water diversions, contaminant input, and illegal harvest will further benefit salmon and steelhead. Restoring a diverse, self-sustaining riparian corridor linked with upstream and downstream areas will be critical in restoring ecosystem function.

Restoring fall-run chinook salmon in the Stanislaus River could have significant benefits to sport and commercial fisheries. Historically, spawning escapements of fall-run chinook in the Stanislaus River have numbered up to 7% of the total fall-run salmon escapement in the Central Valley. The restoration program has the potential to return populations to recent historic levels, which could improve coastal sport and commercial fisheries.

The vision for the Stanislaus River includes reactivating and maintaining important ecological processes that create and sustain habitats for salmon and steelhead. Streamflow should be enhanced below Goodwin Dam by providing base flows recommended by the AFRP and a spring flow event in late April or early May in normal and wet years, and suitable temperatures for juvenile steelhead rearing in summer. Higher, more natural spring flow events will assist young salmon and steelhead on their downstream migration to the Bay-Delta and ocean and also support natural stream channel and riparian habitat restoration. Pulse flows also benefit the river and Bay-Delta foodweb production. The added flows in the Stanislaus River, in combination with similar flow events from the Tuolumne and Merced Rivers, will assist young salmon from all three rivers on their downstream journey through the lower San Joaquin River, Delta, and Bay to the ocean. An improved stream meander corridor and associated SRA habitat, in combination with improved gravel recruitment and water temperatures, will provide more suitable habitat for salmon and steelhead spawning and rearing, which should lead to greater natural salmon and steelhead production in the Stanislaus River. Improvements in the upper watershed health from reduced forest fuel levels and less risk of catastrophic wild fires, along with less erosion from improved road construction and maintenance, will help protect water supply and water quality.

Stream channel and riparian habitat will be improved by increasing streamflow, protecting the natural gravel sources, reducing erosional areas that degrade spawning habitat, and promoting the conservation of the lower river active floodplain. Islands will be protected and restored where possible. Side channels will be restored, and riparian vegetation and SRA habitat and woody debris will be developed to enhance juvenile salmon and steelhead habitat. Planting vegetation or regrading the disturbed channel and floodplain may be required in certain areas to hasten and sustain recovery.

Stressors, including unscreened or poorly screened diversions and illegal and legal harvest, will be evaluated to determine whether actions are necessary to protect salmon and steelhead populations. Measures being considered to reduce harvest of naturally spawning chinook salmon in sport and commercial fisheries include establishing harvest restrictions and marking all hatchery-produced fish, which would allow a selective harvest of hatchery fish. Enforcement would be increased to reduce poaching.

TUOLUMNE RIVER ECOLOGICAL MANAGEMENT UNIT

The vision for the Tuolumne River Ecological Management Unit includes maintaining suitable water temperatures, restoring streamflow, gravel recruitment, and stream channel and riparian habitat to improve habitat for chinook salmon, steelhead, native resident fish, native amphibians and reptiles, and wildlife. The vision also includes restoring important ecological processes that will improve habitat for fall-run chinook salmon, late-fall-run chinook salmon, steelhead, riparian vegetation, and wildlife resources. Managing flow releases to maintain suitable habitat and water temperatures for salmon and steelhead will be essential for restoring the ecosystem. Flow improvements in the revised agreement and FERC license should be implemented and monitored for effectiveness. Streamflow management for the Tuolumne River will need to be integrated with flow management on the other San Joaquin tributaries and the lower San Joaquin River to obtain the greatest benefits.

Also, important will be restoring more natural channel configurations; restoring gravel recruitment, transport, and cleansing processes; and restoring a balanced fine sediment budget. This will be accomplished by implementing improved land use and livestock grazing practices, reducing non-native fish populations and habitats that support them, reducing young salmon losses at water diversions, reducing the input of contaminants, and reducing the illegal salmon harvest. Restoring a diverse, self-sustaining riparian and stream channel corridor linked with upstream and downstream areas will be an essential element in the ecosystem restoration plan.

Restoring fall-run chinook salmon in the lower Tuolumne River could have significant benefits. Historically, spawning escapements in the river have numbered up to 12% of the total fall-run salmon escapement in the Central Valley. Implementing the restoration program has the potential to restore the population to recent historic levels, which will also benefit sport and commercial fisheries along the coast of California.

Streamflows should be enhanced below Don Pedro Dam by providing base flows recommended by DFG. In addition to the DFG recommendation, a spring flow event in late April or early May in dry, normal, and wet years would be provided to support downstream emigration of juvenile salmon and steelhead and to benefit stream channel and riparian habitat. Also, adequate cold water releases from Don Pedro Dam should be made to maintain suitable water temperatures in summer and early fall for juvenile steelhead rearing.

Existing gravel recruitment sources will be protected and supplemented where and when necessary with gravel introductions. A cooperative program among the local counties, agencies, and the aggregate resource industry will be developed to improve or relocate gravel mining from the active stream channel.

Stream channel and riparian habitat will be improved by increasing streamflow, protecting natural gravel sources, reducing erosional areas that degrade spawning habitat, and promoting the conservation of the lower river active floodplain. Islands will be protected and restored where possible. Side channels will be restored, and riparian vegetation and SRA habitat and woody debris will be developed to enhance juvenile salmon and steelhead habitat. Vegetation planting or regrading of the disturbed channel and floodplain may be required in certain areas to hasten and sustain recovery.

Stressors will be addressed. A cooperative evaluation of unscreened and inadequately screened diversions will determine the feasibility of installing positive-barrier fish screens. Measures being considered to reduce naturally spawning chinook salmon harvest in sport and commercial fisheries include establishing harvest restrictions and marking all hatchery-produced fish, which would allow a selective harvest of hatchery fish. A selective fishery on hatchery-produced fish will reduce harvest of naturally produced Tuolumne chinook salmon. Enforcement would be increased to reduce poaching.

If future baseline chinook salmon populations do not respond favorably to improved flow and habitat conditions in the Tuolumne River, San Joaquin River, and the Delta, a comprehensive evaluation will be made of the need for additional artificial propagation of chinook salmon in the basin. This evaluation would consider direct and indirect effects on the wild population, the role of hatchery fish in maintaining naturally spawning and hatchery derived salmon, disease transmission between hatchery and natural stocks, genetic structure and diversity of all stocks in the basin, and the likelihood of maintaining existing genetic diversity of the Tuolumne stock. Efforts relating to artificial propagation of salmon and steelhead will be the subject of monitoring, focused research, and adaptive management.

TUOLUMNE RIVER WATERSHED DEMONSTRATION PROJECT: The Tuolumne River watershed has tentatively been selected as a demonstration watershed for the CALFED Stage 1 (first seven years) Implementation Program. During Stage 1 CALFED will support ongoing and enhanced management and restoration efforts in the watershed. Success in Stage 1 will set the stage for subsequent implementation phases as the restoration and management information gained from the effort in the Tuolumne watershed will have broad application in designing and implementing similar programs in similar watersheds in the San Joaquin Basin and elsewhere in the Central Valley.

Although the ecological integrity of the Tuolumne River has declined, considerable opportunities exist to improve the river corridor through rehabilitating important ecological processes. The following descriptions of attributes of alluvial river ecosystem integrity are cited directly from McBain and Trush (1998). These not only form a basis for the Tuolumne River restoration vision but also provide a basis for selecting actions for CALFED Stage 1 Implementation.

SPATIALLY COMPLEX CHANNEL MORPHOLOGY: No single segment of channel bed provides habitat for all species, but the sum of channel segments provides high-quality habitat for native species. A wide range of structurally complex physical environments supports diverse and productive biological communities.

FLOWS AND WATER QUALITY ARE PREDICTABLE VARIABLE: Inter-annual and seasonal flow regimes are broadly predictable, but specific flow magnitudes, timing, durations and frequencies are unpredictable due to runoff patterns produced by storms and droughts. Seasonal water quality characteristics, especially water temperature, turbidity, and suspended sediment concentration are similar to regional unregulated rivers and fluctuate seasonally. This temporal "predictable unpredictability" is a foundation of river ecosystem integrity.

FREQUENTLY MOBILIZED CHANNELBED SURFACE: In gravel-bedded reaches, channelbed framework particles of coarse alluvial surfaces are mobilized by the bankfull discharge, which on average occurs every 1-2 years. In sand-bedded reaches, bed particles are in transport much of the year, creating migrating channebed "dunes" and shifting sand bars.

PERIODIC MOBILIZED CHANNELBED SCOUR AND FILL: Alternate bars are scoured deeper than their coarse surface layers by floods exceeding 3-to-5 year annual maximum flood recurrences. This scour is typically accompanied by redeposition, such that net change in channelbed topography following a scouring flood usually is minimal. In gravel-bedded reaches, scour was most likely common in reaches where high flows were confined by valley walls.

BALANCED FINE AND COARSE SEDIMENT BUDGETS: river reaches export fine and coarse sediment at rates approximately equal to sediment inputs. The amount and mode of sediment storage within a given river reach fluctuates, but sustains channel morphology in dynamic quasi-equilibrium when averaged over many years. A balanced coarse sediment budget implies bedload continuity; most particle sizes of the channelbed must be transported through the river reach.

PERIODIC CHANNEL MIGRATION AND/OR AVULSION: The channel migrates a variable rates and establishes meander wavelengths consistent with regional rivers with similar flow regimes, valley slopes, confinement, sediment supply, and sediment caliber. In gravel-bedded reaches, channel relocation can also occur by avulsion, where the cannel moves from one location to another, leaving much of the abandoned channel morphology intact. In sand-bedded reaches, meanders decrease their radius of curvature over time, and are eventually bisected, leaving oxbows.

A FUNCTIONAL FLOODPLAIN: On average, floodplains are inundated once annually by high flows equaling or exceeding bankfull stage. Lower terraces are inundated by less frequent floods, with their expected inundation frequencies dependent on norms exhibited by similar, but unregulated river channels. These floods also deposit finer sediment onto the floodplain and low terraces.

INFREQUENT CHANNEL RESETTING FLOODS: Single large floods (e.g., exceeding 10-to-20 years recurrences) cause channel avulsions, rejuvenate mature riparian stands to early-successional stages, form and maintain side channels, and create off-channel wetlands (e.g., oxbows). Resetting floods are as critical for creating and maintaining channel complexity as lesser magnitude floods, but occur less frequently.

SELF-SUSTAINING DIVERSE RIPARIAN PLANT COMMUNITIES: Based on species life history strategies and inundation patterns, initiation and mortality of natural woody riparian plants culminate in early- and late-successional stand structures and species diversities (canopy and understory) characteristic of self-sustaining riparian communities common to regional unregulated river corridors.

NATURALLY-FLUCTUATING GROUNDWATER TABLE: Inter-annual and seasonal groundwater fluctuation patterns in floodplains, terraces, sloughs, and adjacent wetlands are similar to regional unregulated river corridors.

In summary, the types of actions that should be further examined to promote restoration of the Tuolumne River corridor include:

- Encourage inter-annual and seasonal flow variability,
- Increase the magnitude and frequency of short duration peak flows to initiate bed mobility and localized scour and deposition,
- Increase the magnitude and frequency of peak flows to initiate bed scour on alluvial deposits along the low water margin to reduce riparian encroachment,
- Increase coarse sediment input to balance mainstem transport capacity,
- Reduce fine sediment input to the river,
- Reduce human encroachment onto floodplains to allow limited channel migration, and
- Restore channel morphology, with a bankfull channel and floodway scaled to the expected high flow regime.

Cumulatively, an investment in the Tuolumne River watershed during Stage 1 will provide direct benefits to the creek and dependent fish and wildlife resources and provide the types of information required to move the Ecosystem Restoration Program into subsequent implementation phases successfully. A few of the lessons to be learned in the Tuolumne River watershed include methods to improve overall watershed and ecosystem health; how to integrate local, state, federal and private efforts in a large-scale restoration program; how to design and implement actions to benefit anadromous and resident fish species, riparian systems and riparian-dependent mammals and birds; and how to best implement actions below dams in a highly altered hydrologic system to restore function sediment transport and other important ecological processes.

MERCED RIVER ECOLOGICAL MANAGEMENT UNIT

The vision for the Merced River Ecological Management Unit includes maintaining suitable water temperatures, restoring streamflow, coarse sediment recruitment, and stream channel and riparian habitat to improve habitat for fall-run chinook salmon, late-fall-run chinook salmon, steelhead, riparian vegetation, and wildlife resources. The vision also includes restoring the important ecological functions and processes that will improve habitat for fall-run chinook salmon, late-fall-run chinook salmon, steelhead, native amphibians and reptiles, riparian vegetation, and wildlife resources. Managing flow releases to provide suitable habitat and water temperatures for these resources will be essential to restoring the ecosystem. Streamflow management for the Merced River will need to be integrated with flow management on the other San Joaquin tributaries and the lower San Joaquin River to obtain the greatest possible benefits, because the salmon and steelhead must also pass through the lower San Joaquin River and Bay-Delta on their way to and from the Pacific Ocean.

Also important will be:

- restoring more natural channel configurations; restoring gravel recruitment, transport, and cleansing processes,
- restoring a balanced fine sediment budget by implementing improved land use and livestock grazing practices,
- reducing non-native fish habitat,
- reducing the loss of young salmon at water diversions,
- reducing the input of contaminants,
- reducing the number of adult fish straying into areas with no suitable spawning habitat,
- and reducing illegal salmon harvest.

Restoring a diverse, self-sustaining riparian corridor linked with upstream and downstream areas will be critical to restoring ecological health to the Merced River watershed. MID plays an important role in restoration efforts on the lower Merced River. The district is working in cooperation with resource agencies on research and restoration projects for fall-run chinook salmon in the basin.

Streamflow should be enhanced below Lake McClure by providing minimum flows recommended by DFG. In addition to the DFG recommendation, a spring flow event would be provided in dry, normal, and wet years. The pulse flow would emulate a natural pulse flow that would normally occur if flows were unimpaired. A spring flow event will support juvenile salmon and steelhead emigrating to the Delta, Bay, and ocean. It would also support natural stream channel and riparian habitat development. Also, adequate cold water releases from Lake McClure should be made to maintain suitable water temperatures in summer and early fall for juvenile steelhead rearing.

Existing gravel sources will be protected and the natural gravel supply supplemented where and when necessary. A cooperative effort among local counties, agencies, and the aggregate resource industry will be encouraged to evaluate relocating gravel mining to areas outside of the active stream channel.

Stream channel and riparian habitat will be improved by increasing streamflow, protecting the natural gravel sources, reducing erosional areas that degrade spawning habitat, and promoting the conservation of the lower river active floodplain. Islands will be protected and restored where possible. Side channels will be restored, and riparian vegetation and SRA habitat and woody debris will be developed to enhance juvenile salmon and steelhead habitat. Vegetation planting or regrading of the disturbed channel and floodplain may be required in certain areas to hasten and sustain recovery. Large mined-out gravel pits in the stream channel will be isolated or restored to natural conditions.

The effects of stressors, including artificial propagation of salmon and steelhead, water diversions, and illegal and legal harvest, will be assessed and reduced, if necessary. Stocking fall chinook salmon reared in the MRH requires careful consideration of the effects to naturally spawning stocks, not only in the Merced River, but in adjacent Central Valley watersheds. Choice of genetic types of adult salmon selected for the hatchery will be carefully evaluated to minimize potentially damaging effects on the genetic integrity of wild populations in the Central Valley. A cooperative evaluation will be made of the need and feasibility of installing positive-barrier fish screens on diversions. Measures being considered to reduce wild chinook salmon harvest in sport and commercial fisheries include establishing harvest restrictions and marking all hatchery-produced fish, which would allow a selective harvest of hatchery fish. Enforcement would be increased to reduce poaching.

Restoring and maintaining the Merced River could be facilitated by developing and implementing a comprehensive watershed management plan to protect the channel (e.g., maintain flood control capacity and reduce bank erosion) and preserve and restore the riparian corridor.

VISIONS FOR ECOLOGICAL PROCESSES

Important ecological processes and functions in the East San Joaquin Basin Ecological Management Zone include the annual streamflow regime (pattern), coarse sediment supply, stream meander, natural stream channel configurations, and water temperature regime. These processes are in various states of health in the zone. The greatest need is to restore the functions and processes linked to streamflow.

CENTRAL VALLEY STREAMFLOWS: Streamflow shapes stream channels and riparian vegetation; provides fish habitat; keeps water temperature lower in rivers; attracts anadromous fish to spawning streams; and transports young anadromous fish to downstream nursery areas in the San Joaquin River, Bay-Delta estuary, and ocean. Streamflow in each of these rivers is impaired by upstream storage reservoirs and diversions, particularly in dry and normal rainfall years. A healthy streamflow pattern in the rivers would emulate the natural runoff pattern, with a spring flow event and summer-fall-winter base flows that maintain important ecological processes and functions, habitats, and important species. The vision for streamflows is to provide a short-term (10-day) flow event in spring that typically occurred at least once in dry and normal years before dams and reservoirs were built. In addition, base flows would be provided during the remainder of the year to sustain habitats and species.

COARSE SEDIMENT SUPPLY: Gravel recruitment into the rivers is important in providing a natural stream meander process, channel configuration, and stream substrate (bottom materials where plants and animals thrive), as well as essential spawning gravels for salmon and steelhead. A natural sediment supply is also important for restoring riparian and wetland habitat. Sediment transport and gravel recruitment have been greatly reduced below major dams in zone rivers. Not only has sediment from the upper watersheds been eliminated, but sediment from the lower rivers has been interrupted by bank protection, levees, and gravel mining. The vision is to supplement natural gravel below major dams on the three rivers, where needed for salmon and steelhead spawning habitat, riparian habitat, and natural stream channel and meander development. In addition, where bank protection, levees, and gravel mining have hindered natural sediment supply to the river, wherever possible, local sediment supplies will be made available to the river.

STREAM MEANDER: In their floodplains, Central Valley rivers naturally meander through floodplain sediments, progressively eroding the next bank while adding to the previous bank. This stream meander process occurred in the stream corridors of the Stanislaus, Tuolumne, and Merced rivers. A limited stream-meander process in the lower floodplain of the rivers would provide much needed habitat to support healthy riparian systems, wildlife, and aquatic species. Today, the natural meander process in each of the streams is inhibited by dams, altered stream flows, bank protection, bridge abutments, and flood control levees. In some places, bank erosion occurs, but lack of sediment stops forming of the previous banks. The vision is to restore a portion of the natural meander to the rivers by setting back levees, where possible, and removing structures that inhibit the process from the meander corridor.

NATURAL FLOODPLAIN AND FLOOD PROCESSES: The San Joaquin Valley formerly had many natural overflow basins that retained floodwaters, permitted sediment deposition, and provided fish and waterfowl habitat. Partially reactivating these important ecological functions will contribute to overall system health and provide for prolonged periods of natural streamflow and sediment input. Natural overflow basins would also supply important habitat for fish, including chinook salmon and splittail, as well as foraging habitat for many waterfowl. The vision is to restore natural overflow basins within the lower floodplains of the three rivers. This would provide additional flood control protection for other areas in this zone and downstream, as well as valuable natural wetland, riparian, and aquatic habitats for fish and wildlife.

CENTRAL VALLEY STREAM TEMPERATURES: Salmon and steelhead depend on cool water for their survival. In the Stanislaus, Tuolumne, and Merced rivers, salmon and steelhead are confined to the floodplains of the rivers below large, impassable dams. Maintaining cool water below the dams is essential to maintaining salmon and steelhead in these rivers. Summer and early fall water temperatures in floodplains of these rivers are naturally warm, but are kept cool, at least in the upper reaches below the dams, by coldwater releases from deeper bottom waters of the major reservoirs. The extent of cool water habitat below the dams depends on the amount of cold water released from the dams, the extent of shade provided by riparian (waterside) vegetation, the extent that dredger ponds are connected to the rivers, the amount of water diverted from the river channel, and the amount of warm water discharge into the rivers from urban and agricultural drainage. Improving water temperatures in the three rivers below the major reservoirs in this zone can contribute to the overall ecological health of the system and promote sustainable fisheries. Steelhead particularly depend on cool summer water temperatures, because their young remain in the rivers through summer before migrating to the ocean. High fall water temperatures in the lower rivers hinder upstream migrations of adult fall-run chinook salmon and steelhead. The vision for water temperatures in these rivers is to provide sufficient summer and early-fall base flows in the river channels and restore the riparian corridors and natural stream channel characteristics that limit heating of the rivers. Storing sufficient coolwater in the reservoirs during drought will also help to maintain a minimum of coolwater habitat in the rivers.

VISIONS FOR HABITATS

RIPARIAN AND RIVERINE AQUATIC HABITATS: Riparian and shaded riverine aquatic (SRA) habitats are important to the health of the rivers. They provide shade, insects and organic debris that are important to the aquatic foodweb, and soil and bank protection. The riparian corridors and related SRA habitat are impaired by lack of a natural functioning stream meander process, confinement of the river channels by bank protection and levees, and loss of streamside vegetation to animal grazing, levee construction, removal of large woody debris from stream channels and banks, and agricultural clearing. The vision is to improve and restore riparian and SRA habitat along the three rivers, where possible and as needed. Included in this vision is the consideration of other riparian communities such as Great Valley valley oak, Great Valley mixed riparian, cottonwood-willow-sycamore, and elderberry savanna.

FRESHWATER FISH HABITAT: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native and anadromous fish species. The Stanislaus, Tuolumne, and Merced rivers are typical of fall chinook salmon spawning streams (Moyle and Ellison 1991). The quality of freshwater fish habitat in these rivers should be maintained through actions directed at streamflows, coarse sediment supply, stream meander, natural floodplain and flood processes, and maintaining and restoring riparian and riverine aquatic habitats.

ESSENTIAL FISH HABITAT: The Stanislaus, Tuolumne, and Merced rivers have been identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). Key features of EFH to maintain or restore in these rivers include substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

VISIONS FOR REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS: Water diversions along the rivers divert not only water, but small fish. Many diversions are screened to reduce young fish loss. Reducing losses to screened and unscreened diversions will contribute to overall ecosystem health by promoting sustainable fisheries and higher population levels. The vision is to screen those diversions that have no screens or inadequate screens where there is a potential to screen young fish in significant numbers.

DAMS AND OTHER STRUCTURES: Upstream fall-run chinook salmon passage is often limited by the presence of seasonally constructed diversion dams. The vision is to provide alternative diversion methods and to coordinate the annual removal of these dams to improve fish passage. Some adult chinook salmon tend to stray from their natal streams by remaining in the mainstem San Joaquin River and attempting to migrate above the Merced River mouth into agricultural return water. The vision is that chinook salmon spawning populations in the East San Joaquin Basin Ecological Management Zone will be increased by a seasonal weir that prevents fish from migrating above the mouth of the Merced River.

PREDATION AND COMPETITION: Predation on juvenile chinook salmon by warmwater fish, such as largemouth and smallmouth bass, in the lower reaches of streams in the East San Joaquin Basin Ecological Management Zone is a significant source of mortality. The vision is that predation will be reduced by a combination of actions to control predator populations and isolate predator habitat. These actions will contribute to improved survival of native San Joaquin Basin chinook salmon.

HARVEST OF FISH AND WILDLIFE: The legal and illegal anadromous fish harvest in the river, estuary, and ocean limits recovery of wild fall-run chinook salmon populations in the three rivers. Reducing the harvest may be necessary to allow recovery of wild populations. The vision is to continue to reduce the harvest of wild anadromous fish and focus legal harvest on hatchery stocks of salmon and steelhead.

ARTIFICIAL PROPAGATION OF FISH: Stocking hatchery-reared salmon in the Merced River supports important sport and commercial fisheries and helps to compensate for the loss of salmon and steelhead caused by the construction of large dams and reservoirs. Hatchery fish also supplement the numbers of naturally spawning salmon and steelhead in the river. Hatchery supplementation helps sustain fishable populations through periods of poor wild fish production (e.g., droughts). However, hatchery salmon and steelhead may impede the recovery of wild populations by competing with and preying on young of wild fish and reducing the genetic integrity of the wild populations by breeding with wild fish. The vision is to improving hatchery adult fish selection, spawning, rearing, and release practices to minimize potential conflicts with the naturally-spawning salmon and steelhead populations.

SPECIES VISIONS

CHINOOK SALMON: The vision for chinook salmon is to recover all stocks presently listed or proposed for listing under ESA or CESA, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that use fully existing and restored habitats. Fall-run chinook salmon will benefit from improved flows. Enhanced spring flow events will improve transport conditions for downstream migrating fall-run chinook. Fall and winter base-flow improvements will benefit upstream migrating fall-run chinook salmon and survival of eggs and fry. Improvements in wetland, riparian, and SRA habitats; stream channel and meander; and gravel recruitment will also improve spawning and rearing habitat. Screening unscreened and poorly screened diversions will improve young salmon production. Limiting harvest will provide adequate numbers of spawners and help sustain long-term fishery harvest.

STEELHEAD: The vision for steelhead trout is to recover this species listed as threatened under the ESA and achieve naturally spawning populations of sufficient size to support inland recreational fishing and that use fully existing and restored habitat. Steelhead will benefit from improved spring flow events in dry and normal years. Spring flows will provide attraction for upstream migrating adults and support downstream migrating juveniles. Improved summer, fall, and winter base flows will maintain fall and winter upstream migrants and over-summering physical habitat and lower water temperatures. Steelhead will also benefit from improved gravel spawning habitat and stream rearing habitat, especially if summer heating of the river is reduced in the process. Screening unscreened and poorly screened diversions will improve young steelhead production.

GIANT GARTER SNAKE: The vision for the giant garter snake is to contribute to the recovery of this State and federally listed threatened species in order to contribute to the overall species richness and diversity. Achieving this vision will reduce the conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. Protecting existing and restoring additional suitable wetland and upland habitats will be critical to achieving recovery of the giant garter snake. The proposed restoration of aquatic, wetland, and riparian habitats in the East San Joaquin Ecological Management Zone will help in the recovery of these species by increasing habitat quality and area.

WESTERN POND TURTLE: The vision for the western pond turtle is to maintain and restore their abundance and distribution by maintaining or expanding existing populations by improving stream channel, floodplain riparian processes, and reducing predator species.

SWAINSON'S HAWK: The vision for Swainson's hawk is to contribute to the recovery of this State-listed threatened species. Improvements in riparian and agricultural wildlife habitats will aid in the recovery of the Swainson's hawk. Increased abundance and possibly some nesting would be expected as a result of improved habitat.

GREATER SANDHILL CRANE: The vision for the greater sandhill crane is to contribute to the recovery of this California species of special concern. Improvements in pasture lands and seasonally flooded agricultural habitats, such as flooded corn fields, should help toward recovery of the greater sandhill crane population. The population should remain stable or increase with improvements in habitat.

WESTERN YELLOW-BILLED CUCKOO: The vision for the western yellow-billed cuckoo is to contribute to the recovery of this State-listed endangered species. The yellow-billed cuckoo along the San Joaquin River and its tributaries is not a species for which specific restoration projects are proposed. Potential habitat for the cuckoo will be expanded by improvements in riparian habitat areas. These improvements will result from efforts to protect, maintain, and restore riparian and riverine aquatic habitats throughout the San Joaquin River and East San Joaquin Ecological Management Zones, thus sustaining the river meander belt, and increasing the natural sediment supply to support meander and riparian regeneration.

RIPARIAN BRUSH RABBIT: The vision for the riparian brush rabbit is to assist in the recovery of this State-listed endangered species in the Bay-Delta through improvements in riparian habitat and reintroduction to its former habitat. Restoring suitable mature riparian forest, protecting and expanding the existing population, and establishing new populations will be critical to the recovery of the riparian brush rabbit. Restoration of riparian habitats in the East San Joaquin Basin Ecological Management Zone and adjacent upland plant communities will help the recovery of this species by increasing habitat area and providing refuge from flooding.

SAN JOAQUIN WOODRAT: The vision for the San Joaquin Valley woodrat is to contribute to the recovery of this federally proposed endangered species through improvement in its habitat.

SHOREBIRDS AND WADING BIRDS: The vision for shorebirds and wading birds is to maintain and restore healthy populations through habitat protection and restoration. Shorebirds and wading birds will benefit from restoration of wetland, riparian, aquatic, and agricultural habitats. The extent of seasonal use of the East San Joaquin Ecological Management Zone by these birds should increase.

WATERFOWL: The vision for waterfowl is to maintain and restore healthy populations at levels that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses. Many species of resident and migratory waterfowl will benefit from improved aquatic, wetland, riparian, and agricultural habitats. Increase use of the East San Joaquin Ecological Management Zone and possibly increases in some populations would be expected.

NEOTROPICAL MIGRATORY BIRDS: The vision for the neotropical migratory bird guild is to restore and maintain healthy populations of neotropical migratory birds through restoring habitats on which they depend. Protecting existing and restoring additional suitable wetland, riparian, and grassland habitats will be critical to maintaining healthy neotropical migrant bird populations in the Bay-Delta.

NATIVE RESIDENT FISHES: The vision for native resident fish species is to maintain and restore the distribution and abundance.

LAMPREY: The vision for anadromous lampreys is to maintain and restore population distribution and abundance to higher levels that at present. The vision is also to understand life history better and identify factors which influence abundance. Better knowledge of these species and restoration would ensure their long-term population sustainability.

PLANT SPECIES AND COMMUNITIES: The vision for plan species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland and riparian and riverine aquatic habitats.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Maintaining and restoring the health of the Ecological Management Units in the East San Joaquin Basin Ecological Management Zone will depend on the efforts of local and State water management agencies. Efforts in the basin will be linked to activities of the California Waterfowl Association, Ducks Unlimited, and The Nature Conservancy. Overall, these efforts will require cooperation from resource agencies such as DFG, DWR, USFWS, and the National Marine Fisheries Service (NMFS), as well as participation and support from Reclamation, the U.S. Natural Resources Conservation Service, and other private organizations, water districts, and landowners. These groups will work together to maintain and restore streamflows and fish and wildlife habitat, reduce impacts of diversions, minimize poaching, and minimize habitat and water quality degradation in basin streams. In support of this effort, funding may be provided to enhance streamflows, reduce fish-passage problems, screen diversions, restore habitats, and increase enforcement of the California Fish and Game Code to protect recovering populations of salmon and steelhead. Oakdale and South San Joaquin Irrigation Districts also are active participants in ecosystem restoration efforts on the lower Stanislaus River. The Modesto and Turlock Irrigation Districts play important roles in restoration efforts on the lower Tuolumne River. The districts are working in cooperation with resource agencies on research and restoration projects for fall-run chinook salmon in the basin.

CENTRAL VALLEY PROJECT IMPROVEMENT ACT

Restoring and maintaining ecological processes and functions in the East San Joaquin Basin Ecological Management Zone will augment other important ongoing and future restoration efforts for the zone. This program will complement efforts of the USFWS's AFRP (USFWS 1995). The goal of the program is to double the natural anadromous fish production in the system over the average production during 1967 to 1991. CVPIA authorized the dedication and management of 800,000 af of CVP yield annually to implement fish, wildlife, and habitat restoration purposes and measures. Because the Stanislaus River is a CVP-controlled stream, a portion of this allocation has been released to the lower river to improve salmon rearing and emigration (the needs of steelhead were not included in this allocation). CVPIA also directed the Secretary of the Interior to evaluate and determine the existing and anticipated future basin needs in the Stanislaus River basin while preparing the Stanislaus River Basin and Calaveras River Water Use Program Environmental Impact Statement.

SALMON, STEELHEAD TROUT AND ANADROMOUS FISHERIES PROGRAM ACT

The vision will also help the DFG reach its goal of doubling the number of anadromous fish that were produced in 1988.

AGREEMENT ON SAN JOAQUIN RIVER PROTECTION

In an effort to resolve issues brought forth in the State Water Resources Control Board's 1995 Water Quality Control Plan for the Bay/Delta, the San Joaquin River Tributaries Association, San Joaquin River Exchange Contractors Water Authority, Friant Water Users Authority, and the San Francisco Public Utilities Commission collaborated to identify feasible, voluntary actions to protect the San Joaquin River's fish resources. In spring 1996, these parties agreed on a "Letter of Intent to Resolve San Joaquin River Issues." This agreement, when finalized, has the potential of providing the following:

- higher minimum base flows,
- significantly increased pulse flows,
- installation and operation of a new fish barrier on the mainstem San Joaquin River,
- set up a new biological monitoring program, and
- set aside federal restoration funds to cover costs associated with these measures.

One of the important components of the Agreement is the development of the Vernalis Adaptive Management Program (VAMP) to improve environmental conditions on the San Joaquin River. Elements of this potential adaptive management program include a range of flow and non-flow habitat improvement actions throughout the watershed, and an experimental program designed to collect data needed to develop scientifically sound fishery management options for the future.

The future of the Agreement is unknown at this time. However, several actions by the San Joaquin River Stakeholders Policy Group and other parties have been or are presently being implemented throughout the watershed. These actions include:

- Extensive scientific studies of the chinook salmon fishery and habitats on the Tuolumne, Merced, and Stanislaus Rivers;
- Districts have assisted in the bypassing of high river flows around spawning areas as requested by State and federal agencies to provide more stable flows during the fall spawning period;
- Improved instream flows in order to increase naturally occurring chinook salmon populations;
- Water transfers to the USBR pursuant to the CVPIA to help implement a portion of the Anadromous Fish Restoration Program;
- Chinook salmon habitat restoration work;
- Spawning gravel rehabilitation;
- Inventory and development of habitat restoration project proposals;
- Feasibility studies of establishment of a salmon hatchery and rearing facilities.

SAN JOAQUIN RIVER MANAGEMENT PROGRAM (SJRMP)

This program will complement the SJRMP, which was established through State legislation (Chapter 1068/90) to develop comprehensive and compatible solutions to water supply, water quality, flood control, fisheries, wildlife habitat, and recreational needs in the San Joaquin River basin. The program resulted in a final report with recommendations to the California Legislature in February 1995 and has now entered the implementation phase.

FERC LICENCE PROGRAM

Minimum flow requirements below each of the dams on the rivers are required by FERC hydropower licenses. Existing minimum flows in the lower Merced River are designated in FERC License No. 2179 for the New Exchequer Project, issued in April 1964, and the Davis-Grunsky Contract No. D-GGR17 (DWR Contract No. 160282) between DWR and MID, executed in October 1967. The Davis-Grunsky contract requires MID to maintain a continuous flow of between 180 cfs and 220 cfs in the lower Merced River from November 1 through April 1 throughout the reach from Crocker-Huffman Dam to Shaffer Bridge. An agreement was executed in 1995 for the Tuolumne River between 10 stakeholder and resource agencies. It amended the license for the New Don Pedro Project to increase instream flow releases from New Don Pedro Dam. Flows in this agreement were incorporated into a FERC Order Amending License for the New Don Pedro Project.

CALFED BAY-DELTA PROGRAM

CALFED has funded 13 ecosystem restoration projects in the East San Joaquin Ecological Management Zone. Many of the projects restore portions of the Tuolumne and Merced rivers that have been damaged by gravel extraction operations. Another project places gravel in the Tuolumne River to replace gravel captured by upstream reservoirs.

LINKAGE TO OTHER ECOLOGICAL MANAGEMENT ZONES

Many of the resource elements in the East San Joaquin Basin Ecological Management Zone depend extensively on conditions or elements in other zones. Anadromous fish, for example, are highly migratory and depend on conditions in the mainstem San Joaquin River, the Delta, San Francisco Bay, and the nearshore Pacific Ocean. Because these fish are affected by stressors throughout their range, such as unscreened diversions, toxic contaminants, water quality, and harvest, restoring populations in the East San Joaquin Basin Ecological Management Zone will require corresponding efforts in other zones.

The ecosystem health of the East San Joaquin Basin Ecological Management Zone is highly dependent on conditions in the San Joaquin River and Sacramento-

San Joaquin Delta Ecological Management Zones. Stressors there (water diversions and water quality) have a significant effect on resources in this zone. Conditions in San Francisco Bay and the Pacific Ocean can also have a significant effect on resources in this zone.

Stressors in the mainstem San Joaquin River have significant effects on resources in its tributary streams. In particular, reduced streamflow and the high input of contaminants into the mainstem San Joaquin River reduces survival of anadromous fish migrating up and down the river, to and from spawning and rearing areas in the tributary streams.

Water, sediment, nutrient supply, and input of contaminants from the tributary streams in this zone all influence habitat conditions in the mainstem San Joaquin River. Changes in these factors from historical conditions have contributed to habitat degradation on the mainstem river. Maintaining a healthy riparian zone and balanced sediment budget in the mainstem San Joaquin River will depend on appropriate nutrient, water, and sediment input from the major tributaries. Water supply from the tributaries is critical to maintaining aquatic habitat in the mainstem river between the Merced River confluence and Vernalis, because Friant Dam diverts nearly all of the flow from the upper San Joaquin River watershed.

The Sacramento-San Joaquin Delta Ecological Management Zone provides essential habitat for upstream migration of adult anadromous fish and downstream migration and rearing of juvenile anadromous fish from the San Joaquin River basin. Conditions in the Bay-Delta significantly affect anadromous fish production in the San Joaquin River basin, because, in most years, much of the inflow from the basin is diverted in the Delta, and the loss of juvenile salmon and steelhead in Delta water diversions is high. In turn, the magnitude of inflow and the input of nutrients, contaminants, and sediments from the San Joaquin River and its tributaries significantly affect the health of the Bay and Delta ecosystem. Restoring and maintaining a healthy ecosystem in this zone will be critical to restoring the ecosystem in the Bay and Delta.

Additionally, stressors affecting fish and wildlife species using the San Joaquin River basin during at least part of their life cycle occur outside the identified Ecological Management Zones. For example, ocean recreational and commercial fisheries have a significant effect on the numbers of anadromous fish returning to spawn and rear in the San Joaquin River basin. New harvest management strategies for the ocean fisheries may be needed to ensure restoration of San Joaquin tributary salmon runs.

RESTORATION TARGETS AND PROGRAMMATIC ACTIONS

ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOWS

TARGET 1: Maintain the following base flows in the Stanislaus River below Goodwin Dam (◆◆):

- in critical, dry, and below-normal years, minimum flows should be 200 to 300 cfs, except for a flow event of 1,500 cfs for 30 days in April and May,
- in above-normal years, minimum flows should be 300 to 350 cfs, except for 800 cfs in June and 1,500 cfs in April and May, and
- in wet years, minimum flows should be 300 to 400 cfs, except for 1,500 cfs from April through June.

PROGRAMMATIC ACTION 1A: Develop a cooperative approach to coordinate flow releases to attain target levels.

TARGET 2: Provide the following 10-day spring flow events on the Stanislaus River: 2,500 to 3,000 cfs in late April or early May in normal years and 3,000 to 4,000 cfs in wet years. Such flows would be provided only when inflows to New Melones Reservoir are at these levels (◆◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative approach to coordinate flow releases to attain target levels.

TARGET 3: Maintain the following base flows in the Tuolumne River below Don Pedro Dam (◆◆):

- in critical and below years, flow release should be 50 cfs from June through September, 100 cfs from October 1-15, 150 cfs from October 16-May 31, plus an 11,091 acre-foot outmigration pulse flow,

- in median critical dry years, flow release should be 50 cfs from June through September, 100 cfs from October 1-15, 150 cfs from October 16-May 31, plus a 20,091 acre-foot outmigration pulse flow,

- in intermediate critical dry years, flow release should be 50 cfs from June through September, 150 cfs from October 1-15, 150 cfs from October 16- May 31, plus a 32,619 acre-foot outmigration pulse flow,

- in median dry years, flow release should be 75 cfs from June through September, 150 cfs from October 1-15, 150 cfs from October 16- May 31, plus a 37,060 acre-foot outmigration pulse flow,

- in intermediate dry-below normal years, flow release should be 75 cfs from June through September, 180 cfs from October 1-15, 180 cfs from October 16- May 31, plus a 35,920 acre-foot outmigration pulse flow and a 1,676 acre-foot attraction pulse flow,

- in median below normal years, flow release should be 75 cfs from June through September, 200 cfs from October 1-15, 175 cfs from October 16- May 31, plus a 60,027 acre-foot outmigration pulse flow and a 1,736 acre-foot attraction pulse flow,

- in all other year types (intermediate below normal/above normal, median above normal, intermediate above normal-wet, and median wet/maximum years), flow release should be 250 cfs from June through September, 300 cfs from October 1-15, 300 cfs from October 16- May 31, plus a 89,882 acre-foot outmigration pulse flow and a 5,950 acre-foot attraction pulse flow.

PROGRAMMATIC ACTION 3A: Develop a cooperative approach to coordinate flow releases to attain target levels.

TARGET 4: Maintain the following base flows in the Merced River below Lake McClure (◆◆):

- in dry years, minimum instream flows at Shaffer Bridge should be 15 cfs from June through October 15, 60 cfs from October 16 through October 31 and January through May, and 75 cfs in November and December, and

- in normal years, minimum instream flows at Shaffer Bridge should be 25 cfs from June through October 15, 75 cfs from October 16 through October 31 and January through May, and 100 cfs in November and December.

PROGRAMMATIC ACTION 4A: Develop a cooperative approach to coordinate flow releases to attain target levels.

TARGET 5: Provide the following 10-day spring flow events on the Merced River: 1,000 to 1,500 cfs in late April or early May in dry years, 2,000 to 2,500 cfs in normal years, and 3,000 to 4,000 cfs in wet years. Such flows would be provided only when inflows to Lake McClure are at these levels (◆◆).

PROGRAMMATIC ACTION 5A: Develop a cooperative approach to coordinate flow releases to attain target levels.

RATIONALE: *The proposed supplemental flows were selected as a representative value for impact analysis in the Programmatic EIS/EIR. Throughout the ERP, the need to determine optimal streamflow for ecological processes, habitats, and species is repeated. The issues of supplemental flows are complex in term of ecosystem improvements. The frequency, magnitude, duration, timing and rate of change of streamflows that form channels, create and maintain riparian habitat (including all species of vegetation), and promote all life stages of the various aquatic species dependent on a particular stream will never occur within a single year. An optimal flow regime will have to vary, perhaps significantly, from year to year. The supplemental flow recommendations will be an intensive exercise in adaptive management and must be based on credible scientific underpinnings.*

Flows in the Stanislaus, Tuolumne, and Merced Rivers are controlled by releases from foothill storage reservoirs (New Melones, New Don Pedro, and New Exchequer Reservoirs, respectively). Improving base flows would increase habitat for spawning, rearing, and migration of salmon and steelhead. Pulse flows in spring would help to restore natural stream channel processes; gravel recruitment, cleansing, and transport; and riparian vegetation development and survival. These flows also would help to support juvenile salmon and steelhead emigration to the Delta.

In all cases, flows will continually subject to the developing aspects of adaptive management in which decisions are based on the development and evaluation of testable hypotheses. Flow recommendations are linked to water quantity and quality and in the long-term should be designed to contribute to species maintenance and restoration, improving natural or semi-natural ecological functions, and assist in promoting the sustainability of specific types of habitat important to fish, wildlife and plant communities.

Given the wide variety of past and recent flow recommendations, it is apparent that much additional information is required to use existing water supplies to meet all the beneficial uses better, with particular focus on the ecosystem requirements. The basis for ERP flow recommendations eventually will differ significantly from flow recommendations based on the needs of chinook salmon migration, spawning, and rearing. Salmon flows will likely continue to form the core of flow needs, but from the ecosystem perspective, flows will need to meet the need of sediment transport and other channel maintenance processes as well as contribute to sustaining a diversity of aquatic, floodplain and other closely linked habitats such as seasonal wetlands and riparian forests. Still, the present recommendations for "ecosystem" flows suffer from insufficient data regarding better estimates of sediment transport and channel maintenance flows. These are very important aspects of integrating flow prescriptions with actual ecosystem restoration requirements and will require the development of testable hypotheses and the monitoring and research programs necessary to collect and evaluate data to support or refute the hypotheses.

The recommended flow event on the Stanislaus River may be constrained in the short-term by flood control concerns below Goodwin Dam. Full implementation of the proposed flows may depend on land use changes in the floodplain that could be inundated by the flow events. The flow event is closely related to recommendations in this section regarding stream meander corridor and natural floodplains and flood processes.

Minimum flows are necessary in the salmon and steelhead spawning and rearing areas of each of the three rivers to sustain adequate physical habitat, water temperatures, and food supply for juvenile salmon and steelhead, both of which may be year-round residents. In some cases, base flows may be higher than unimpaired flow. Such flows are necessary, because spawning and rearing habitats for juvenile salmon and steelhead, traditionally located upstream of the dams, now are located downstream.

Flow events are recommended during spring to more closely emulate the natural spring peak-flow pattern. Such flows stimulate and support downstream juvenile salmon and steelhead migration. The spring flow will also mobilize, clean, and transport spawning gravels; create point bars and other instream habitat types; and contribute to a natural channel meandering pattern and riparian scrub and woodland habitat development and maintenance.

DFG (1993) believes existing flow requirements are inadequate for fall-run chinook salmon migration, spawning, egg incubation, juvenile rearing, and smolt emigration on the Merced River. Adequate releases for upstream attraction of adults and spawning begin on November 1, but migration typically begins in October. The current spawning and rearing flow requirements are not the result of scientific studies and may be too low to meet spawning and rearing needs. Flows in the spawning reach during the spawning and early rearing period are further depleted by water diversions. Spring flows for smolt emigration are particularly inadequate.

Flow targets recommended by DFG (1993) for the lower Merced River were derived from instream flow study and smolt survival data from similar drainages. Recommended flows during the spring emigration period are consistent with proposed spring outflow objectives for the basin at Vernalis on the San Joaquin River. Although the proposed flows are a significant improvement over the current flow releases, they are not the most favorable for salmon spawning, rearing, or emigration, particularly in drier years (California Department of Fish and Game 1993).

Flow targets recommended by USFWS (1995) for the Merced River were developed by the AFRP San Joaquin Basin Technical Team. Recommended flows were derived from historical flows and results of biological studies. The team believes that implementing the flow schedule, along with other recommended actions, would double natural fall-run chinook salmon production in the Merced River.

For the lower Tuolumne River, an agreement was executed in 1995 between 10 stakeholder and resource agencies. It amended the license for the New Don Pedro Project to increase instream flow releases from New Don Pedro Dam. Flows in this agreement were incorporated into a FERC Order Amending License for the New Don Pedro Project (July 1996). This new flow agreement is based on ten different water year types. These new flows should be viewed as the experimental baseline for restoring chinook salmon and for their contribution in promoting a healthy alluvial river system.

Flow targets were recommended by DFG (1993) for the lower Tuolumne River following results of an instream flow study (U.S. Fish and Wildlife Service 1993) and smolt survival studies. Flow needs recommended by DFG are met in many year-types by flows specified in the settlement agreement. However, DFG (1993) stated that, although its flow recommendations were a significant improvement over the recent historical flow releases, they are not the most favorable for salmon spawning, rearing, or emigration, particularly in drier years. The recommended flow pulses in April and May are prescribed to meet these needs in drier years better and to support stream channel and riparian habitat processes.

Existing minimum fishery flows in the lower Stanislaus River are designated in a 1987 study agreement between Reclamation and DFG. This agreement, enacted under a DFG protest of Reclamation's water right applications to redivert water from New Melones Dam, specifies interim annual flow allocations for fisheries between 98,300 af and 302,100 af, depending primarily on carryover storage at New Melones and inflow. Instream flow schedules are set annually by DFG in the total annual flow allocation specified in the agreement. In recent years, coordinating fishery and water quality flow releases and releases for water sales and transfers have resulted in additional flow releases that significantly benefit anadromous fish.

DFG (1993) stated that the existing flow requirements are inadequate for fall-run chinook salmon migration, spawning, egg incubation, juvenile rearing, and smolt emigration on the Stanislaus River. Spring flows for smolt emigration are particularly inadequate. There is a positive relationship between spring outflow at Vernalis on the San Joaquin River and at Ripon on the Stanislaus River to adult escapements into the basin 2½ years later. Results of smolt survival studies completed on the Stanislaus River thus far indicate a positive relationship between smolt survival and spring flow releases. April through May flow events are prescribed for these reasons.

Flow targets recommended by DFG (1993) for the lower Stanislaus River were formulated from results of an instream flow study (U.S. Fish and Wildlife Service 1993) and smolt survival studies. Flows for October through March were determined from results of the instream flow study for salmon spawning, egg incubation, and rearing. Flows during April and May determined from results of the smolt survival studies. The flows are consistent with spring outflow objectives proposed for the basin at Vernalis on the San Joaquin River. Summer flows addressed needs of oversummering yearling salmon and steelhead. Although these flow targets are a significant improvement over the current flow releases, they are not the best possible for salmon spawning, rearing, or emigration, particularly in drier years (California Department of Fish and Game 1993). Again, this is the reason for recommending additional April through May flow pulses.

Flow targets recommended by USFWS (1995) for the Stanislaus River were developed by the San Joaquin Basin Technical Team. Recommended flows were derived from historic flows and results of biological studies. The team believes that implementing the flow schedule, in concert with other recommended actions, would double natural fall-run chinook salmon production in the Stanislaus River.

It is important to note that all of the agreed upon or proposed flows (AFRP, Tuolumne River Settlement Agreement, FERC, VAMP, Davis-Grunsky, and DFG recommended flows) in the Stanislaus, Tuolumne, and Merced rivers were designed to facilitate chinook salmon recovery, and little or no consideration was given to steelhead recovery in the design of these flow strategies. Flow and temperatures requirements of steelhead will need to be evaluated and integrated into the proposed flow regimes.

COARSE SEDIMENT SUPPLY

TARGET 1: Reduce existing levels of erosion and maintain gravel recruitment in tributaries that sustain an adequate level of gravel recruitment, or restore desirable levels by directly manipulating and augmenting gravel supplies where the natural flow process has been interrupted by dams or other features that retain or remove the gravel supply (◆◆).

PROGRAMMATIC ACTION 1A: Evaluate the feasibility and need for establishing long-term coarse sediment augmentation and fine sediment control programs for streams below major impoundments in the East San Joaquin Ecological Management Zone.

PROGRAMMATIC ACTION 1B: Evaluate spawning gravel quality in areas used by chinook salmon in the Stanislaus River. If indicated, renovate or supplement gravel supplies to enhance substrate quality by importing additional gravel as conditions require.

PROGRAMMATIC ACTION 1C: Evaluate spawning gravel quality in areas used by chinook salmon in the Tuolumne River. If indicated, renovate or supplement gravel supplies to enhance substrate quality.

PROGRAMMATIC ACTION 1D: Evaluate spawning gravel quality in areas used by chinook salmon in the Merced River. If indicated, renovate or supplement gravel supplies to enhance substrate quality.

RATIONALE: *Gravel transport is the process whereby flows carry away finer sediments that fill gravel interstices (spaces between cobbles). Gravel cleansing is the process whereby flows transport, grade, and scour gravel. Gravel transport and cleansing, by flushing most fines and moving bedload, are important processes to maintain the amount and distribution of spawning habitat in the Sacramento-San Joaquin River basin. Human activities have greatly reduced or altered these processes. Opportunities to maintain and restore these processes include changing water flow, sediment supplies, and basin geomorphology (earth forming process); removing stressors; or manipulating channel features and stream vegetation directly.*

A feasibility study that emphasizes the hydrologic and fluvial geomorphologic aspects of the three watershed need to be conducted early in the program to provide guidance of the development and implementation of potential sediment augmentation programs. This will require the expertise and knowledge of trained experts. It may be that gravel deposits in streams of the East San Joaquin Basin Ecological Management Zone are essential to maintain spawning and rearing habitats of fall-run chinook salmon, steelhead, and other native fish. Opportunities to maintain and restore gravel recruitment include manipulating natural processes and controlling or managing environmental stressors that adversely affect recruitment.

STREAM MEANDER

TARGET 1: Preserve and expand the stream-meander belts in the Stanislaus, Tuolumne, and Merced Rivers by adding a cumulative total of 1,000 acres of riparian lands in the meander zones (◆◆◆).

PROGRAMMATIC ACTION 1A: Acquire riparian and meander-zone lands by purchasing them directly or acquiring easements from willing sellers, or provide incentives for voluntary efforts to preserve and manage riparian areas on private land.

PROGRAMMATIC ACTION 1B: Build local support for maintaining active meander zones by establishing a mechanism through which property owners would be reimbursed for lands lost to natural meander processes.

PROGRAMMATIC ACTION 1C: Develop a cooperative program to improve opportunities for natural meander by removing riprap and relocating other structures that impair stream meander.

TARGET 2: On the Merced River between the towns of Cressey and Snelling, isolate gravel pits, reconfigure (rearrange) dredge tailings, and restore a more natural channel configuration to 5 to 7 miles of disturbed stream channel. On the Tuolumne River, between river miles (RMs) 25 and 51, isolate 15 to 30 gravel pits, reconfigure dredge tailings, and restore a more natural stream channel to 6 to 9 miles of disturbed stream channel. On the Stanislaus River, restore a more natural stream channel to 2.5 to 5 miles of disturbed stream channel (◆◆◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program, consistent with flood management, to restore more natural channel configurations to reduce salmonid predator habitat and improve migration corridors.

PROGRAMMATIC ACTION 2B: Work with permitting agencies to appropriately structure future gravel extraction permits. Coordinate the design and implementation of gravel pit isolation and stream channel configuration with the Corps, local water management agencies, and local governments.

PROGRAMMATIC ACTION 2C: Develop a cooperative program with the counties, local agencies, and aggregate (sand and gravel) resource industry to develop and implement gravel management programs for each of the three rivers.

PROGRAMMATIC ACTION 2D: Develop a cooperative program to implement a salmonid spawning and rearing habitat restoration program, including reconstructing channels at selected sites by isolating or filling in inchannel gravel extraction areas.

RATIONALE: *Stream meander, natural sediment supply, and floodplain and flood processes are closely linked and some of the programmatic actions under stream corridor would also be appropriate for natural sediment supply or floodplain processes. Between 1942 and 1993, approximately 6.8 to 13.6 million tons of bed material were mined from the active Merced River channel. The pits that resulted from this excavation occupy approximately 4 miles of the existing river channel between the towns of Cressey and Snelling (Kondolf et al. 1996). Restoration planning for the lower Tuolumne River has identified the need for channel reconstruction in approximately 8.5 total miles, or 42%, of the spawning reach (from RM 45.3 to RM 25.1), isolation of backwater areas at approximately 20 sites located from RM 50.3 to RM 30.1, and isolation of gravel pits from the active channel at approximately 10 locations from RM 50.0 to RM 30.5. Gravel mining was less extensive on the lower Stanislaus River, but channel improvements there are also needed.*

Stream channel restoration to isolate or reduce gravel extraction pits has been identified as an important component of a comprehensive spawning and rearing habitat improvement program in the basin (California Department of Fish and Game 1993, U.S. Fish and Wildlife Service 1995).

Additional research or technical advice is required to understand better and develop specific projects designed to improve stream channel meander, improve sediment supplies, and to increase the benefits of the interaction of streams with their floodplains.

NATURAL FLOODPLAIN AND FLOOD PROCESSES

TARGET 1: Restore and improve opportunities for rivers to inundate (flood) their floodplain on a seasonal basis (◆).

PROGRAMMATIC ACTION 1A: Conduct a feasibility study to construct setback levees in the Stanislaus, Tuolumne, and Merced River floodplains.

PROGRAMMATIC ACTION 1B: Restore, as needed, stream channel and overflow basin configurations within the floodplain.

PROGRAMMATIC ACTION 1C: Minimize effects of permanent structures, such as bridges and diversion dams, on floodplain processes.

PROGRAMMATIC ACTION 1D: Develop a floodplain management plan for the Stanislaus River.

PROGRAMMATIC ACTION 1E: Develop a floodplain management plan for the Tuolumne River.

PROGRAMMATIC ACTION 1F: Develop a floodplain management plan for the Merced River.

RATIONALE: *Setback levees will provide greater floodplain inundation, room for stream meander, and greater amounts of riparian forest and seasonal wetland habitats along the lower rivers. Channel configuration adjustments may be necessary to accelerate restoration of natural floodplain habitats and to restore and maintain configurations that may not occur naturally due to remaining constraints from new setback levees. Permanent structures, such as bridges and diversions dams can interrupt and impair natural floodplain processes and habitat development and succession, thus requiring removal of the structures, rebuilding, or some continuing maintenance or mitigative efforts to minimize their effects.*

The present channel capacity of the Tuolumne river is about 9,000 cfs which is not large enough to meet the needs of maintaining a healthy alluvial river ecosystem. The January 1997 flood on the lower Tuolumne River peaked at 60,000 cfs and provided a glimpse of the resiliency of the Tuolumne River. While the high flows damaged development in the floodplain, it also created alternate bars in the channel, recruited gravel from the banks as the river meandered, and placed large woody debris in the *stream channel. As a result of the 1997 floods, the Governor's Flood Emergency Action Team Final Report (May 10, 1997) recommended that the U.S. Army Corps of Engineers conduct a study to increase the channel capacity in the Tuolumne river to convey flows up to 20,000 cfs. This would more than double the present 9,000 cfs capacity, mimic the seasonal peak to a greater degree, and provide additional ecological benefits while providing greater flexibility to manage floods. An expanded floodway on the Tuolumne river would also address the implementation objectives related to natural sediment supply, stream meander, and stream temperatures.*

Other benefits of improving the quantity of floodplains include:

- *increased shading and food web support,*
- *re-establishment of stream meander, and*
- *potential conversion of agricultural land to floodplain and the reduced need for diversion.*

CENTRAL VALLEY STREAM TEMPERATURES

TARGET 1: Maintain maximum surface water temperatures on the lower Merced, Tuolumne, and Stanislaus rivers to the downstream boundary of the salmon spawning area (as defined by Fish and Game Code section 1505) during summer, fall and winter and to the mouth of the river during the spring as follows (◆◆◆):

- October 15 through February 15, 56°F, and
- April 1 through May 31, 65°F.

PROGRAMMATIC ACTION 1A: Cooperatively evaluate the use of temperature control devices/reservoir management options to reduce water temperatures during critical periods.

PROGRAMMATIC ACTION 1B: Evaluate the impact of irrigation returns on stream temperature.

PROGRAMMATIC ACTION 1C: Cooperatively develop temperature models for all three tributaries to determine flows necessary to maintain 60°F in the designated salmon spawning areas from June 1 through September 30 to provide the necessary conditions for steelhead rearing.

RATIONALE: *Water temperatures in the lower rivers in fall and spring often exceed stressful or lethal levels for fall-run chinook salmon. High temperatures typically occur in drought periods, when storage levels in reservoirs have dropped sufficiently to allow warm surface waters to be included in storage releases to the lower river. Retaining water over the summer that may otherwise be released for downstream irrigation or other purpose may allow the cold water in the reservoirs to be retained through the early fall critical temperature period. Elevated temperatures are thought to delay migration and spawning (California Department of Fish and Game 1992), reduce egg survival, and increase mortality of rearing and outmigrating juveniles (California Department of Fish and Game 1993). The target temperature levels would maintain suitable habitat for chinook salmon for spawning, rearing, and outmigration throughout the lower rivers. These levels are identified in DFG (1993) and in USFWS (1995). Temperature models need to be developed and calibrated to determine the feasibility of providing the flows necessary to maintain 60° F in the designated salmon spawning areas from June 1 through September 30 to provide the necessary conditions for steelhead rearing.*

High water temperature below dams in summer is a critical stressor for steelhead throughout the Central Valley drainages (IEP Steelhead Project Workteam 1999). Because juvenile steelhead must rear for at least one year in fresh water, adequate temperatures must be maintained year-round. Providing the necessary cool temperatures in the reaches that contain rearing habitat will be necessary to achieve steelhead recovery in these streams.

HABITAT

GENERAL HABITAT RATIONALE

The primary focus of habitat restoration in the East San Joaquin Ecological Management Zone is directed at restoring riparian and riverine aquatic habitats. Many other habitats are important in providing for the diversity of fish, wildlife and plant species in this zone including seasonal wetlands, fresh emergent wetlands, and agricultural lands. Important areas that will provide these types of habitats include Merced National Wildlife Refuge and San Joaquin River National Wildlife Refuge which overlaps the East San Joaquin and San Joaquin River Ecological Management Zones. In addition, the Central Valley Habitat Joint Venture is implementing recommendations to improve seasonal wetlands and *agricultural lands through out the San Joaquin River and East San Joaquin Ecological Management Zones.*

Expansion of the San Joaquin River NWR will be an important component in providing the habitats required by waterfowl, shorebirds, and other neotropical migrant species. Congress has approved the 10,300 acre San Joaquin River NWR. Presently, the San Joaquin NWR encompasses about 800 acres of land along the east side of the San Joaquin River near the confluence of the Tuolumne River, and is working to acquire an additional 6,200 acres of fish and wildlife habitat on land adjacent to the existing refuge. Part of this expansion has recently been funded through the CALFED Category III habitat restoration program. This project will benefit Aleutian Canada geese, greater sandhill crane, western yellow-billed cuckoo, Swainson's hawk, riparian brush rabbit, riparian wood rat, valley elderberry longhorn beetle, splittail, waterfowl, shorebirds, herons, and neotropical migratory birds.

The Central Valley Habitat Joint Ventures goals for the San Joaquin Valley, including the East San Joaquin Ecological Management Zone, are to:

- *Protect 52,500 acres of existing wetland in perpetuity through fee acquisition or conservation easements,*
- *Restore and protect in perpetuity 20,000 acres of former wetlands,*
- *Enhance 120,300 acres of existing wetlands, and*
- *Enhance 15,290 acres of private agricultural lands to support nesting and wintering waterfowl.*

Some of these habitat improvement and restoration projects will occur in the East San Joaquin Ecological Management Zone.

RIPARIAN AND RIVERINE AQUATIC HABITAT

TARGET 1: Provide conditions for riparian vegetation growth along sections of rivers in the East San Joaquin Basin Ecological Management Zone (◆◆).

PROGRAMMATIC ACTION 1A: Purchase streambank conservation easements from willing sellers, or establish voluntary incentive programs to improve salmonid habitat and instream cover along the Stanislaus River.

PROGRAMMATIC ACTION 1B: Evaluate the benefits of restoring aquatic and riparian habitats on the Stanislaus River, including creating side channels to serve as spawning and rearing habitats for salmonids.

PROGRAMMATIC ACTION 1C: Purchase streambank conservation easements from willing sellers, or establish voluntary incentive programs to improve salmonid habitat and instream cover along the Tuolumne River.

PROGRAMMATIC ACTION 1D: Purchase streambank conservation easements from willing sellers, or establish voluntary incentive programs to improve salmonid habitat and instream cover along the Merced River.

RATIONALE: *Many wildlife species, including several species listed as threatened or endangered under the State and federal Endangered Species Acts (ESA) and several special-status plant species in the Central Valley, depend on or are closely associated with riparian habitats. Riparian habitats support a greater diversity of wildlife species than all other habitat types in California. Degradation and loss of riparian habitat have substantially reduced the habitat area available for associated wildlife species. Loss of this habitat has reduced water storage, nutrient cycling, and foodweb support functions.*

Improving low- to moderate-quality SRA habitat will benefit juvenile chinook salmon and steelhead by improving shade, cover, and food. Other wildlife in this Ecological Management Zone will also benefit from improved habitat. Protecting and improving SRA habitat may involve land use changes that will require the consensus of local landowners and local, State, and federal agencies. Limitations on land suitable or available for restoration will require establishing priorities, with efforts directed at acquiring high-priority, low-cost sites first.

Riparian habitat along the lower portions of the three rivers has been significantly reduced. Before the loss of habitats, riparian forests were an important component of the mosaic (mixture) of habitats in the San Joaquin Valley, providing habitat for many native wildlife species. The riparian community provides nutrient and woody debris input to the *aquatic system, as well as shade and increased bank stability. To restore the riparian community along the lower rivers, further riparian vegetation removal should be restricted, improved land management and livestock grazing practices should be implemented, and a riparian restoration program should be developed and implemented. Restoration actions will need to be consistent with flood control requirements. The importance of riparian restoration was identified by DFG (1993) and USFWS (1995).*

FRESHWATER FISH HABITAT AND ESSENTIAL FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination (◆◆).

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for East San Joaquin Ecological Management Zone ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater and essential fish habitats. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of the rivers in this ecological management zone and their floodplains, and in maintaining and restoring riparian and riverine aquatic habitats.*

STRESSORS

WATER DIVERSIONS

TARGET 1: Reduce entrainment of fish and other aquatic organisms into diversions to a level that will not impair salmon and steelhead restoration by screening 50% of the water volume diverted in the basin (◆◆◆).

PROGRAMMATIC ACTION 1A: Improve existing diversion screens on the lower Merced River.

PROGRAMMATIC ACTION 1B: Evaluate the feasibility of installing state-of-the-art screens on small pump agricultural diversions along the three streams.

PROGRAMMATIC ACTION 1C: Provide alternative water sources to diverters who legally divert water from spawning and rearing areas of the three streams.

PROGRAMMATIC ACTION 1D: Purchase water rights from willing sellers whose diversions entrain significant numbers of juvenile salmon or steelhead.

RATIONALE: *Five medium-sized gravity riparian diversions are located in the designated salmon spawning reach of the lower Merced River between Crocker-Huffman Dam and the State Route 59 bridge. Water-powered screens and nominal bypass systems were installed on two larger diversions in the mid-1980s. Gabion-type screens without bypass systems remain on the other three diversions. In addition, DFG surveys have identified numerous small pump diversions throughout the basin, none of which are adequately screened to prevent juvenile salmon entrainment. Entrainment losses at these pump diversions are unknown. Screening 50% of the diverted water volume at diversions with greatest risk to juvenile salmon and steelhead, as determined by monitoring, will help to define further screening needs.*

DAMS AND OTHER STRUCTURES

TARGET 1: Eliminate the loss of adult fall-run chinook salmon that stray into the San Joaquin River upstream of the Merced River confluence (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to eliminate blockage of upstream-migrating fall-run chinook salmon and steelhead at temporary irrigation diversion dams erected during the irrigation season.

PROGRAMMATIC ACTION 1B: Continue annual installation of a temporary weir on the San Joaquin River immediately upstream of the confluence with the Merced River to block adult salmon migration.

PROGRAMMATIC ACTION 1C: Evaluate the need to remove temporary diversion dams that block upstream salmon and steelhead passage into spawning grounds of three streams.

TARGET 2: Evaluate the feasibility of restoring steelhead access to historical habitats (◆).

PROGRAMMATIC ACTION 2A: Investigate the feasibility of providing access to historical steelhead spawning and rearing habitat above the dams on at least one of the three tributaries.

RATIONALE: *In recent years, drainage practices in western Merced County have increased agricultural return flows from Salt and Mud Sloughs into the mainstem San Joaquin River. These flows attract significant numbers of adult salmon into the sloughs and, subsequently, into irrigation canals, where no suitable spawning habitat is available (California Department of Fish and Game 1993). In fall 1991, an estimated 31% of the San Joaquin basin run strayed into westside canals. In the late 1980s, DFG established an adult trapping station at Los Banos Wildlife Refuge, where eggs were taken and reared at MRH. In fall 1992, DFG installed a temporary electrical barrier across the mainstem San Joaquin River immediately upstream from the confluence with the Merced River, which was highly effective in blocking fish passage into the westside irrigation canals. Since that time, a temporary weir has been installed at the site annually, which has also been effective in blocking passage.*

Temporary diversion dams are sometimes constructed in the river channel during the irrigation season. Such structures may hinder upstream salmon migration in the fall and early winter.

Because of the magnitude of spawning and rearing habitat loss for steelhead, providing access to historical habitat that is currently inaccessible due to dams will be a key element in their recovery. The feasibility of providing a means to transport adults and juveniles around the large dams needs to be investigated in the San Joaquin River system.

PREDATION AND COMPETITION

TARGET 1: Reduce adverse effects of non-native fish species that have a significant effect on juvenile salmon production in the rivers (◆).

PROGRAMMATIC ACTION 1A: Eliminate gravel pits within or connected to the rivers.

RATIONALE: *Introduced warmwater fish, such as largemouth and smallmouth bass, prey on juvenile salmonids rearing in the lower Merced River. Predation has been identified as a major factor contributing to the poor survival of salmon smolts emigrating from the river. Large pit areas created by inchannel gravel mining are excellent habitat for warmwater fish. Implementing a predator control program has been identified as a salmonid restoration action by USFWS (1995). Habitat improvement actions described above should help to reduce predator populations of largemouth and smallmouth bass. Other species of possible concern include striped bass, American shad, and resident rainbow and brown trout. All potentially occur in the three rivers, and all are known to feed on juvenile salmon and possibly steelhead. If any of these species become a problem, steps will be taken to reduce their effects.*

HARVEST OF FISH AND WILDLIFE

TARGET 1: Develop harvest management strategies that allow the spawning population of wild, naturally produced fish to attain levels that fully use existing and restored habitat; focus harvest on hatchery-produced fish (◆◆◆).

PROGRAMMATIC ACTION 1A: Control illegal harvest through increased enforcement.

PROGRAMMATIC ACTION 1B: Develop harvest management plans with commercial and recreational fishery organizations, resource management agencies, and other stakeholders to meet target.

PROGRAMMATIC ACTION 1C: Reduce the harvest of wild, naturally produced steelhead populations by continuing to mark all hatchery-reared fish and continuing to institute a selective fishery.

PROGRAMMATIC ACTION 1D: Evaluate a marking and selective fishery program for chinook salmon.

RATIONALE: *Restoring and maintaining chinook salmon and steelhead populations, as well as striped bass and white and green sturgeon, to levels that fully take advantage of available habitat may require restrictions on harvest during and even after the recovery period. Stakeholder involvement should help to balance available harvest allocation fairly. Target population levels may preclude existing harvest levels of wild, naturally produced fish. For populations supplemented with hatchery fish, selective fisheries may be necessary to limit the wild fish harvest while hatchery fish are harvested to reduce their potential to disrupt the genetic integrity of wild populations.*

The Fish and Game Commission recently adopted DFG recommendations to establish a selective fishery for hatchery steelhead and to reduce incidental hooking of wild steelhead in the San Joaquin and other Central Valley streams.

ARTIFICIAL PROPAGATION OF FISH

TARGET 1: Minimize the likelihood that hatchery-reared salmon and steelhead could stray into adjacent non-natal rivers and streams to protect naturally produced salmon and steelhead (◆◆◆).

PROGRAMMATIC ACTION 1A: Cooperatively evaluate the benefits of limiting stocking of MRH-reared salmon and steelhead to the Merced River.

TARGET 2: Employ methods to limit straying and loss of genetic integrity of wild and hatchery-supported stocks (◆◆◆).

PROGRAMMATIC ACTION 2A: Rear hatchery salmon and steelhead in hatcheries on natal streams to limit straying.

PROGRAMMATIC ACTION 2B: Limit stocking of salmon and steelhead fry and smolts to natal watersheds to minimize straying that may compromise the genetic integrity of naturally producing populations.

RATIONALE: *In watersheds like the San Joaquin basin, where dams and habitat degradation have limited natural spawning, some hatchery supplementation may be necessary to sustain fishery harvest at former levels and to maintain a wild or natural spawning population during adverse conditions, such as droughts. However, hatchery augmentation should be limited so it does not inhibit recovery and maintenance of wild populations. Hatchery-reared salmon and steelhead might directly compete with and prey on wild salmon and steelhead. Straying of adult hatchery fish into non-natal watersheds might also threaten the genetic integrity of wild stocks. Hatchery fish might also threaten the genetic makeup of stocks in natal rivers. Some general scientific information and theory from other river systems indicate that hatchery supplementation may limit the recovery and long-term maintenance of naturally producing salmon and steelhead populations. Further research and experimentation are necessary to determine how this issue is addressed. Long-term hatchery augmentation of healthy wild stocks may genetically undermine that stock and threaten the genetic integrity of other stocks.*

Adult straying into non-natal streams might result in interbreeding with a wild population specifically adapted to that watershed and thus lead to the loss of genetic integrity in the wild population. Releasing hatchery-reared fish into the San Joaquin River and its tributaries, other than the Merced River, could compromise the genetic integrity of wild salmon and steelhead populations.

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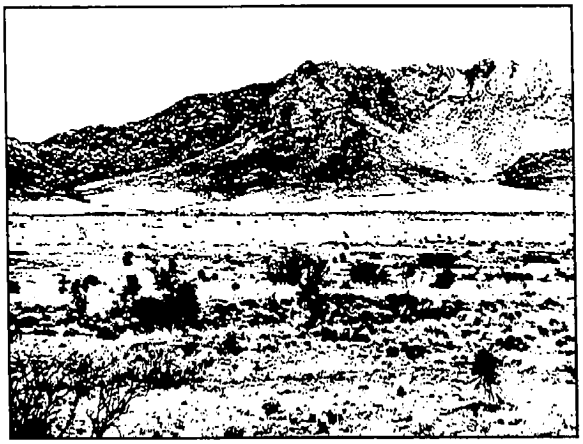
◆ West San Joaquin Basin Ecological Management Zone



Introduction

The West San Joaquin Basin Ecological Management Zone includes the eastern slope of the Coast Range and portions of the southwestern Central Valley. The zone is bounded on the north by the southern and western boundaries of the Sacramento-San Joaquin Delta Ecological Management Zone, on the east by the west bank of the San Joaquin River from the Stanislaus River to Mendota Pool, on the south by Panoche Creek, and on the west by the west slope of the Interior Coast Range. The West San Joaquin Basin Ecological Management Zone can indirectly contribute to the health of the Bay-Delta by providing much needed habitat for California red-legged frog, neotropical migrant birds, and waterfowl. Included in this Ecological Management Zone is the area between Orestimba Creek and Los Banos, a region which supports a number of federal and state-listed species, including the San Joaquin kit fox and blunt-nosed leopard lizard. About 33% of the remaining wetland acres in the Central Valley are clustered between Merced and Los Banos along the San Joaquin River. This is the largest contiguous block of remaining wetland habitat and associated upland communities.

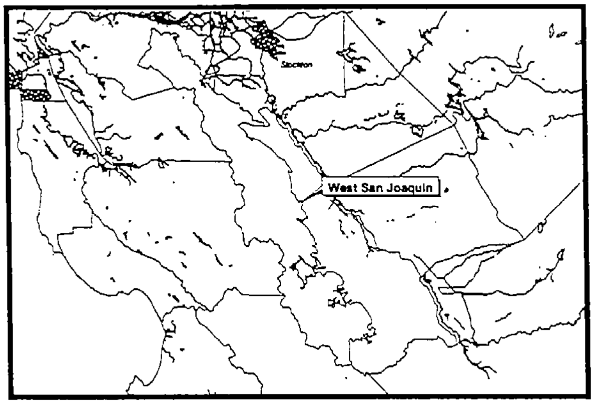
The West San Joaquin Ecological Management Zone also contains several stands of Central California sycamore alluvial woodlands. The largest of these stands is located on Los Banos Creek, in Merced County. The principal environmental conditions necessary for the perpetuation of this community are intermittent flooding over broad floodplains and stable subterranean water table during dry summer months (California Department of Fish and Game 1997).

Although the overall vision for this Ecological Management Zone is directed by its ability to contribute to the ecological health of the Sacramento-San Joaquin Delta, there exist many opportunities to build upon the CALFED vision to provide many additional landscape ecological benefits in the region. For example, CALFED actions could contribute, in part, to a long-term goal of providing a continuous band of connective habitats (riparian, wetland, vernal pool, grassland, and other upland habitats) joining the Sierra (Yosemite National Park) with grassland and vernal pool complexes on the east side of the valley.

Description of the Management Zone

The West San Joaquin Valley Ecological Management Zone has two distinct geomorphological (landform) areas: the hilly west-side arid watersheds and the valley floodplain on the eastern side adjacent to the San Joaquin River. The Delta-Mendota Canal of the Central Valley Project (CVP) and the California Aqueduct of the State Water Project (SWP) are dominant features of the zone from north to south, separating the hills from the valley. All watersheds in this zone flow east toward the San Joaquin River. Restoration efforts associated with the San Joaquin River corridor are addressed in the section on the San Joaquin River.

The zone has a Mediterranean climate. The northwestern portion of the zone is adjacent to the Delta, where the rain shadow effect and fog still have some influence. Within the rest of the zone, summers are hotter and longer winters are colder,



Location Map of the West San Joaquin Ecological Management Zone.

and rainfall averages are lower. The southern and eastern portion of the zone is best described as an agricultural belt with large blocks of seasonally managed wetlands on both public and privately managed lands in the Grasslands Subarea. While some other habitats exist in the Grasslands Subarea, they are extremely narrow, fragmented, and widely scattered. Habitats that do remain include grasslands, seasonal wetlands, and riparian woodlands. The grasslands have been reduced to narrow strips within the rights-of-way along the California Aqueduct and Delta-Mendota Canal; other grasslands persist in scattered cattle ranches. Low quality seasonal wetlands can be found as small clumps of vegetation that persist in drainages and sumps associated with the Aqueduct and Canal. In addition, remnant riparian areas can be found along some drainages and tributaries associated with the Aqueduct and Canal.

The northern and western portions of the zone are best characterized as rolling hills of the coastal mountain range. The upper third is still within the influence of weather patterns associated with the Carquinez Strait. Fog and moisture from the rain shadow effect separates this area from the southern two-thirds of the unit, where the climate is more Mediterranean. While the northern area receives greater rainfall and moisture, the habitats found in the north and south are relatively similar. The dominant type is grassland, managed as cattle pastures. Savannas (grasslands with few trees) are common on the hills as the slopes stretch out of the Valley, while woodlands are prevalent along the creeks and their watersheds. Patches of seasonal wetlands can also be found along some creeks.

The Orestimba Creek and Los Banos Creek drainages are excellent examples of relatively undisturbed, natural, coast range watersheds. While the grasses have become predominately annuals (before European influence, these grasslands were dominated by perennial grass species), they still flourish and lead into wooded areas at the higher elevations and riparian woodlands along the creeks. There are two very significant stands of Sycamore Alluvial Woodlands that compose more than one-third of all remaining acreage of this habitat type within the Central Valley. Most of the landscape is rolling hills of the coastal range, with grasslands in the lower elevations and woodlands higher up. The geomorphology of these watersheds has remained relatively unchanged.


Orestimba Creek showing a sycamore alluvial woodland.

Biological resources in this area include the San Joaquin kit fox, San Joaquin antelope squirrel, kangaroo rats, neotropical migrant birds, California red-legged frog, foothill yellow-legged frog, waterfowl, upland game, western pond turtles, sycamore alluvial woodlands, vernal pools, as well as many other native plants and wildlife found in the several habitat types. Some unique animal and plant communities are found in some equally unique habitats, such as the vernal pool-hog wallow grassland found on the Flying M Ranch in Merced County.

Important ecological processes essential to maintaining and restoring a healthy West San Joaquin Basin Ecological Management Zone are floodplain, stream, and watershed processes, including streamflow, overbank flooding (which is particularly important for maintaining the remnant Central California sycamore alluvial woodlands), floodplain inundation, sedimentation and erosion, and fire. Fire is important for maintaining, or altering grassland and shrubland health through fuel reduction and plant succession and reproduction.

Streamflow in this arid zone, despite being intermittent and prone to flash flooding, is an essential determinant of habitat, as well as species distribution and abundance. Floodplain and stream channel processes are essential for dissipating the forces of flood flows and distributing sediments carried by them.

Though many of the streams along the west side of the San Joaquin Valley are naturally intermittent, maintaining natural winter and spring flows in the streams is important for maintaining floodplain processes, such as meander belts, and stream channel configurations, as well as riparian and wetland habitats. Streamflows have been modified by water diversions, subsidence (lowering) in groundwater tables, and watershed activities, such as grazing, road building, forest management, and agriculture.

In addition to changes in streamflow, floodplain processes have been altered by floodplain development, including flood control levees, gravel mining, and other land uses.

The West San Joaquin Basin Ecological Management Zone has many habitat types including:

- **AGRICULTURE:** the hills and lowlands of the valley that support crops,
- **WETLANDS:** the lowlands of the valley that are permanently or seasonally watered,
- **COASTAL SCRUB:** a low growing shrubby cover on the coastal hills,
- **CHAPARRAL:** dense shrubs found growing above the coastal scrub community,
- **OAK WOODLAND:** almost park-like sites with trees and shrubs in fairly open stands with a rich carpet of grass and other herbaceous growth,
- **OAK SAVANNA:** the transitional community between the woodlands of the hills and the grasslands of the broad valleys, where the trees are fewer in number and more widely spaced than those of the woodlands,
- **GRASSLAND:** areas that stand below the hillside wooded areas, and are green and littered with wildflowers in the spring followed by the gold of summer as the annual and perennial grasses go dormant during the dry season,
- **RIPARIAN FOREST:** a continuum of plant communities following the topographic line from the stream channel through the low and high terrace deposits of the floodplain; transition to non-riparian is usually abrupt, especially near agriculture;
- **SEASONAL WETLANDS:** areas within the grasslands and along the tributaries and drainages that remain inundated with water for varying periods after the rains and high flows have subsided; and
- **SYCAMORE ALLUVIAL WOODLANDS:** sycamore woodlands found along Los Banos and Orestimba creeks that require high soil moisture during the initial growth annual cycle followed by a significant reduction in the water table during the later part of the growing season.

These habitats are used by a wide variety of fish, wildlife, and plants, including many listed species (i.e., species identified by resource agencies as threatened or endangered). Coastal scrub and chaparral provide habitat for a variety of wildlife. Numerous rodents inhabit chaparral; deer and other herbivores often make extensive use of this habitat type, which provides critical summer range foraging areas, escape cover, and fawning habitat. Many birds, such as quail, fulfill a variety of their habitat needs in the chaparral, such as foraging needs (seeds, fruits, insects), protection from predators and climate, as well as singing, roosting, and nesting sites.

The oak woodland and savanna habitats are home to as many as 29 species of amphibians (salamanders) and reptiles, 79 bird species, and 22 mammal species. Seasonal wetlands provide habitat for many species, such as waterfowl, pond turtles, salamanders, as well as endemic (adapted to a particular locality) plants. Grassland habitat, as well as some of the special habitat features, such as cliffs, caves, and ponds found within grasslands, are used by many species, including tiger salamanders. Some of the more arid grassland species are listed as threatened or endangered. The riparian habitats provide food; water; migration and dispersal corridors; and escape, nesting, and thermal cover for wildlife. As many as 147 bird species, nesters, or winter visitants, as well as 55 species of mammals, are known to use this habitat type within this Ecological Management Zone.

Sloughs and ponds within and adjacent to wetlands in the San Joaquin Valley are important habitat for waterfowl, as well as many plant and wildlife species. They include many rare or declining species that have special status, such as being listed under the State or federal Endangered Species Acts (ESA).

Marshes, once the most widespread habitat in the San Joaquin Valley floodplain, are now restricted to remnant patches. There have been extensive fresh emergent wetland habitat losses to agricultural development. Most of the remaining wetlands lack adjacent upland transition habitat and other attributes of fully functioning wetlands because of agricultural practices. Emergent wetland habitat provides important habitat for many species of plants, waterfowl, and wildlife. In addition, wetlands contribute important plant detritus and nutrient recycling to the aquatic foodweb of the San Joaquin River and Bay-Delta estuary, as well as important habitat to some species of fish and aquatic invertebrates.

Seasonal wetlands include portions of the floodplain that seasonally flood, usually in winter and spring, especially in high flow years. Most of this habitat is located in the valley floor adjacent to the San Joaquin River and nearby perennial wetlands. Such habitats were once very abundant during the winter rainy season or after seasonal flooding. With reclamation (draining wetlands for other uses), flooding occurs primarily from accumulation of rainwater behind levees, directed overflow of flood waters to bypasses, or flooding leveed lands (e.g., managed wetlands). Seasonal wetlands are important habitat to many species of fish, waterfowl, shorebirds, and other wildlife.

Upland habitats are found on the outer edges of valley wetlands and consist primarily of grasslands and remnant oak woodland and oak savanna. Of these, perennial grasslands are an important transition habitat for many wildlife species. They act as buffers to protect wetland and riparian habitats. Much of the grassland habitat associated with wetland and riparian habitat has been lost to agriculture (e.g., pasture, grain, vineyards, and orchards) and development (e.g., home construction, golf courses). Grasslands provide habitat for many plant and animal species.

Riparian habitat, both forest and shrub, is found on the water and land side of levees and along stream channels of the zone. This habitat ranges in value from disturbed (i.e., sparse, low value) to relatively undisturbed (i.e., dense, diverse, high value). The highest value riparian habitat has a dense and diverse canopy structure with abundant leaf and invertebrate biomass. The canopy and large woody debris in adjacent aquatic habitat provide shaded riverine aquatic (SRA) habitat on which many important fish and wildlife species depend during some portion of their life cycles. The lower value riparian habitat is frequently mowed, disced, or sprayed with herbicides, resulting in a sparse habitat structure with low diversity. Riparian habitat along intermittent streams is lost to excessive erosion and livestock grazing. Riparian habitat is used by more wildlife than any other habitat type. From about 1850 to the turn of the century, most of the riparian forests in the Central Valley were decimated for fuelwood as a result of the gold rush, river navigation, and agricultural clearing. Remnant patches are found on levees, along stream channels, and along the margins of marshes. Riparian habitats and their adjacent SRA habitat benefit fish and wildlife species.

Agricultural habitats also support populations of small animals, such as rodents, reptiles, and amphibians, and provide opportunities for foraging raptors (soaring birds of prey). Nonflooded fields and pastures are also habitat for pheasants, quail, and doves. The marshes along the Valley floor support a variety of wintering and breeding raptors. Preferred habitat consists of tall trees for nesting and perching near open agricultural fields, which support small rodents and insects for prey. Both pasture land and alfalfa fields support abundant rodent populations. The Swainson's hawk, a raptor species listed by the State as threatened, breeds and occasionally winters in the Central Valley.

Stressors to ecological processes, habitats, and species within this zone include land uses, such as urban and industrial development; water diversions; land reclamation; water conveyance structures; livestock grazing; exotic (non-native) species; gravel mining; contaminants; wildfire, levees; bank protection; stream channelization; irrigation canals; and agricultural practices. These stressors have contributed to a change in native plant communities, fragmentation of riparian habitats, and interrupted migration corridors for species, such as the State and federally listed San Joaquin kit fox. Streamflows patterns and natural stream meandering have been altered by many of these stressors.

There are increased amounts and concentrations of contaminants in the San Joaquin River. Agricultural drainage and associated contaminants that originate in the West San Joaquin Basin Ecological Management Zone, or are transported to this Ecological Management Zone from agricultural lands to the south in the Westlands Subarea, are a significant source of contaminants reaching the Bay-Delta.

Other stressors include dams, reservoirs, and other structures. They have further contributed to habitat fragmentation and are barriers to wildlife movement and dispersal.

Water diversions from streams and adjacent marshes divert streamflow that is important to habitat and species of the zone. Diverted water is used primarily locally.

Toxins continue to enter the streams and adjacent marshes in large amounts from municipal, industrial, and agricultural discharges. The toxins have had a demonstrated effect on the health, survival, and reproduction of waterfowl, fish, and wildlife.

The riparian zones of west San Joaquin Valley streams are typical habitat of the California red-legged frog. Loss of riparian and adjacent upland habitats have led to declining frog populations in this zone and elsewhere in the Central Valley. Non-native predatory fish, such as largemouth bass in Central Valley ponds have also contributed to the decline of the frog.

Neotropical migratory birds depend on the riparian corridors of the creeks and wetlands of the San Joaquin Valley. Conversions of vegetative cover by agricultural practices and loss of riparian habitats, along with competition and predation by non-native species, have reduced populations of these migrants.

The San Joaquin Valley, with its wetland complexes, is an important waterfowl area. Large numbers of ducks, geese, and swans winter in the Valley, depending on the high-quality foraging habitat of the wetlands and adjacent riparian, upland, and agricultural habitats to replenish their energy reserves.

LIST OF SPECIES TO BENEFIT FROM RESTORATION ACTIONS IN THE WEST SAN JOAQUIN BASIN ECOLOGICAL MANAGEMENT ZONE

- native resident fishes
- neotropical migrant birds
- California red-legged frogs and other native anuran amphibians,
- native resident fishes,
- upland game,
- plant community groups, and
- waterfowl.

VISION FOR THE ECOLOGICAL MANAGEMENT ZONE

The vision for the West San Joaquin Basin Ecological Management Zone includes improved water quantity and quality from the basin to wetlands and the San Joaquin River. The vision also includes a range of sustainable aquatic, wetland, riparian, and upland habitats that support abundant natural production of resident fish and wildlife, as well as waterfowl and other migrant birds that use the Pacific Flyway each winter. The vision includes enlarging remaining native habitats and connecting those areas.

The vision focuses on improving watershed, stream channel, and floodplain processes. The result would be increased seasonal flows of quality water to the San Joaquin River and area wetlands and reduced input of agricultural waste runoff and associated contaminants into zone watersheds and wetlands and the San Joaquin River. Improved quality and quantity of water for publicly and privately managed wetlands will reduce stresses on waterfowl populations. Improved water quality and quantity in the San Joaquin River will directly benefit fish and wildlife of the San Joaquin River and the Bay-Delta.

The ERP will focus on habitat restoration and water quality improvements in the southern and eastern portions of this zone. A particular focus is agricultural drainage that contains extremely high selenium concentrations. Selenium is present in such high concentrations in some areas that there are potential human and wildlife health problems. Seasonal wetlands for migratory species, such as waterfowl and shore birds, should be expanded and improved. Present restoration efforts can be expanded by providing adequate high quality water to the seasonal wetlands. Water supplies can be improved by reducing or eliminating diversions in streams and sloughs that flow into agricultural lands. Restoring natural watershed, stream, and floodplain processes on west side tributaries to the San Joaquin River, including Mud and Salt sloughs, Orestimbe Creek, and Los Banos Creek, will promote natural habitat restoration. Emphasis should also be placed on connecting habitats and providing unbroken habitat corridors necessary for species such as the San Joaquin kit fox, kangaroo rats, waterfowl, and neotropical birds.

Throughout much of the northern portion of the zone are numerous intermittent creeks and streams. Restored, they would provide higher quality water and improved habitats. Excluding cattle along the streams and creeks, removing gravel mining, and reducing diversions would improve stream channels and riparian corridors. Reforestation of sycamores has not been possible, because cattle range through the creek bottoms and landowners are continuously moving the rock beds around to pool water for the cattle during the summer months, when surface flows are minimal.

The narrow strips of grasslands along the California Aqueduct and Delta-Mendota Canal are managed intensively to suppress wildfires and erosion. The adjacent tributaries or drainages are also managed for vegetation control to increase the runoff into the conveyance systems. Practices should be modified to benefit species such as the San Joaquin kit fox, kangaroo rats, California red-legged frog, and native plants, such as perennial grasses. Alternatives to pesticides should be developed, or pesticides eliminated. This would encourage natural recovery of predator species like the kit fox, which help keep pest species in balance, while reducing contaminants entering the system. Vegetation control practices should also be modified to support the recovery of native plants, such as perennial grasses and wetland species in the local watersheds.

Extensive wetland areas in the eastern portions of the zone adjacent to the San Joaquin River should be protected and expanded. Stream flow into the wetland-slough complexes should be improved. Water quality should also be improved. Natural floodplain processes should be enhanced through setback levees, stream meanders, and seasonal flood overflow basins, which should reduce peak flood flows to the San Joaquin River.

VISIONS FOR ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOW: Where possible, natural streamflows will be protected, enhanced, and restored to support riparian habitat and important species.

NATURAL FLOODPLAIN AND FLOOD PROCESSES: Where possible, natural floodplain processes will be preserved by allowing winter-spring flows to overflow into riparian and wetland habitats. Natural stream meanders will be encouraged by removing, where possible, constraints on meander belts, such as levees and bank protection. Natural floodplain overflow will help to collect floodwaters and sediment and dissipate the erosive forces of flood waters.

VISIONS FOR HABITATS

RIPARIAN AND RIVERINE AQUATIC HABITATS: Riparian habitat, both forest and shrub, will be protected and expanded along zone streams and wetlands. Remnant patches of high-quality riparian habitat will be protected. Disturbed habitat will be restored, where possible. Agricultural and grazing practices will be modified in riparian zones to encourage riparian and SRA habitat recovery along streams. Improvements in stream flows will also benefit riparian zones.

NONTIDAL PERENNIAL AQUATIC HABITAT: Existing sloughs and ponds within and adjacent to wetlands in the San Joaquin Valley will be protected and new aquatic habitat created.

EMERGENT WETLAND HABITAT: Remnant patches of marshlands will be expanded and connected, where possible. New wetlands will be created.

SEASONAL WETLAND HABITAT: Existing seasonal flooding areas will be protected and sources of water maintained or expanded to promote higher quality wetlands, especially in drier years. Areas where seasonal flooding develops, seasonal wetlands will be expanded.

PERENNIAL GRASSLANDS: Upland habitats around the outer edges of wetlands will be protected and expanded. Grasslands and remnant oak woodland and oak savanna will be restored, where possible.

FRESHWATER FISH HABITAT: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native fish species. The streams in the West San Joaquin Basin Ecological Management Zone are typical California roach streams that are small, mid-elevation stream that typically contain deep pools in canyons and are often intermittent in flow by late summer (Moyle and Ellison 1991).

AGRICULTURAL LANDS: Agricultural practices that provide valuable wildlife habitat will be encouraged. Riparian and upland habitats will be protected and expansion encouraged.

VISIONS FOR REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS: Water diversions along valley streams and adjacent marshes will be reduced, where possible and needed, to protect and enhance riparian and wetland habitats. Greater streamflows, especially in drier years, will provide for expanded riparian habitat.

CONTAMINANTS: Reduced input of toxins to valley streams and wetlands will improve health, survival, and reproduction of many important waterfowl and other wildlife. Reduced toxins also will reduce contaminant effects on fish and wildlife in the San Joaquin River and the Bay-Delta. Levels of toxins in the fish tissues should be reduced.

VISIONS FOR SPECIES

RESIDENT NATIVE FISH SPECIES: Many native fish species will benefit from improved aquatic habitats and stream channel/floodplain processes. Population abundance indices should remain stable or increase and population sizes should be large enough fully to recover from natural and human-induced disasters. The distribution of native resident fishes should increase with widespread habitat restoration.

NEOTROPICAL MIGRANT BIRDS: Protection, restoration, and enhancement of large, contiguous areas of riparian and wetland habitats that contain a great diversity in composition, density, and make-up will benefit the recovery of listed neotropical migrants such as yellow-billed cuckoo as well as aid in the prevention of future listing of additional bird species.

CALIFORNIA RED-LEGGED FROG: Protection, restoration, and enhancement of the zone streams and associated riparian and upland habitats will benefit the recovery of the red-legged frog. Efforts to manage invasive species such as the bullfrog will also be carried out, where necessary, to benefit the recovery as well.

WESTERN POND TURTLE: The vision for the western pond turtle is to maintain the abundance and distribution of this California species of special concern in order to contribute to the overall species richness and diversity. Protecting existing and restoring additional suitable wetland and upland habitats will be critical to achieving recovery of the western pond turtle.

NATIVE ANURAN AMPHIBIANS: The vision for the native anuran species is to stop habitat loss and the introduction of other species that prey on the different life stages of these amphibians. Ongoing surveys to monitor known populations and find additional populations is essential to gauge the health of the species in this group. To stabilize and increase anuran populations, non-native predator species should be eliminated from historic habitat ranges. Increasing suitable habitat and maintaining clean water supplies that meet the needs of the various species in this group is essential.

WATERFOWL: Protection, restoration, and enhancement of wetland complexes and beneficial agricultural habitats with adjacent upland habitats will improve waterfowl use.

PLANT SPECIES AND COMMUNITIES: The vision for plan species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland and riparian and riverine aquatic habitats.

VALLEY ELDERBERRY LONGHORN BEETLE: The vision fr the valley elderberry longhorn beetle is to recover this federally listed threatened species by increasing its populations and abundance through restoration of riparian systems.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Much of the vision for the West San Joaquin Valley can be accomplished through cooperative efforts of landowners, agencies, and other stakeholders. Watershed conservancy organizations should be established to structure such cooperative efforts. Funding and technical support should be provided to these conservancies to oversee and conduct much of the restoration work.

Some lands marginal for agriculture because of poor drainage can be purchased from willing sellers for conversion to wildlife habitat. Incentive plans should be developed to allow land owners to maintain their lands and habitats consistent with the vision. Agricultural management plans that are more friendly to wildlife, because studies have shown that soil productivity can be increased by leaving land out of production for extended periods. Such practices, programs, and efforts can restoring blocks of wildlife habitat for relatively long periods of time while enhancing crop production and lessening the need for fertilizers and chemicals. Incentives should be developed to encourage landowners maintain at least 10% of their land as fallow or non-agriculture. Additional incentives should be offered to land owners to convert portions of their lands to natural habitats permanently. This would effectively reduce the stress of land use practices and the use of contaminants and improve wildlife habitat. An additional incentive program might entail livestock exclosures to protect stream banks and allow sycamores and opportunity to regenerate.

Much of the vision can be accomplished through established restoration programs on federal and State lands, as well as on private lands. The Southern San Joaquin Valley Ecosystems Protection Program was initiated in 1986 to provide a foundation for planning now to protect future ecosystems and sensitive species in the Southern San Joaquin Valley. This program identifies opportunities to protect and to restore the connectivity of the remaining natural habitat. The San Joaquin Drainage Implementation Program is similar.

NONGAME MIGRATORY BIRD HABITAT CONSERVATION PLAN

The U.S. Bureau of Land Management administers a habitat conservation plan for nongame migratory birds. Recommendations are provided; however, no funding is presently available.

CENTRAL VALLEY HABITAT JOINT VENTURE

The Central Valley Habitat Joint Venture is a component of the North American Waterfowl Management Plan of the USFWS with funding and cooperative projects of federal, State, and private agencies. New sources of funding including CALFED restoration funds are being sought to implement the joint venture. The joint venture has adopted an implementation plan that includes the west side of the San Joaquin Valley. Objectives include protection of wetlands through acquisition of in-fee title or conservation easements, and enhancement of waterfowl habitat in wetlands and agricultural lands. The objectives and targets of the joint venture have been adopted by the ERP.

MANAGEMENT PLAN FOR AGRICULTURAL SUBSURFACE DRAINAGE AND RELATED PROBLEMS ON THE WESTSIDE SAN JOAQUIN VALLEY

This plan is a framework for reducing impacts of contamination by agricultural drainage water. The plan was prepared by the California Resources Agency, DWR, Reclamation, USFWS, and USGS.

San Joaquin River Management Plan

State Assembly Bill 3606 authorizes the San Joaquin River Management Plan to identify factors adversely affecting the San Joaquin River and its tributaries. Problems being considered are flood protection, water supply, water quality, recreation, and fish and wildlife. Emphasis is on a plan to restore and manage riparian corridors, floodways, non-native vegetation removal, wetland restoration, and basin water quality. The plan was developed by DWR and is administered by the San Joaquin River Parkway and Conservation Trust.

Linkage to Other Ecological Management Zones

Many of the habitats, processes, and stressors found within this Ecological Management Zone are similar to those found in the Fresno Slough/Mendota Basin Subregion, and East San Joaquin Ecological Management Zone. Efforts within one Ecological Management Zone should be similar to those in adjacent zones providing connectivity where needed and cumulative benefits to the system.

Restoration Targets and Programmatic Actions

Ecological Processes

Central Valley Streamflows

Target 1: Provide flows of suitable quality water that more closely emulate (imitate) natural annual and seasonal streamflow patterns in West San Joaquin tributary watersheds. Provide a total watershed flow of 250 to 500 cfs to the San Joaquin River in dry and normal years for a 10-day period in late April to early May (approximately 5,000 to 10,000 af) (◆).

Programmatic Action 1A: Enter into agreements with water districts and wetland managers to provide return flows of high quality water from irrigated agriculture and seasonal wetlands to the San Joaquin River.

Programmatic Action 1B: Enter into agreements with landowners and water districts to limit diversions of natural flows from streams to improve streamflows.

Programmatic Action 1C: Make seasonal releases from the California Aqueduct or Delta-Mendota Canal into streams and wetlands.

Programmatic Action 1D: Limit capture of natural stream flows from westside tributaries into irrigation canals and ditches and State and federal aqueducts.

Rationale: *The proposed supplemental flows were selected as a representative value for impact analysis in the Programmatic EIS/EIR. Throughout the ERP, the need to determine optimal streamflow for ecological processes, habitats, and species is repeated. The issues of supplemental flows are complex in term of ecosystem improvements. The frequency, magnitude, duration, timing and rate of change of streamflows that form channels, create and maintain riparian habitat (including all species of vegetation), and promote all life stages of the various aquatic species dependent on a particular stream will never occur within a single year. An optimal flow regime will have to vary, perhaps significantly, from year to year. The supplemental flow recommendations will be an intensive exercise in adaptive management and must be based on credible scientific underpinnings.*

Natural streamflow patterns are important in maintaining geomorphology of watersheds, as well as riparian and floodplain vegetation along stream banks. Streamflow is also essential for the well being of valley wetlands and contributes to the flow of the San Joaquin River and to Delta inflow.

Natural Floodplain and Flood Processes

Target 1: Restore 10 to 25 miles of stream channel, stream meander belts, and floodplain processes along westside tributaries of the San Joaquin River (◆◆).

Programmatic Action 1A: Enter into agreements with willing landowners and irrigation districts to set back levees and allow floodplain processes such as stream meander belts.

PROGRAMMATIC ACTION 1B: Expand existing floodplain overflow basins by obtaining easements of titles from willing sellers of floodplain lands.

PROGRAMMATIC ACTION 1C: Reduce or eliminate gravel mining and stream bed altering from active stream channels.

RATIONALE: *Restoring natural stream channel and floodplain processes will help restore natural habitat and vegetation.*

HABITATS

NONTIDAL PERENNIAL AQUATIC HABITAT

TARGET 1: Evaluate the feasibility of restoring 1,000 acres of perennial aquatic habitat within and adjacent to existing wetlands (◆◆).

PROGRAMMATIC ACTION 1A: Manage existing wetlands so that they maintain 40 percent open water and 60 percent vegetation.

RATIONALE: *Aquatic habitats provide valuable foraging and resting habitats for waterfowl.*

FRESH EMERGENT WETLAND HABITAT

TARGET 1: Evaluate the feasibility of restoring or creating fresh emergent wetland habitat (◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to acquire, in-fee title or through a conservation easement, the land needed for tidal restoration, and complete the needed steps to restore the wetlands.

RATIONALE: *Aquatic habitats provide valuable foraging and resting habitat for waterfowl and habitat for a variety of special status species.*

PERENNIAL GRASSLAND HABITAT

TARGET 1: Evaluate the feasibility of preserving and restoring perennial grassland habitats (◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to restore perennial grasslands by acquiring conservation easements or purchasing land from willing sellers.

RATIONALE: *Restoring wetland, riparian, and adjacent upland habitats in association with aquatic habitats is an essential element of the restoration strategy for this Ecological Management Zone. Eliminating fragmentation and restoring connectivity will enhance habitat conditions for special-status species.*

SEASONAL WETLAND HABITAT

TARGET 1: Evaluate the feasibility of creating or improving seasonal wetland habitats (◆).

PROGRAMMATIC ACTION 1A: Acquire lands adjacent to existing seasonal wetlands from willing sellers or conservation easements.

TARGET 2: Provide 150,000 af of water to existing wetlands to improve waterfowl habitat (◆).

PROGRAMMATIC ACTION 2A: Provide water to wetlands on a seasonal basis from the California Aqueduct, Delta-Mendota Canal, or other source.

RATIONALE: *Improved seasonal wetland habitat will provide additional seasonal habitat for waterfowl.*

RIPARIAN AND RIVERINE AQUATIC HABITATS

TARGET 1: Restore 5 miles of riparian habitat totaling 500 to 1,000 acres (◆◆).

PROGRAMMATIC ACTION 1A: Restore riparian forest habitat on lands purchased from willing sellers or obtained via conservation easements.

RATIONALE: *Additional riparian forest habitat would improve habitat for many special status plant and animal species.*

FRESHWATER FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination (◆◆).

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat is evaluated in terms of its quality and quantity. Actions described for West San Joaquin Basin Ecological Management Zone ecological processes, stressor reduction, and riparian and riverine aquatic habitat* *should suffice to maintain and restore freshwater fish habitats. For example, maintaining freshwater fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of the rivers in this ecological management zone and their floodplains, and in maintaining and restoring riparian and riverine aquatic habitats.*

AGRICULTURAL LANDS

TARGET 1: Restore and maintain migration corridors of native plants of more than one mile in width (◆).

PROGRAMMATIC ACTION 1A: Purchase land or conservation easements on which to restore wildlife habitat to connect existing grassland or agricultural wildlife habitat.

RATIONALE: *Corridors of habitat are necessary between larger habitat areas to ensure potential recovery of kit fox populations in the San Joaquin Valley.*

STRESSORS

CONTAMINANTS

TARGET 1: Evaluate the feasibility of reducing the application of herbicides, pesticides, fumigants, and other agents toxic to fish and wildlife on 20,000 acres of agricultural lands that have the greatest risk to fish and wildlife populations (◆).

PROGRAMMATIC ACTION 1A: Acquire land from willing sellers in areas with demonstrated subsurface agricultural drainage problems and elevated levels of selenium and return those lands to native alkaline scrub habitat.

PROGRAMMATIC ACTION 1B: Enter into conservation easements with willing landowners to modify agricultural practices in ways to reduce loads and concentrations of contaminants.

PROGRAMMATIC ACTION 1C: Provide incentives to landowners to modify agricultural or other land use practices that contribute to the input of contaminants into waterways.

RATIONALE: *Reducing the inputs of contaminants into waterways from the lands with the greatest inputs would provide significant improvement in water quality in streams and wetlands, as well as in the San Joaquin River and Bay-Delta.*

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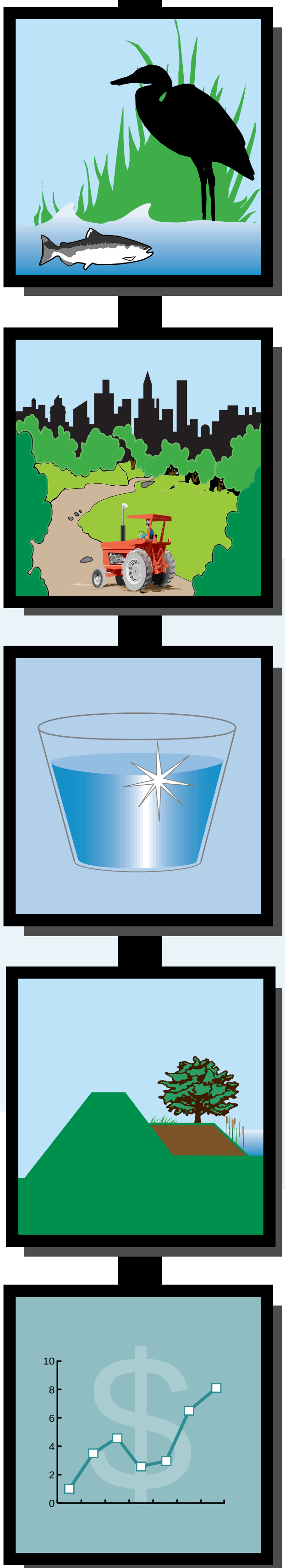
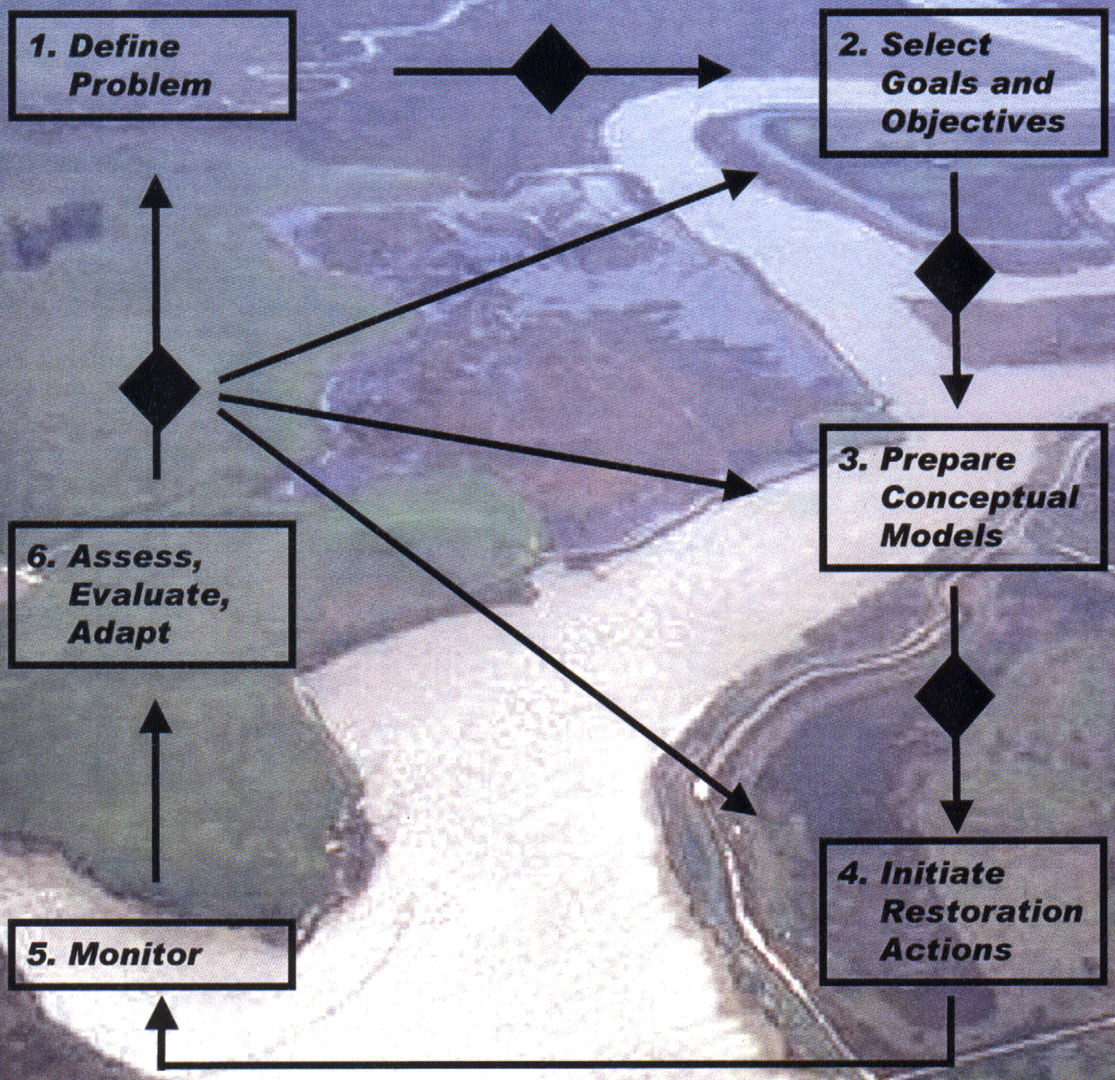


CALFED
BAY-DELTA
PROGRAM

Ecosystem Restoration Program Plan
Strategic Plan for Ecosystem Restoration

Final Programmatic EIS/EIR Technical Appendix
July 2000

ECOSYSTEM RESTORATION PROGRAM



STRATEGIC PLAN FOR ECOSYSTEM RESTORATION

CALFED
BAY-DELTA
PROGRAM

July 2000

CALFED BAY-DELTA PROGRAM STRATEGIC PLAN FOR ECOSYSTEM RESTORATION

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Overview of the Development of the CALFED Strategic Plan for Ecosystem Restoration

Impetus for the Strategic Plan: Scientific Review Panel

In October 1997, CALFED convened a panel of eight independent scientists for a four-day workshop to review the 1997 version of the three-volume Ecosystem Restoration Program Plan (ERPP). To ensure an independent and objective review, the panel was composed of nationally recognized scientists with experience in many of environmental restoration programs around the country but were not involved in Bay-Delta system issues. The following scientists served on the panel:

- Panel Chair, Dr. Ken Cummins, South Florida Water Management District, presently with the Cooperative Fisheries Unit, Humboldt State University, Arcata, California
- Dr. Paul Angermeier, Virginia Tech, Blacksburg, Virginia
- Dr. Michael Barbour, University of California, Davis, California
- Dr. Chris D'Elia, Maryland Sea Grant College State University New York, Albany, New York
- Dr. Tom Dunne, University of California, Santa Barbara, California
- Dr. Jack McIntyre, fisheries consultant, Henderson, Nevada
- Dr. Dennis Murphy, University of Nevada, Reno, Nevada
- Dr. Joy Zedler, San Diego State University, San Diego, California (Currently at University of Wisconsin)

In reviewing the ERPP, the panel drew upon their broad expertise in terrestrial, wetland and aquatic ecology, fisheries, plant and conservation biology, and physical processes. They also drew upon their experience in the nation's largest ecosystem management efforts including Chesapeake Bay, South Florida/Everglades, Columbia River, and other programs. Due to the brief review period and the panelists' limited experience in the Bay-Delta system, the panel did not evaluate individual actions described in the ERPP documents, but instead focused their comments on the conceptual framework of the Ecosystem Restoration Program. (The panel's Key Points and Recommendations are included in the text box on the following page.) The panel offered many constructive comments and recommendations on improving the presentation of the program's approach, utilizing scientists in the development and review of the program, employing conceptual models as educational and analytical tools, and developing an adaptive management strategy.

A key criticism by the panel was that the 1997 version of the ERPP was a plan—a menu of options—without a clear strategy for implementation. The panel provided specific recommendations on preparing a concise strategic plan document. One purpose of the strategic plan would better describe the approach of the program. It should clarify whether the program strives for true "restoration"—reverting to an historic condition—or simply rehabilitation of the ecosystem. It should also simplify and clarify ERP goals and objectives on the basis of conceptual models. The strategic plan should also provide better definition to the adaptive management strategy, including the use of conceptual and quantitative models; the use of goals and objectives to organize the adaptive management process; the development of testable hypotheses for management actions; and the design of actions as experiments. Lastly, the plan should also describe how new scientific expertise would be engaged in the development and review of the program.

Strategic Plan Core Team

Interested agricultural, urban and environmental stakeholders and CALFED staff collaborated to identify components of a strategic plan that would address the panel's key recommendations. Staff and stakeholders also recruited a team of distinguished independent scientists and environmental planners to prepare the document. A six-member team, referred to as the Core Team, spent four months during the summer and fall of 1998 developing the independent report entitled: "Strategic Plan for the Ecosystem Restoration Program." The following environmental scientists and planners served on the Core Team:

- Dr. Michael Healey, University of British Columbia, Vancouver, British Columbia
- Dr. Wim Kimmerer, San Francisco State University, Romberg Tiburon Center, Tiburon, California
- Dr. Matt Kondolf, University of California, Berkeley, California
- Dr. Peter Moyle, University of California, Davis, California
- Mr. Roderick Meade, R.J. Meade Consulting, La Jolla, California
- Dr. Robert Twiss, University of California, Berkeley, California

The focus of the Core Team's effort was to describe the ecosystem-based, adaptive management approach that will be used to refine and implement the Ecosystem Restoration Program. In particular, the plan identifies a process for prioritizing the programmatic actions described in Volume II of the ERPP. The plan added clear restoration goals and quantifiable objectives, replacing the less-specific implementation objectives in the 1997 version of the ERPP. The Core Team also identified critical ecological issues that must be addressed early in implementation as well as restoration opportunities to address those critical issues.

INTERIM SCIENCE BOARD

In January 2000, CALFED convened the Interim Science Board (ISB), which is comprised of nationally recognized independent scientists, to help CALFED staff refine the ERP and ingrain adaptive management in the implementation of the ERP. This standing science body must be of an interim duration because the final CALFED structure of governance is still being developed. CALFED anticipates that the Interim Science Board will be engaged through the Record of Decision and certification of final environmental documentation, with the possibility of extension until the final governance structure is defined and in place. Many of the ISB members have served either on the 1997 Scientific Review Panel or the 1998 Strategic Plan Core Team. The following individuals serve as members of the ISB:

- Dr. Michael Healey, University of British Columbia, Vancouver, British Columbia
- Dr. Wim Kimmerer, San Francisco State University, Romberg Tiburon Center, Tiburon, California
- Dr. Matt Kondolf, University of California, Berkeley, California
- Dr. Peter Moyle, University of California, Davis, California
- Dr. Robert Twiss, University of California, Berkeley, California
- Dr. Tom Dunne, University of California, Santa Barbara, California
- Dr. Paul Angermeier, Virginia Tech, Blacksburg, Virginia
- Dr. Dennis Murphy, University of Nevada, Reno, Nevada
- Dr. Ken Cummins, Humboldt State University, Arcata, California
- Dr Robert Spies, Applied Marine Sciences, Livermore, California
- Dr. Duncan Patten, Montana State University, Bozeman, Montana
- Dr. Denise Reed, University of New Orleans, New Orleans, Louisiana

The broad goal of the ISB is to assist the CALFED Ecosystem Restoration Program (ERP) by providing scientific advice and guidance with a management orientation. More specifically, the ISB will assist the CALFED staff to:

1. Establish a solid scientific/technical foundation for the ERP;
2. Provide scientific review, advice, and guidance;
3. Help ingrain ecosystem-based adaptive management in the implementation of the ERP; and,
4. Engage the scientific and technical questions at the root of policy issues and priorities.

The ISB meets every 4-6 weeks, with a portion of every meeting being open to the public. Meeting summaries will also be developed for every ISB meeting and made available to the public. Consult the CALFED website (http://calfed.ca.gov/) for notices of ISB meetings and to access meeting summaries.

Ecosystem Restoration Program Focus Group

The ERP Focus Group was convened by CALFED in October 1999 to assist CALFED in the period prior to the Record of Decision to identify, address, and resolve key policy issues associated with the ERP and its implementation. The most significant issues addressed by the group included:

1. **Program Integration**: Ensure that the Ecosystem Restoration Program, the Multi-species Conservation Strategy, the Environmental Water Account, and other CALFED, and CALFED related, programs and actions are well integrated and work together.

2. **Priority Setting**: Recommend a process to set priorities, select Stage I actions, evaluate results and refine the longer-term implementation strategy.

3. **Strategic Objectives**: Refine strategic objectives and recommend a process to quantify targets.

The ERP Focus Group is a joint agency/stakeholder policy forum involving the following individuals and organizations:

- Margit Aramburu, Delta Protection Commission;
- Gary Bobker, The Bay Institute;
- Mike Bonner, U.S. Army corps of Engineers;
- Byron Buck, California Urban Water Agencies;
- Steve Johnson, The Nature Conservancy;
- Dan Keppen, Northern California Water Association;
- Laura King, San Luis Delta Mendota Water Authority;
- Patrick Leonard, U.S. Fish and Wildlife Service;
- Dave Nesmith, Save the Bay;
- Tim Ramirez, Resources Agency;
- Pete Rhoads, Metropolitan Water District of Southern California;
- Steve Shaffer, CA Department of Food and Agriculture;
- Lawrence Smith, U.S. Geological Survey;
- Gary Stern, National Marine Fisheries Service;
- Frank Wernette, CA Department of Fish and Game;
- Leo Winternitz, CA Department of Water Resources;
- Steve Yaeger,; CA Department of Water Resources
- Carolyn Yale, U.S. Environmental Protection Agency.

The ERP Focus Group recommended the following to assist CALFED agencies in developing the Record of Decision:

1. Collectively adopt a policy statement, which clearly commits to the concept of a single blueprint for ecosystem restoration.

2. Endorse and support the development and refinement of ecological conceptual models as the basis for understanding the ecosystem and making informed management and regulatory decisions.

3. Commit to using sound science and the development of a comprehensive Science Program, including independent scientific review , to serve as a common resource available to all agencies and interested parties

(including agencies and programs outside the formal CALFED agencies and programs).

4. Execute a formal agreement, which defines how parties will coordinate and interact in pursuit of a single blueprint for ecosystem restoration.

5. Adopt the goals of the CALFED Ecosystem Restoration Program (herein referring to the ERPP plus the MSCS), as the shared vision of the single blueprint. In carrying out existing programs, agencies will continue to pursue the goals of those programs but will strive to be consistent with and to advance the restoration goals established in the ERP.

6. Establish the geographic scope of the blueprint as follows: "Bay-Delta estuary and its watersheds, which includes the Delta, Suisun Bay and Marsh, San Pablo Bay and their local watersheds, the Sacramento River and San Joaquin River watersheds, and San Francisco Bay and its local watersheds; and, limited to salmonid species issues, the near-shore portions of the Pacific Ocean out to the Farallon Islands and north to the Oregon border".

7. Commit to using the goals of the ERP for environmental water management, including the Environmental Water Account (EWA) and the Environmental Water Program (EWP).

NEXT STEPS

CALFED will continued to refine the 1998 Strategic Plan developed by the Core Team. While the Core Team's Strategic Plan significantly advanced the description of the adaptive management process, considerable work is needed to institutionalize and fully employ the concepts into an implementation strategy. Staff are working with members of the Core Team and the broader scientific community to prepare white papers that summarize our knowledge of the system and expected benefits of actions. These papers will be presented in a series of scientific, technical workshops in order to articulate adaptive management strategies for Stage 1 of implementation. Staff will then work with local scientists, landowners, county and city planners and others in regional and local meetings to identify restoration actions consistent with the adaptive management strategies. A more detailed description of the Regional Planning process is included in Chapter 5.

Scientific Review Panel Key Points and Recommendations

Excerpt from: "Summary Report of the Facilitated Scientific Review of the CALFED Bay-Delta Program's Draft Ecosystem Restoration Program Plan (ERPP)," prepared by CONCUR, October 31, 1997

A) **In revising the ERPP, CALFED should clearly state whether the goal of the program is restoration or rehabilitation and name the document accurately.** The term ecosystem restoration, as commonly used by ecologists, involves reverting to the extent possible to historic conditions. Another option, and perhaps a more realistic one, is to rehabilitate the ecosystem. This could involve improving habitat for native and exotic species. The ecosystem enhancement activities that encourage exotic fish species constitute rehabilitation and not restoration. The decision to restore or rehabilitate need not be made on a system-wide level -- it could be made for individual watersheds or ecological zones. One example of this choice would be to restore diked wetlands to tidal marsh downstream (restoration) as opposed to creating many impoundments upstream (such as rice fields) for upstream waterfowl habitat (rehabilitation). This distinction between "rehabilitation" and "restoration" is one among several examples of the need for refining the use of phrases and terms in the ERPP, as indicated at other points in this summary report.

B) **Simplify and focus the presentation of the program and its goals on the basis of conceptual models.** The goals should be explicit, quantifiable, and attainable. The panel agrees with CALFED's tiering approach. The use of conceptual models will be essential to determine the allocation of effort to each tier. However, a coherent defense of the tiering decision, based on ecological and other policy arguments still needs to be articulated to explain the approach to stakeholders.

C) **From the outset, the Program should embed outside scientific expertise in the adaptive management process.** This requires continuous involvement of independent science in the formulation and implementation of the ERPP. Involvement should include: 1) reviewing the rationale, methods, results, and analyses; 2) developing and reviewing recommendations and funding proposals; and 3) pointing out new opportunities. Later portions of this report provide additional guidance on how to accomplish this involvement.

D) **In order to utilize science as a basis for the adaptive management system, there is a need for the development and use of models of physical and biotic ecosystem processes with links to key biotic components.** There are several kinds of models that may be useful in the ERPP. Some are large scale, qualitative, conceptual and concerned with expressing ecosystem operation. An example of such a model is found in the U.S. Forest Service's Northwest Forest Plan. A second type is a more focused model, which may or may not be quantitative, that addresses selected aspects of ecosystem operation. It should present hypotheses that can be tested through measurements and experiments. A third type of model is a quantitative simulation that can be useful for making predictions.

E) **The ERPP report wisely promises that the program will involve an adaptive management framework incorporating decisions that are based incrementally in scientific analysis, hypothesis testing, and monitoring. Therefore the monitoring component of the adaptive management framework should be developed from testable hypotheses.** Information from monitoring should guide management of resources in the following manner: 1) The program would propose a management action to improve the ecosystem; 2) Managers would formulate alternative hypotheses that describe the outcomes of the management action; 3) The action would be conducted as an experiment, and 4) Results would be monitored by gathering data to determine which alternatives are most plausible. The panel acknowledges that not all management actions can be structured as experiments, but recommends that this method be applied wherever practicable.

F) **The recommendations the panel has made above will require continual interaction of agency managers, agency scientists, and independent scientists. Part of this interaction should entail the creation of a standing science body, a scientific and technical advisory board, composed of agency scientists, stakeholder scientists, and scientists independent of the program.** The body would facilitate the introduction of science into long-term management. The panel notes that other efforts of this kind and scale have failed due to the lack of independent scientific review. Activities to be carried out by the science body would include generating and reviewing hypotheses, formulating monitoring schemes, and reviewing and interpreting data. Another function of this body could be to resolve technical conflicts over data, analyses, interpretations, and conclusions. Designing the terms of reference and modes of operation for such a body could involve another round of review and discussions between this panel and CALFED staff.

♦ CHAPTER 1. INTRODUCTION

PURPOSE

The purpose of the Strategic Plan is to guide restoration of the Bay-Delta ecosystem. It defines an ecosystem-based approach that is comprehensive, flexible, and iterative, designed to respond to changes in the complex, variable Bay-Delta system and changes in the understanding of how this system works. The Strategic Plan:

- establishes "adaptive management" as the primary tool for achieving ERP objectives and preparing to make future decisions for large-scale ecosystem restoration;
- describes the opportunities and constraints to be considered in developing a restoration program;
- presents broad goals and specific objectives for ecosystem restoration;
- presents a stepwise procedure for selecting restoration actions in which goals are linked through objectives to actions with appropriate consideration of the degree of confidence that objectives will be achieved;
- defines a coordinated approach for integrating the Ecosystem Restoration Program and the Multi-Species Conservation Strategy;
- provides the concept of a single blueprint for ecosystem restoration and species recovery in the Bay-Delta system.

The Strategic Plan does not:

- attempt to resolve issues of land use or conflicts with activities outside the ecosystem restoration program;
- attempt to resolve conflicts between species or between habitats, except for priorities implied by the statement of objectives; or
- recommend specific projects for implementation, although general classes of projects and a method for selecting projects are presented.

> The Strategic Plan provides the conceptual framework and process that will guide the refinement, evaluation, prioritization, implementation, monitoring, and revision of ERP actions.

RELATIONSHIP OF THE ERP TO THE CALFED BAY-DELTA PROGRAM MISSION

The CALFED Bay-Delta Program was established to reduce conflicts in the Bay-Delta system by solving problems in ecosystem quality, water quality, water supply reliability, and levee system integrity. The mission of the CALFED Bay-Delta Program is to develop a long-term, comprehensive plan that will restore the ecological health and improve water management for beneficial uses of the Bay-Delta system. The Ecosystem Restoration Program (ERP) is the principal Program component designed to restore the ecological health of the Bay-Delta ecosystem. The approach of the ERP is to restore or mimic ecological processes and to increase and improve aquatic and terrestrial habitats to support stable, self-sustaining populations of diverse and valuable species.

The ERP will also help fulfill the mission of improving water management for beneficial uses of the Bay-Delta system. Current protections for endangered and threatened fish species require that exports of Bay-Delta water be reduced or curtailed when they pose a risk to the species. By helping to recover currently endangered and threatened species and by maintaining populations of non-listed species, the ERP can help ease current diversion restrictions and preclude more stringent export restrictions in the future, thereby improving the reliability of Bay-Delta water supplies.

The ERP represents one of the most ambitious and comprehensive ecosystem restoration projects ever undertaken in the United States. It encompasses a wide range of aquatic, riparian and upland habitats throughout the Bay-Delta ecosystem and near-shore ocean environment, and it addresses numerous aquatic and terrestrial species that rely upon the Bay-Delta ecosystem for part or all of their life cycle.

THE STRATEGIC PLAN FOR ECOSYSTEM RESTORATION

The ERP identifies over 600 programmatic actions that, after being refined and prioritized, will be implemented throughout the Bay-Delta ecosystem and near-shore ocean environment over the 30 or more year implementation period of the Program. The ERP is described in a two volume restoration plan, the Ecosystem Restoration Program Plan (ERPP), and the Strategic Plan for Ecosystem Restoration (Strategic Plan). Volume I of the ERPP describes the health and interrelationships of the elements of the Bay-Delta ecosystem and establishes the basis for restoration actions which are presented in Volume II of the ERPP. Volume II provides programmatic restoration prescriptions for ecological management zones and their respective units. The Strategic Plan provides the conceptual framework and process that will guide the refinement, evaluation, prioritization, implementation, monitoring, and revision of ERP actions.

The Strategic Plan signals a fundamental shift in the way the ecological resources of the Bay-Delta ecosystem will be managed, because it embodies an ecosystem-based management approach with its attendant emphasis upon adaptive management. Traditional management of ecological resources has usually focused upon the needs of individual species. Ecosystem-based management, however, is a more integrated, systems approach that attempts to recover and protect multiple species by restoring or mimicking the natural physical processes that help create and maintain diverse and healthy habitats.

THE STRATEGIC PLAN:

- describes an **ECOSYSTEM-BASED MANAGEMENT APPROACH** for restoring and managing the Bay-Delta ecosystem (Chapter 2);
- describes an **ADAPTIVE MANAGEMENT PROCESS** that is sufficiently flexible and iterative to respond to changing Bay-Delta conditions and to incorporate new information about ecosystem structure and function (Chapter 3 and Appendix C);
- describes the value and application of **CONCEPTUAL MODELS** in developing restoration actions and defining information needs, with examples of their development and use (Chapter 3 and Appendix B);
- presents **DECISION RULES** and criteria to help guide the selection and prioritization of restoration actions (Chapter 3);
- presents CALFED's broad **GOALS**, specific **OBJECTIVES AND RATIONALES** for ecosystem restoration (Chapter 4);
- presents **TWELVE CRITICAL ISSUES** that need to be addressed early in the restoration program (Chapter 5);
- describes **OPPORTUNITIES FOR RESTORATION** to address the twelve critical issues in the first seven years of implementation; (Chapter 5);
- describes Guiding Principles of the ERP and the approach for selecting actions for the **IMPLEMENTING THE ERP**, the first 7 years of Program implementation (Chapter 5); and
- describes **INSTITUTIONAL AND ADMINISTRATIVE CONSIDERATIONS** necessary to implement adaptive management, to ensure scientific credibility of the restoration program, and to engage the public in the restoration program (Chapter 6).

THE BAY-DELTA ECOSYSTEM

The Bay-Delta ecosystem is large, complex, diverse and variable. It contains California's two largest rivers, the Sacramento River (which drains an area of more than 25,000 square miles) and the San Joaquin River (draining more than 14,000 square miles). These two rivers converge in the Delta (Figure 1-1), which coupled with greater San Francisco Bay, forms the largest estuary on the West Coast. Tributaries that drain the Sierra Nevada Mountains, the Cascade Range, and the Coast Ranges provide freshwater flow to the Bay-Delta estuary, thus connecting the salty water of the Pacific Ocean with mountain forests and meadows into a vast ecosystem that encompasses most of the Central Valley.

California's semi-arid climate produces pronounced variations in both seasonal and inter-annual precipitation. For instance, the Bay-Delta watershed receives the vast majority of its annual precipitation between the months of October and April, with little precipitation between May and September. The amount of precipitation that falls in the Bay-Delta watershed can vary dramatically from year to year, as demonstrated during the last decade by the drought from 1987-1992 and the floods of 1995-1998. These seasonal and inter-annual variations in precipitation produce highly variable flows of freshwater through Delta tributaries and the estuary. Historically, during wet years, much of the Central Valley would flood to form a large inland sea of shallow water habitat, and during prolonged droughts, Bay-Delta tributaries were reduced to trickles confined within narrow low-flow channels.

Regional differences in temperature and geology further cause variable flows of freshwater and sediment through Delta tributaries and the estuary. For instance, because of milder winter temperatures, most of the precipitation in the Coast Ranges falls as rain so that tributaries draining the eastern slope of the Coast Ranges produce peak flows during the rainy winter months, with reduced base flows from the late-spring through fall. In contrast, tributaries that drain the western flank of the Sierra Nevada Mountains usually carry peak flows later during the late-spring and early-summer months because they are fed by melting snow stored in the mountains by colder winter temperatures, with late-summer and fall base flows greatly reduced following the snowmelt. Tributaries that drain volcanic formations around Mount Shasta and Mount Lassen also carry peak flows during late spring, but summer and fall base flows are relatively higher and colder since they are fed by cold-glacial melt water that flows from springs.

Such variation in the amount and timing of runoff—in conjunction with regional and local differences in soils, topography and microclimates—create an extraordinarily diverse ecosystem that contains numerous distinct habitats and communities and that supports numerous plant and animal species. For example, four distinct runs of chinook salmon that rely upon the Bay-Delta ecosystem demonstrate a fine-tuning of species to a fluctuating yet productive environment. Fall-run chinook spawn in low-elevation rivers, beginning their spawning migrations in fall months as soon as water temperatures are cool so that their young can emerge and leave the rivers before unfavorable flow and temperature conditions in the early summer. Spring-run chinook salmon beat the summer low flows and high temperatures by migrating far upstream in the spring and holding in deep, cold pools through summer, waiting to spawn in the fall. Tributaries draining volcanic formations (such as the little Sacramento, McCloud and Pit rivers) provided cool water temperatures during summer months, allowing late-fall-run and winter-run chinook salmon to spawn late in the season. The ERP reflects the diversity within the Bay-Delta ecosystem by delineating 14 ecological management zones, each of which is subdivided further into smaller ecological management units.

THE NEED FOR RESTORATION

Numerous plant and animal species that rely upon the Bay-Delta ecosystem are listed as endangered or threatened, or experiencing declines in population abundance or geographic distribution. Some species that depended on the Delta, such as the thicktail chub, are now extinct. Such species declines indicate a much broader problem with

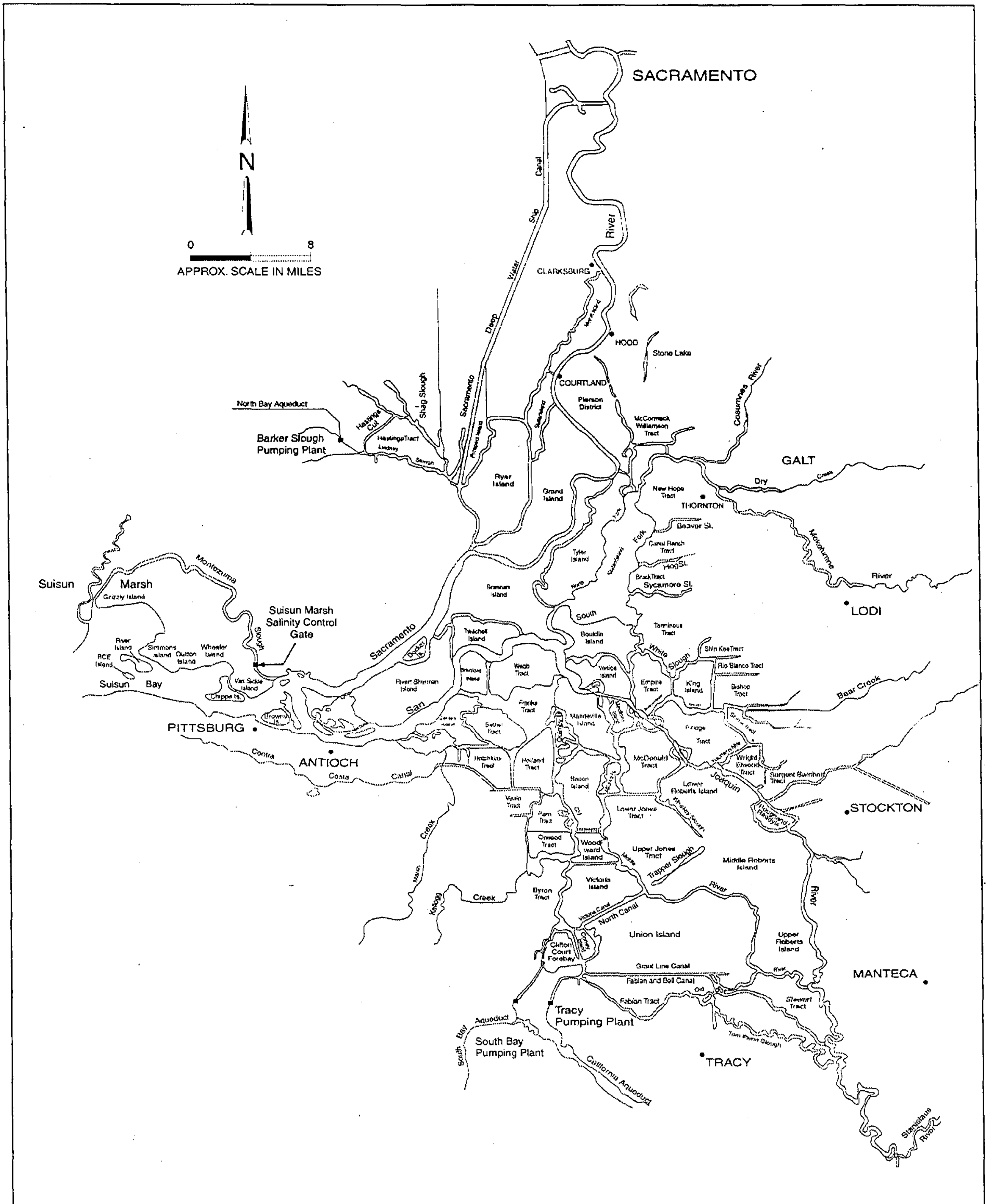


Figure 1-1: CALFED Problem Scope, Suisun Bay, Suisun Marsh, and the Sacramento-San Joaquin River Delta Regions.

deteriorating ecological health in the Bay-Delta ecosystem, as indicated by:

- a reduction in the quantity, quality, and diversity of aquatic and terrestrial habitat available to support a variety of fish, plants, birds, reptiles, amphibians, and other species;
- the alteration of the amount and pattern of water and sediment movement in Delta tributaries and through the Delta;
- the disconnection of rivers from their floodplains by levees and from their headwaters by dams;
- the alteration of the movement patterns of fish and other organisms by dams, channel modifications, changes in hydrology, and water diversions;
- the introduction of numerous non-native species, some with tremendous capacity for damage to the extant ecosystem, and the establishment of conditions that favor these species; and
- the degradation of water quality from pesticides, herbicides, industrial and municipal discharges, non-point-source discharges, and concentration of natural toxins through leaching from farms.

Healthy ecosystems provide more than habitat for plants and wildlife; they also meet the needs of human communities. Some of the obvious human benefits include drinking water supply, recreational opportunities, and amenity values. But healthy ecosystems also provide more subtle, but no less important, benefits to human communities. For instance, vegetation helps to improve air quality and sequester carbon, rivers help transport and dilute our wastes, biotic organisms can help improve water quality and pollinate crops and vegetation, etc. In this manner, ecological processes provide valuable goods and services. Similarly, the amenity values associated with high-quality environments can help attract businesses to locate in the state, thereby stimulating local, regional, and state economies (Power 1996).

What is Ecosystem Restoration?

Ecosystem restoration does not entail recreating any particular historical configuration of the Bay-Delta environment; rather, it means re-establishing a balance in ecosystem structure and function to meet the needs of plant, animal, and human communities while maintaining or stimulating the region's diverse and vibrant economy. The broad goal of ecosystem restoration, therefore, is to find patterns of human use and interaction with the natural environment that provide greater overall long-term benefits to society as a whole.

Historically, human activities have focused on the extractive value of natural resources and ecological processes without sufficient consideration of the concomitant loss of other social and economic benefits when ecological systems are altered (Healey 1998). However, growing public recognition of the social, economic, and ecological costs of environmental degradation, coupled with a growth in environmental values, has stimulated interest not only in preserving remnant ecosystems, but also in restoring already degraded ecosystems

WHAT IS ECOSYSTEM RESTORATION?

Ecosystem restoration projects throughout the world—such as projects in the Chesapeake Bay and Florida Everglades—have helped to publicize and popularize the concept of ecosystem restoration. However, a significant amount of confusion and contention still surround the concept of ecosystem restoration (Richardson and Healey 1996). Much of the confusion and contention stems from the perceived goal of ecosystem restoration; that is, the term itself seems to imply that the ecosystem will be restored to its pristine, pre-disturbance condition or some structural and functional configuration defined by a particular historic baseline. Thus, some stakeholders worry that ecosystem restoration will require the cessation of particular human activities that disturb an ecosystem, with subsequent economic dislocations. Although ecosystem restoration does require change and adjustment, there is no benefit to ecosystem restoration if it destroys the fabric of the society it is intended to serve.

Ecosystem restoration does not entail recreating any particular historical configuration of the Bay-Delta environment; rather, it means re-establishing a balance in ecosystem structure and function to meet the needs of plant, animal, and human communities while maintaining or stimulating the region's diverse and vibrant economy. The broad goal of ecosystem restoration, therefore, is to find patterns of human use and interaction with the natural environment that provide greater overall long-term benefits to society as a whole. **FOR THE ERP, WE USE THE TERM "RESTORATION" TO ENCOMPASS THE CONCEPTS OF REHABILITATION, RESTORATION, PROTECTION AND CONSERVATION.**

ACKNOWLEDGING EXISTING CONSTRAINTS TO ECOSYSTEM RESTORATION

Several human activities in the Bay-Delta watershed have irreversibly altered important ecological processes (see Appendix A). Nevertheless, these activities provide important public benefits and ecosystem restoration must occur within the parameters established by these human activities. For example, the large reservoirs and diversion facilities that comprise the Central Valley Project and State Water Project have radically altered the hydrology of the Bay-Delta ecosystem. Reservoir storage in the Sacramento River Basin captures approximately 80% of annual average runoff, while storage capacity in the San Joaquin River system detains nearly 135% of annual average runoff (San Francisco Estuary Project 1992, Bay Institute 1998). Such profound hydrologic changes underscore the numerous ecological processes that dams alter: they reduce the frequency and magnitude of flood flows that drive channel migration, scour encroaching vegetation, and cleanse spawning gravels; they trap sediment and woody debris necessary to maintain important instream habitat; they reduce the natural flow variability to which native species and communities have adapted; and they block access to historical spawning habitat for anadromous fish. Although dam removal may be possible in a limited number of cases, in most cases ecosystem restoration must occur within the parameters established by existing reservoirs. The multiple public benefits provided by most existing dams—water supply, flood storage, hydropower, recreation—simply preclude their removal.

Ecosystem restoration attempts to maintain the public benefits that existing dams provide while enhancing other public benefits associated with ecosystem restoration by better managing human activities. For instance, habitats, communities and species in the Bay-Delta ecosystem have evolved in response to the fluctuating flow conditions produced by variable precipitation patterns. Dams have reduced the natural variability of flows in Bay-Delta tributaries to the detriment of the ecosystem, but it is possible to re-operate reservoir releases so that they restore or mimic natural flow variability. In this manner, existing reservoirs can still provide—though they may diminish—water supply, flood storage, hydropower, and recreational benefits, but they can also enhance the public benefits of a healthier ecosystem by approximating a more natural flow regime.

ACKNOWLEDGING FUTURE CONSTRAINTS TO ECOSYSTEM RESTORATION

The existing constraints to ecosystem restoration in the Bay-Delta are a function of human uses of Bay-Delta resources. The California Department of Finance projects that the state's population will grow by approximately 15 million people (or nearly 48%) over the life of the Program, thereby increasing demands upon Bay-Delta resources and introducing additional constraints to restoration (see Appendix A). Ecosystem restoration must balance the need to provide resources for future consumptive use with the need to provide high-quality environments that fulfill the needs of plant, animal, and human communities.

THE SCOPE AND FOCUS OF THE ERP

The CALFED Bay-Delta Program was created to develop solutions for water and environmental management problems of the Bay-Delta system. The Program's legally defined **PROBLEM SCOPE** is the Sacramento-San Joaquin Delta and Suisun Bay and Marsh, the hub of the state's water system as well as an important estuary that many imperiled species are critically dependent on. The geographic scope for developing solutions to environmental problems is the entire watershed and near-shore ocean environment of the Bay-Delta system. While the ERP identifies programmatic actions to be implemented throughout the watershed and near-shore ocean, the ERP delineates a more focused area where the majority of actions will be implemented—the **STUDY AREA**. The Study Area includes the legally defined Delta, Suisun Bay and Marsh, North San Francisco Bay, the Sacramento and San Joaquin Rivers and their tributaries downstream of major dams (Figure 1-2). Within the Study Area, 14 Ecological Management Zones and their associated Ecological Management Units (52 units total) are delineated. Volume II of the ERPP describes the health of these management areas and presents specific management prescriptions.

This focused Study Area reflects existing constraints to ecosystem restoration. For example, large dams represent irreducible discontinuities in rivers by altering flows, trapping sediment, and impeding fish passage, such that restoration efforts in the upper watersheds are unlikely to contribute significantly to key ERP goals such as restoring ecological processes and recovering endangered and threatened species. Restoration and management actions implemented in the upper watersheds can yield other Program benefits, such as water quality and water supply improvements and reductions in reservoir sedimentation. Accordingly, other Program components, such as the Watershed Management Program and the Water Quality Program, address the upper watersheds. Similarly, there are relatively fewer management actions relevant to the CALFED mission available for central and southern San Francisco Bay.

Numerous plant and animal species rely upon the Bay-Delta ecosystem for part or all of their life cycle, and the ERP aims to maintain current population abundances of these species, at a minimum. However, a majority of programmatic actions contained in the ERP focus on improving ecological processes and habitats upon which endangered and threatened species or species proposed for listing depend since there is a more immediate need to stabilize their populations and since their recovery will help reduce conflicts in the Bay-Delta system.

RELATION OF THE STRATEGIC PLAN TO THE MULTI-SPECIES CONSERVATION STRATEGY

CALFED has developed a Multi-Species Conservation Strategy to serve as the platform for compliance with the Federal Endangered Species Act (ESA), the California Endangered Species Act (CESA), and the State's Natural Community Conservation Planning Act (NCCPA) (Multi-Species Conservation Strategy 1999). The Conservation Strategy has identified a subset of species which are federally and State listed, proposed, or candidate species, other species identified by CALFED that may be affected by and for which the CALFED Program and the ERP have responsibility related to (1) recovery of the species, (2) contribute to their recovery, or (3) maintain existing populations. The "recover species" depend on habitat conditions in Suisun Bay, the Delta, Sacramento River, San Joaquin River, and many of their tributary streams. For these reasons, the primary geographic focus of the ERP is the Sacramento-San Joaquin Delta, Suisun Bay, the Sacramento River below Shasta Dam, the San Joaquin River below the confluence with the Merced River, and their major tributary watersheds directly connected to the Bay- Delta system below major dams and reservoirs. In addition, streams such as Mill Creek, Deer Creek, Cottonwood Creek, and Cosumnes River, are emphasized due to their free-flowing status and relative high quality of habitats and ecological processes.

Secondarily, the ERP addresses, at a broader, programmatic level, Central and South San Francisco Bay and their local watersheds. These 14 ecological management zones constitute the geographic areas in which the majority of restoration actions will occur. The upper

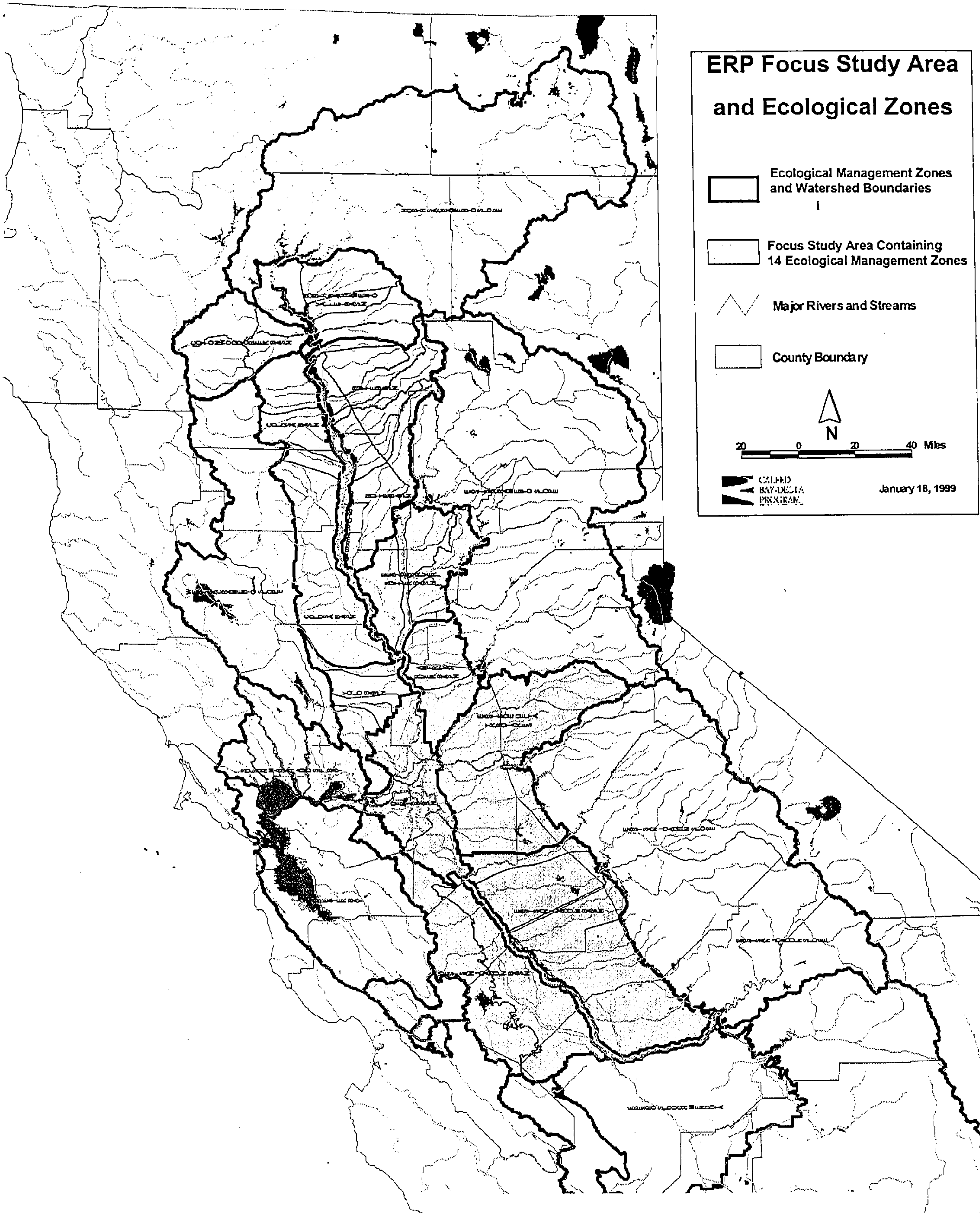


Figure 1-2: Ecosystem Restoration Program Study Area and Ecological Management Zones

watersheds surrounding the primary focus area are important and addressed through general actions that focus on watershed processes and watershed planning, management and restoration. The CALFED Watershed Program addresses the coordination of planning and restoration actions in the upper watershed .

The MSCS and the ERP are distinct parts of CALFED, but they are neither severable nor redundant. The ERP is the means by which CALFED will restore the Bay-Delta ecosystem and is the CALFED element most relevant and important for FESA, CESA, and NCCPA compliance. The MSCS conservation measures do not comprise all actions that will be credited toward, or required for, compliance with FESA, CESA, and NCCPA. The MSCS is not a separate or supplemental restoration program and does not supplant the ERP.

Rather, the MSCS:

- assesses the aggregate effects of CALFED, including implementation of the entire ERP;

- identifies species goals consistent with the ERP that reflect regulatory standards;

- refines and emphasizes certain ERP actions that are of special importance to the MSCS evaluated species; and

- identifies avoidance, minimization, and compensation measures for evaluated species.

The MSCS's species goals and conservation measures are consistent with and are incorporated in the ERP. ERP actions that are not emphasized or refined in the MSCS may nonetheless be important for FESA, CESA and NCCPA compliance. USFWS, NMFS and DFG will consider all proposed CALFED actions that would benefit or harm the MSCS's NCCP communities and evaluated species, including all ERP actions, for purposes of determining whether CALFED complies with FESA, CESA, and NCCPA.

♦ CHAPTER 2. ECOSYSTEM-BASED MANAGEMENT

THE ADVANTAGES OF ECOSYSTEM-BASED MANAGEMENT

Natural resource management is often guided by the need to recover and protect populations of endangered and threatened species. Efforts to combat population declines of endangered and threatened species often focus on specific factors in a species' environment believed to affect birth or death rates. While this species-based approach has often prevented the extinction of a species, it has also resulted in piecemeal attempts that usually fail to recover and stabilize populations of threatened and endangered species. Additionally, this species-based approach fails to address the needs of unlisted species experiencing population declines that might necessitate their future listing.

Ecosystems are more than just a collection of species; they are complex, living systems influenced by innumerable climatic, physical, chemical, and biological factors, both within and outside of the ecosystem. A new paradigm in natural resource management has emerged that acknowledges this complex interplay of forces that shape and animate ecosystems. Ecosystem-based management is an integrated-systems approach that attempts to protect and recover multiple species by restoring or mimicking the natural physical processes that create and maintain diverse and healthy habitats
By incorporating an ecosystem-based approach, the ERP and the Strategic Plan signal a fundamental shift in the way the ecological resources of the Bay-Delta system will be managed.

By adopting an ecosystem-based approach, CALFED is not relinquishing its responsibility to recover endangered and threatened species, nor is it abandoning all species-based management efforts. Ecosystem-based management encompasses species management by enhancing and sustaining the fundamental ecological structures and processes that contribute to the well-being of a species. The ERP aims to recover threatened and endangered species not only by restoring habitats, but also by restoring the ecological processes that help create and sustain those habitats.

CONTRASTING ECOSYSTEM-BASED AND SPECIES-BASED MANAGEMENT

The difference between process-based restoration and conventional species-based management can be illustrated by the contrast between using hatcheries and ecosystem-based approaches to restore salmon. Hatcheries were initially constructed to compensate for habitat lost behind dams, but they are now used to compensate for a broad range of impacts on salmon production, including habitat degradation. This conventional, engineering-oriented, species-based approach yields an increase in fish populations, at least in the short term; however, hatcheries are vulnerable to disease and impose a variety of selection pressures that

Advantages of an Ecosystem-Based Approach over the Traditional Species-Based Approach

- Restoration of physical processes reproduces subtle elements of ecosystem structure and function in addition to the more obvious elements, thereby possibly enhancing the quality of restored habitat.
- Restoration of physical processes can benefit not only threatened and endangered species, but also unlisted species, thereby reducing the likelihood of future listings.
- Restoration of physical processes reduces the need for ongoing human intervention to sustain remnant or restored habitats.
- Restoration of physical processes may produce a more resilient ecosystem capable of withstanding future disturbances.

may make the fish less successful in the wild. Hatchery-produced fish compete with, and interbreed with wild fish, thereby affecting the gene pool and possibly reducing the fitness and overall vigor of local populations.

By contrast, a process-based ecosystem management approach seeks to restore the dynamic processes of flow, sediment transport, channel erosion and deposition, and ecological succession that create and maintain the natural channel and bank conditions favorable to salmon. If the processes that create the habitat for salmon can be restored, ecosystem restoration can be truly sustainable and can result in a system that benefits a range of other species as well, thereby avoiding future need for further listings of endangered species.

Elements of Ecosystem-Based Management

In its monograph on the scientific basis of ecosystem management, the Ecological Society of America (1995) identified eight elements of ecosystem-based management that illustrate the character of this emerging paradigm:

1. **Long-term sustainability is a fundamental value.** This element highlights the importance of intergenerational equity, suggesting that resources should be managed today to ensure that the needs of future generations will not be compromised (World Commission on Environment and Development 1987). In ecological terms, this is coming to be defined as passing on to future generations a set of natural capital resources equivalent to that which the present generation has available (Costanza and Daly 1992). The ERP addresses this element in by emphasizing the recovery of native species, by preserving biodiversity, and by emphasizing the restoration of ecological processes that allow ecosystems to be more self-sustaining.

2. **Decisions must be based on clearly defined goals and objectives.** This element highlights the need to be clear about what we want to achieve through management. Goals and objectives are to be stated in terms of desired future states, behaviors, or trajectories for ecosystem structure and function. Objectives are also to be stated in terms that can be measured and monitored. In this way, ecosystem management is not tied to an undefinable or unattainable pristine condition; instead, it provides considerable latitude for negotiating and defining desirable future conditions. Furthermore, because goals are to be stated in terms of measurable criteria, progress can be explicitly evaluated. The ERP and the Strategic Plan include both general goals and more specific measurable objectives.

3. **Decisions must be based on sound ecological models and under-standing.** This element highlights the importance of rational, science-based models to decision making in ecosystem-based management. However, because humans are integral to the ecosystem to be managed, it also highlights the importance of models that integrate social, economic, and environmental components of the larger system. Conceptual models as heuristics and as a foundation for modeling expected outcomes in adaptive management are part of the Strategic Plan.

4. **Complexity and connectedness are fundamental characteristics of healthy ecosystems.** Evidence from management failures of the past suggests that there is considerable risk in attempting to manage individual resources independently of one another. By focusing attention on connectedness, ecosystem management reduces the risk of such failures. Restoration of Delta and estuarine ecosystems inevitably involves a concern with connectedness because of the importance of fluvial and tidal dynamics to their functioning. Recognition of the importance of interconnected habitats is also paramount when anadromous salmonids are one subject for restoration. The nested hierarchy of ecosystem management units in the ERP focus area is a further acknowledgment of the interconnectedness among elements of structure and function in the ERP focus area.

5. **ECOSYSTEMS ARE DYNAMIC.** Ecosystems are complex, self-organizing systems. With complexity comes uncertainty and imprecision in prediction. Ecosystem-based management cannot eliminate surprises or uncertainty. Rather, it acknowledges that unlikely and even unimagined events may happen. The management process must be designed to cope with such events. The Strategic Plan describes an adaptive management process that helps to account for the uncertainty inherent in restoring and managing an ecosystem. The program also recognizes the importance of dynamic processes in its concern over effects of the seasonal hydrograph on particular species and in its plan to recreate meander corridors along river courses. Other dynamic elements may have to be built into the restoration program over time, however, and adaptive experimentation can help to define the necessary degree of dynamic change to maintain ecosystem function.

6. **CONTEXT AND SCALE ARE IMPORTANT.** Each aspect of ecosystem structure and function has its own time and space scale. Spatial and temporal domains of management planning and implementation need to be congruent with those of critical ecological processes in the system to be managed. Management activities tend to be tied to social and economic schedules, not ecological schedules. Staged implementation, monitoring, and assessment schedules and adaptive experimentation all provide tools for strengthening the spatial and temporal patterning of restoration.

7. **HUMANS ARE INTEGRAL COMPONENTS OF ALL ECOSYSTEMS.** Humans are the single greatest modifier of ecosystem structure and function. Humans will also suffer the most serious consequences of changes that make ecosystems less able to sustain human life. Therefore, management of human activities must be an integral component of plans to manage ecosystems. This element may seem rather obvious but serves to emphasize the importance of linking the ERP with activities related to water quality, water supply reliability, and levee integrity. This element also reminds us that ecosystem management is a human problem, not an ecological one.

Elements of Ecosystem-Based Management

1. Long-term sustainability is a fundamental value.
2. Decisions must be based on clearly defined goals and objectives.
3. Decisions must be based on sound ecological models and understanding.
4. Complexity and connectedness are fundamental characteristics of healthy ecosystems.
5. Ecosystems are dynamic.
6. Context and scale are important.
7. Humans are integral components of all ecosystems.
8. Ecosystem management must be adaptable and accountable.

8. **ECOSYSTEM MANAGEMENT MUST BE ADAPTABLE AND ACCOUNTABLE.** Our understanding of ecosystems is incomplete and subject to change, so management planning and programs must be sufficiently flexible to respond to new information. Adaptive management provides this flexibility, and it employs the problem-solving power of the scientific method to maximize the information value of restoration actions so that we can improve our knowledge of the ecosystem as we restore it, thus improving the process of management over time.

ADDRESSING THE UNCERTAINTY INHERENT IN NATURAL SYSTEMS THROUGH ADAPTIVE MANAGEMENT

Through decades of scientific research, we have come to understand much about the Bay-Delta ecosystem and the species that depend on it; however, we do not understand all of the ecological processes and interactions that animate the ecosystem. Additional research can greatly improve our understanding, but it will never erase all of the uncertainty that is inherent in restoring and managing such a large, diverse, complex, and variable natural system. Ecosystem processes, habitats, and species are continually modified by changing environmental conditions and human activities; consequently, it is impossible to predict exactly how the Bay-Delta will respond to implementation of the ERP and other CALFED components. Restoring and managing the Bay-Delta ecosystem requires an approach that acknowledges the uncertainty in both the dynamics of complex systems and the effects of management interventions.

Holling (1998) classifies the practice of ecology according to two cultures, a dichotomy that can also describe the management of ecological systems. The first, traditional culture, is analytical and based on formally testing hypotheses to assess single causative relationships and attempting to find the single correct answer to questions and the single correct approach to solving problems. The second culture is integrative and exploratory, based on a comparative analysis of multiple hypotheses and an acknowledgment of uncertainty in management. Previous management of the Bay-Delta system has proceeded according to the first set of cultural practices. That is, historically, we have disregarded most of this complexity in resource management and treated such problems as though they were well defined in time and space and amenable to analysis (understanding) and remediation by standard methods. As failures in resource management based on this approach have become more visible and more serious, resource managers have shown increasing interest in methods that explicitly recognize the uncertainty inherent in management actions (Holling 1998). A suite of techniques collectively termed "adaptive environmental assessment and management," or simply "adaptive management," (Holling 1978, Walters 1986) has been adopted by several state and federal resource agencies as a practical approach to management under uncertainty.

According to Walters (1986), designing an adaptive management strategy involves four basic issues:

1. bounding the management problem in terms of objectives, practical constraints on action, and the breadth of factors to be considered in designing and implementing management policy and programs;

2. representing the existing understanding of the system(s) to be managed in terms of explicit models of dynamic behavior that clearly articulate both assumptions and predictions so that errors or inconsistencies can be detected and used as a basis for learning about the system;

3. representing uncertainty and how it propagates through time and space in relation to a range of potential management actions that reflect alternative hypotheses about the system and its dynamics; and

4. designing and implementing balanced management policies and programs that provide for continuing resource production while simultaneously probing for better understanding and untested opportunity.

Put another way, adaptive management involves: 1) having clear goals and objectives for management that take into account constraints and opportunities inherent in the system to be managed; 2) using models to explore the consequences of a range of management policy and program options in relation to contrasting hypotheses about system behavior and uncertainty; and 3) selecting and implementing policies and programs that sustain or improve the production of desired ecosystem services while, at the same time, generating new kinds of information about ecosystem function.

REDUCING UNCERTAINTY BY LEARNING FROM RESTORATION AND MANAGEMENT ACTIONS

Restoring and managing the Bay-Delta ecosystem requires a flexible management framework that can generate, incorporate, and respond to new information and changing Bay-Delta conditions. Adaptive management provides such flexibility and opportunities for enhancing our understanding of the ecosystem. Within an adaptive management framework, natural systems are managed in such a way as to ensure their recovery and improvement while simultaneously increasing our understanding of how they function. In this manner, future management actions can be revised or refined in light of the lessons learned from previous restoration and management actions.

The key to successful adaptive management is learning from all restoration and management actions. Learning allows resource managers and the public to evaluate and update the problems, objectives, and models used to direct restoration actions. Subsequent restoration actions can then be revised or redesigned to be more effective or instructive. In an adaptive management process, learning must be continuous so that ecological restoration continuously evolves as the ecosystem responds to management actions and to unforeseen events, and as management actions are revised in light of new information. Without effective learning, ineffective management programs are likely to be perpetuated, unanticipated successes will go unrecognized, and resources will not be efficiently allocated.

To facilitate learning, adaptive management emphasizes the use of the scientific method to maximize the information value of restoration and management actions. Resource managers explicitly state hypotheses about ecosystem structure and function based upon the best available information, and then they design restoration actions to test these hypotheses. In this respect, adaptive management treats all management interventions as experiments. This does not suggest that management interventions are conducted on a trial-and-error basis, because management actions are guided by the best understanding of the ecosystem at the time of implementation.

Adaptive management is analogous to the "clinical trial" in medicine. In a clinical trial, a new therapy is tested on many patients, the trial is carefully monitored, and the progress of the trial is evaluated at regular intervals to determine whether to continue with the trial, abandon the trial, or declare the new therapy a success. Clinical trials are not initiated unless there is a reasonable expectation of success. Similarly, CALFED will not initiate large-scale ecological restoration unless there is a reasonable expectation of success.

By treating interventions as experiments, resource managers ensure that management is as efficient and successful as possible in achieving its objectives—unsuccessful interventions will not be perpetuated or expanded and successful interventions can be modified to use resources efficiently (e.g., land, water, tax dollars). Designing management interventions as experiments can have significant benefits when it comes to evaluating success or failure, increasing understanding of system dynamics, and making better decisions in the future (Walters et al. 1988 and 1989, Walters and Holling 1990). In adaptive management, treating interventions as experiments involves:

- making management decisions based on the best available analyses and modeling of the system;
- being clear about what management intervention is expected to achieve in terms of restoring ecological structure and function and the implications for species conservation;
- designing management intervention to help distinguish among alternative hypotheses about ecosystem behavior, where practical and compatible with the long-term goals of the program; and
- monitoring the effects of management intervention and communicating the results widely so that progress relative to expectations can be evaluated, adjustments made, and learning achieved.

As in clinical trials, an adaptive management program should incorporate Bayesian statistical techniques to judge progress and update probabilities among competing hypotheses. These techniques differ from the traditional hypothesis-testing approaches that play such a dominant role in ecological practice. Bayesian techniques are used to determine the probability that a hypothesis is true given the available information; when more than one hypothesis is proposed, probabilities can be compared among hypotheses. Decision rules can therefore be built into the program that are more socially and ecologically relevant than the 0.05 significance criterion commonly used in ecology. This approach is more in keeping with the notion of the second alternative culture of ecology (Holling 1998).

MODES OF ADAPTIVE MANAGEMENT

Walters (1986) recognized three approaches to management:

- **TRIAL-AND-ERROR**, in which early management options are chosen at random and later choices are made from a subset of the early options that performed best;
- **PASSIVE ADAPTIVE**, in which a best management option is chosen on the basis of the current beliefs about system dynamics and this option is fine-tuned in relation to experience; and
- **ACTIVE ADAPTIVE**, in which two or more alternative hypotheses about system dynamics are explored through management actions.

TRIAL-AND-ERROR MANAGEMENT. The first approach is illustrated by early attempts at stream habitat rehabilitation in which alterations were made to streams, and those that proved successful (e.g., stayed in the stream, attracted fish) became favored interventions. Some element of trial-and-error is a part of virtually every management policy.

PASSIVE ADAPTIVE MANAGEMENT. Passive adaptive management is perhaps the most common form of management intervention these days. It is highly defensible in that the best management action is chosen based on the best available scientific information (although which information is best may be subject to debate). It fits well with the incremental remedial approach to policy evolution that is common to public agencies (Lindblom 1959). It is administratively simple because all "units" are treated alike, and information needs and information management are relatively simple. Learning about the system using this approach, however, is confined to a very narrow window, and there is practically no possibility of determining whether the underlying hypothesis about the system is right or wrong; therefore, although passive adaptive management takes uncertainty into account, it has only limited capacity to reduce uncertainty.

Many elements of the ERP may have to be implemented as passive adaptive projects. Passive adaptive management may be dictated because the value of knowing that option A is a better description of system dynamics than option B is less than the cost of obtaining the information, or the alternative action poses too great a threat to public safety or valuable infrastructure, or for a variety of other reasons. Despite its limitations as a tool for learning about the system, a properly designed passive adaptive experiment can provide important insights into workable, if not optimal, solutions.

Unfortunately, strict adherence to experimental protocols is impossible in such a large-scale, passive adaptive program such as the ERP. There is, after all, only one Bay-Delta system, and its various component parts are all strongly interconnected. Independent replication of control and treatment measures is impossible in either space or time, violating an important principle of experimental design. The degree to which cause and effect can be determined should be tempered by this unavoidable limitation. All manipulations within the ERP should be based on careful and creative design to enhance the opportunity for learning and an analytical program that will allow as much distinction between confounded effects as possible.

ACTIVE ADAPTIVE MANAGEMENT. Active adaptive management is the most powerful approach for learning about the system under management but also is often the most contentious. Active adaptive management programs can create the false impression that managers or scientists are going to toy with the resources on which other people's livelihoods depend. Nevertheless, there is an important role for active adaptive management in the ERP, notwithstanding the critical status of many of the species the ERP is intended to benefit. It is important to realize that the purpose of active adaptive management is not to push the system to its limits and see how it responds. Rather, the purpose is to use management as a tool to generate information about the system when the long-term value of the information clearly outweighs the short-term costs of obtaining it.

It may be useful to distinguish between two kinds of active adaptive management. For many situations, it may be clear what kind of intervention is needed (e.g., increased spring and summer flows into the Delta for salmonid conservation), but the magnitude of the intervention is uncertain. The concern is not with the form of the model relating flow to conservation, but with the parameters of the model. An active adaptive management experiment could be designed to improve the estimation of parameters by manipulating spring and summer flow in appropriate ways. For purposes of this discussion, this kind of adaptive experiment will be referred to as "adaptive probing". In some instances, adaptive probing can be designed around natural fluctuations in environmental variables. A good example is the experiment conducted to improve estimates of optimal sockeye salmon escapement to the Fraser River. The principal issue was the level of escapement that would maximize yield to the fishery. The benefit-cost ratio of the experiment to test the benefits of higher escapements was very high, but involved fishers foregoing catch to achieve higher escapements in the short term. The experiment was initiated in the 1980s with very positive results in terms of yields in the late 1980s and early 1990s. Another example of adaptive probing is the Vernalis Adaptive Management Program (VAMP) which is designed to improve the scientific basis for the protection of San Joaquin fall-run chinook salmon smolts during their migration through the Delta. The program is based on a conceptual design which is to test the hypotheses related to smolt survival from five sets of San Joaquin inflow and Delta export levels.

In other instances, the greatest uncertainty may be about the best kind of intervention. For example, which would be the management action for spring-run chinook: increased spawning escapement or reduced cross-channel transport? In this case, the concern is with the form of the model (although obviously the size of the intervention is also important). Again, an adaptive probing experiment could be designed to determine which model (escapement or Delta transport) was the more important in chinook conservation. For purposes of this discussion, experiments designed to distinguish among fundamentally different models (hypotheses) will be referred to as "adaptive exploration." The Bay-Delta ecosystem is replete with such unresolved alternatives. To the extent feasible, the ERP will capitalize on opportunities to distinguish among such alternatives through active adaptive experimentation. Tools for assigning probabilities to models and updating probabilities in the light of new information, as well as rules for efficient design of adaptive experiments, are provided in Walters (1986) and Hilborn and Mangel (1996).

EXPERIMENTAL PROTOCOL FOR ADAPTIVE MANAGEMENT

For all experiments, whether passive or active, the general protocol should be as follows:

1. **MODEL THE SYSTEM IN TERMS OF CURRENT UNDERSTANDING AND SPECULATION ABOUT SYSTEM DYNAMICS** and use the model to explore issues, such as the magnitude of effects that will derive from particular manipulations, how uncertainty affects outcomes, efficiency of various experimental designs, and the value of information about alternative dynamics. Models of the system may suggest that the most efficient approach is large-scale intervention, pilot or demonstration projects, targeted research, or some combination of these.

2. **DESIGN THE MANAGEMENT INTERVENTION TO MAXIMIZE BENEFITS IN TERMS OF BOTH CONSERVATION AND INFORMATION.** Where the modeling of management options suggests that more research is needed before any intervention should be attempted, other management measures may be necessary in the short term to ensure that endangered species do not suffer further declines.

3. **IMPLEMENT MANAGEMENT AND MONITOR SYSTEM RESPONSE.** In the case of large-scale manipulations, this must go beyond merely monitoring the response variables of interest

(e.g., fish abundance) to provide a report at the end on whether they changed in the desired direction. Monitoring, modeling, and analysis, perhaps together with targeted research, must be designed specifically to determine the extent to which the manipulation affected the variable of interest.

4. **UPDATE PROBABILITIES OF ALTERNATIVE HYPOTHESES** based on analytical results and, if necessary, adjust management policy.

5. **DESIGN NEW INTERVENTIONS BASED ON IMPROVED UNDERSTANDING.**

The experimental protocols for adaptive management are described in further detail in Chapter 3.

ADDRESSING POLITICAL, REGULATORY AND ECONOMIC UNCERTAINTY

The large scope of the ERP requires that it be implemented in stages over the course of several decades. Staged implementation facilitates an adaptive management approach by allowing resource managers to evaluate actions implemented early so that future restoration will benefit from the knowledge gained. It also allows restoration costs to be spread over several years.

Owing to the long implementation timeframe for the ERP, the ecosystem-based, adaptive management process must account for uncertainty produced by non-biological factors in addition to the ecological uncertainty inherent in restoring complex ecosystems. During the projected implementation period for the CALFED Program, there will be approximately eight presidential and gubernatorial elections. These state and national elections will inevitably affect the way existing public policies and programs are interpreted and implemented. Changes in administrations could lead to new state or federal laws, regulations, and programs relating to the regulation and management of water resources, endangered/threatened species, habitat, and ecosystem protection. Current debates concerning the need for new species listings, legal challenges to federal policies (such as Habitat Conservation Plans [HCPs], the "No Surprise" Rule and "Safe Harbor" provisions), and legal challenges to California's Natural Community Conservation Planning Act (NCCPA) process, reflect the potential for changes in law, regulation, and policy that could affect implementation of the ERP and the overall CALFED Program.

Similarly, the volatile nature of global economics has the potential to affect federal, state, and regional budgets and incomes. Fluctuations in the business cycle could ripple into the implementation of the ERP by affecting the funding available for ecosystem restoration or the demands placed upon Bay-Delta resources. The flexibility of an adaptive management approach can allow resource managers to respond to such external forces in much the same way that they respond to new information or unforeseen environmental events.

ONE BLUEPRINT FOR ECOSYSTEM RESTORATION

A single blueprint for ecosystem restoration and species recovery in the Bay-Delta System is a key ingredient for a successful and effective restoration program. Such a blueprint can be the vehicle for ensuring coordination and integration; not only within the CALFED Program, but between all resource management, conservation, and regulatory actions affecting the Bay-Delta System.

A single blueprint represents a unified and cooperative approach defined by three primary elements:

1. integrated, shared science and a set of transparent ecological conceptual models which provide a common basis of understanding about how the ecosystem works;

2. a shared vision for a restored ecosystem ; and

3. a management framework that defines how management and regulatory authorities affecting the Delta will interact and how management and regulatory decisions (including planning, prioritization, and

implementation) will be coordinated and integrated over time.

The integrated science and ecological conceptual models provide a common basis of understanding about how the ecosystem works. These elements, which include competing hypotheses and models, represent the foundation for transparent decision making based upon sound science. This is not to imply that these models are fixed, as they will be tested and modified over time in response to new information in accordance with the principles of adaptive management as part of the CALFED Science Program. Rather, the models represent a basis for guiding management and regulatory decisions at a given point in time. They also provide the rationales for these decisions.

The shared vision of ecological restoration serves to define the desired outcome. While each of the management and regulatory programs have their own distinct set of goals, establishing a unified approach requires that in meeting these goals the various programs also contribute to meeting common goals with respect to ecosystem restoration. The goals for ecological restoration and species conservation established in the ERP and MSCS provide a broad set of goals that provide the common vision for the single blueprint concept.

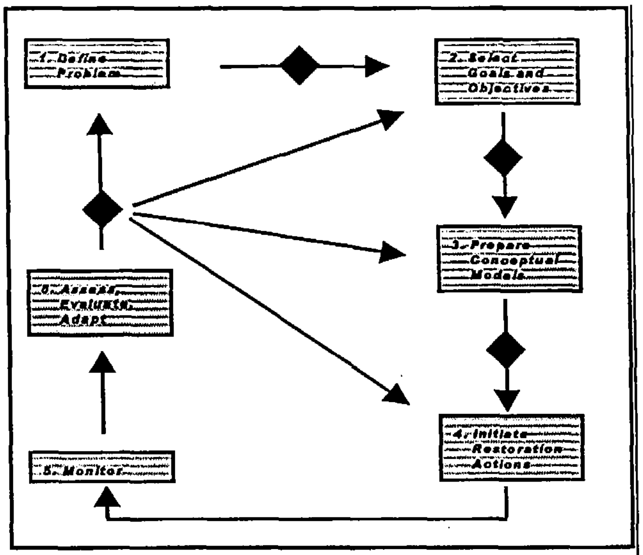
The management framework defines how parties will interact and how management and regulatory decisions will be coordinated and integrated over time. The management framework is designed to foster coordinated and consistent decision making over time. This management framework must be flexible, incorporating and responding to new information and changing Bay-Delta conditions. The framework must be designed to promote coordinated planning, prioritization, and implementation. It must also incorporate provisions for resolving management and regulatory conflicts that may arise.

BENEFITS OF A SINGLE BLUEPRINT

The benefits of a single blueprint approach include the following:

- improved understanding, both of the consequences of certain actions and why specific actions are undertaken;
- increased probability of achieving the desired level of ecosystem health for the Bay-Delta system;
- cost effectiveness;
- avoiding and/or reducing the potential for conflicts that could be counterproductive;
- providing greater management and regulatory certainty; and
- increased support for the program and program funding.

♦ CHAPTER 3. THE ADAPTIVE MANAGEMENT PROCESS



This chapter describes a stepwise procedure that will help incorporate adaptive management in the restoration and management of the Bay-Delta ecosystem. The succeeding discussion describes the steps involved in an adaptive management process, and Figure 3-1 illustrates the process.

DEFINING THE PROBLEM

The first step of an adaptive management process requires clearly defining a problem or set of problems affecting ecosystem health. Defining a problem usually requires determining the geographic bounds of the problem; the ecological processes, habitats, species, or interactions affected by the problem; and the time that the problem affects the ecosystem. Volumes I and II of the ERPP define problems that affect the health of the Bay-Delta ecosystem.

DEFINING GOALS AND OBJECTIVES

Once a problem has been bounded, it is necessary to articulate clear restoration goals and tangible, measurable objectives to provide direction to restoration efforts and to measure progress. Objectives must be tangible and measurable so that progress toward achieving them can be clearly assessed. For example, the following objective statement is too vague: "Improve the quality of habitat for winter-run chinook salmon." By contrast, a more specific statement is: "Restore flows and accessibility of Battle Creek to winter-run chinook salmon spawning within 7 years." Although objectives may sometimes be stated broadly, they must ultimately be made specific through models and hypotheses that translate the objectives into restoration actions.

The Strategic Plan defines broad goals and objectives for the Bay-Delta ecosystem in Chapter 4. Volume II of the ERPP defines targets and programmatic actions for the ecological management zones and units that comprise the larger Bay-Delta ecosystem.

DEVELOPING CONCEPTUAL MODELS

Many resource managers, scientists, and stakeholders interested in the restoration and management of the Bay-Delta ecosystem have *implicit* beliefs about how the ecosystem functions, how it has been altered or degraded, and how various actions might improve conditions in the system. That is, they have simplified mental illustrations about the most critical cause-and-effect pathways. Conceptual modeling is the process of articulating these implicit models to make them explicit.

Conceptual models can provide several benefits. The knowledge and hypotheses about ecosystem structure and function summarized in conceptual models can lead directly to potential restoration actions. They can highlight key uncertainties where research or adaptive probing might be necessary. Alternative, competing conceptual models can illustrate areas of uncertainty, paving the way for suitably-scaled experimental manipulations designed to both restore the system (according to more widely accepted models) and explore it (to test the models). Conceptual models can also help to define monitoring needs, and they

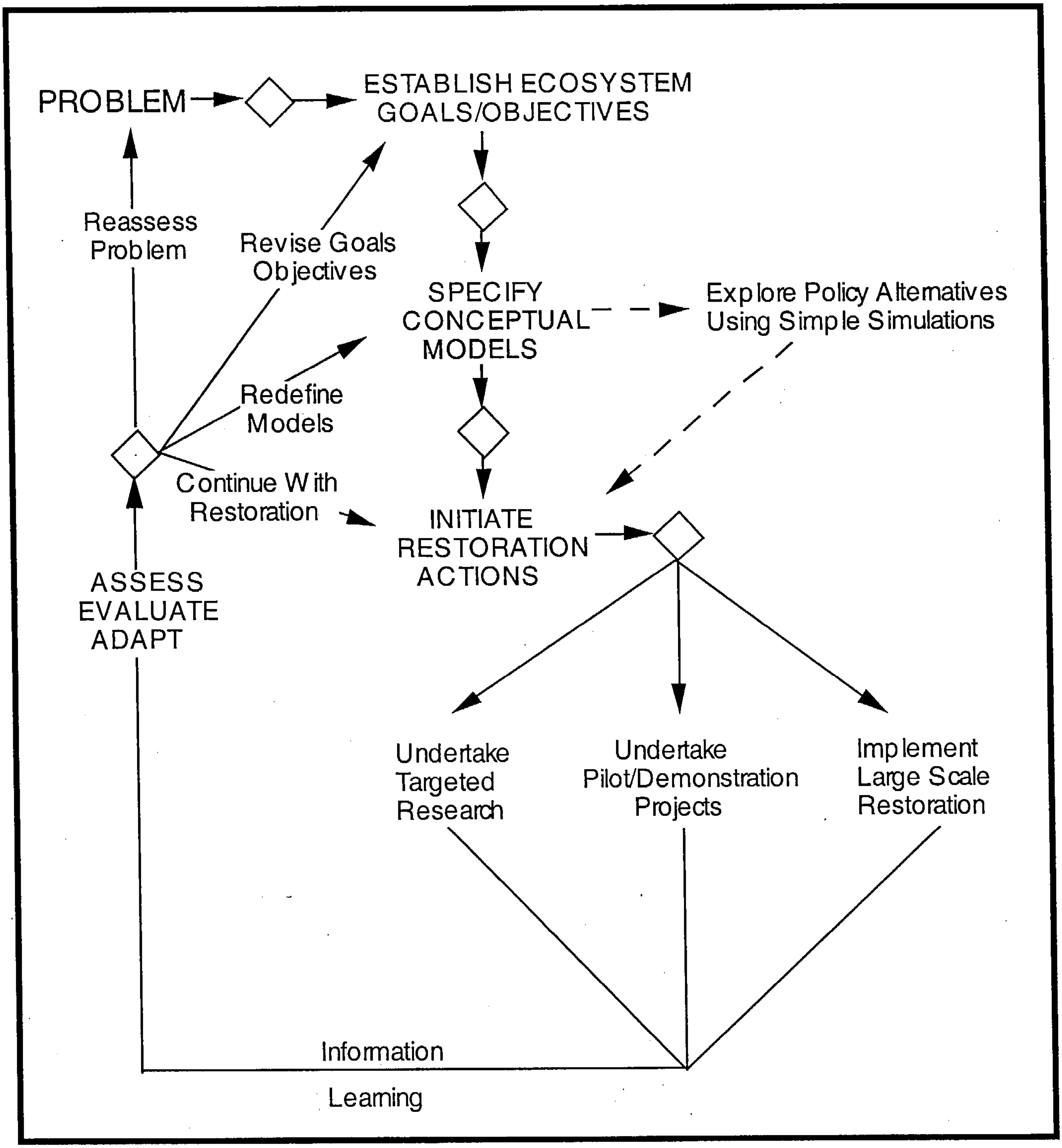


Figure 3-1: Diagram of the Adaptive Management Process.

can also provide a basis for quantitative modeling. Articulating conceptual models can also facilitate dispute resolution since differences between implicit conceptual models often underlie disagreements about appropriate restoration actions.

Conceptual models often suggest many possible restoration actions. In evaluating alternative actions, it is usually very helpful to conduct exploratory simulation modeling based on the conceptual models (Figure 3-1). These simulations are not intended to capture the complexity and richness of ecological processes, but to capture the essential elements of ecological structure and function that underlie management decision making. They are greatly simplified, clear caricatures of the system, just as the conceptual models are clear caricatures. Their purpose is to allow explicit exploration of the main pathways of causal interaction and feedback processes in the conceptual models and provide preliminary predictions of the consequences of different management actions. The simple simulations can aid the decision-making process in many ways. For example, simulation modeling can:

- identify logical inconsistencies in the conceptual models,
- clarify where the nodes of greatest uncertainty are in the conceptual models and where new information would be most useful to decision making,
- allow comparison of the benefits and costs of alternative models of the system and alternative management actions,
- provide a basis for determining how much of a particular kind of restoration action will be required to achieve measurable benefits within a specified period of time,
- provide a basis for determining the value to the ecosystem of new information that might be obtained through adaptive experimentation, and
- help communicate to a broader audience the current understanding of the problem and the explicit rationale for particular restoration measures or targeted research.

> **Developing Conceptual Models**
>
> **Conceptual modeling:** the process of articulating implicit models (simplified mental illustrations about the most critical cause-and-effect pathways) to make them explicit
> - summarize knowledge and hypotheses about ecosystem structure and function
> - highlight key uncertainties where research or adaptive probing might be necessary
>
> **Exploratory Simulation Modeling:** to allow explicit exploration of the main pathways of causal interaction and feedback processes in the conceptual models
> - greatly simplified, clear caricatures of the system
> - provide preliminary predictions of the consequences of different management actions
>
> **Quantitative Modeling:** to refine conceptual models or simulation models themselves when a more detailed evaluation of potential alternatives is required

Quantitative modeling may also be a helpful tool to refine conceptual models or simulation models themselves when a more detailed evaluation of potential alternatives is required (Figure 3-1).

Conceptual models are based on concepts that can and should change as monitoring, research, and adaptive probing provide new knowledge about the ecosystem. When key concepts change, the conceptual models should be updated to reflect those changes, thereby paving the way toward changes in management. This will not happen by itself but must be accomplished through a systematic, periodic (e.g., every 3 years) reevaluation of the conceptual models.

An Example of Conceptual Models

There is no recipe for developing conceptual models; nor is there a template for what they should look like. There is no unique set of conceptual models that provides a basis for ecosystem restoration and that can be determined deductively. Conceptual models should be designed for a particular purpose and should contain only those elements relevant to solving a particular problem, including alternative explanations that might yield alternative solutions. The models presented below and in Appendix B are, therefore, simply illustrations of such models and their uses

This section provides an explicit example of a conceptual model (the effects of freshwater flow on fish and invertebrates in the upper estuary) to illustrate the ways such models can be used. Several additional examples of conceptual models are described in Appendix B. The models presented here and in the appendix cover the hierarchy of spatial scales important to ecological restoration, from the landscape scale to the scale of specific ecological processes.

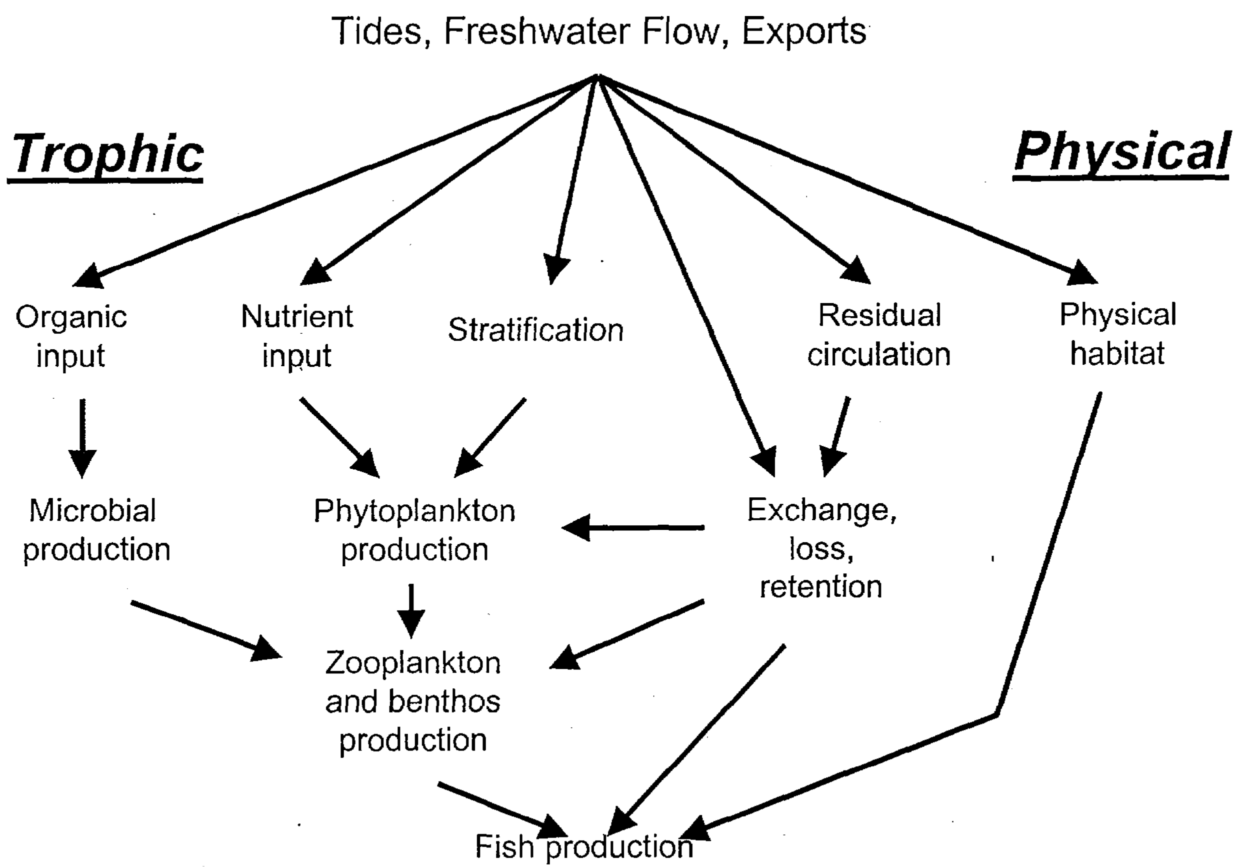
In the "Fish-X2" relationships (Jassby et al. 1995), abundance or survival of several estuarine and anadromous species is related to X2, the distance up the axis of the estuary at which daily average near-bottom salinity is 2 practical salinity units (psu). Because X2 is controlled by freshwater outflow from the Delta, it varies with both inflow and export flows. However, the relationship is entirely empirical and provides no indication of the mechanism controlling abundance or survival. The principal issue addressed here is how different concepts of the mechanism underlying the Fish-X2 relationship define different management tools for maintaining or enhancing populations of estuarine species.

Figure 3-2 illustrates the diverse mechanisms that could account for the X2 relationship for different species. The principal causative variables are freshwater flow and exports, both controllable at least to some extent, and tides, which are not under human control. Briefly, the relationships could arise (as similar ones do in estuaries in other parts of the world) as a result of stimulation of growth at the bottom of the food chain, which then propagates upward, eventually to fish. On the other hand, evidence from this estuary suggests that two kinds of direct physical effects on fish are the more likely mechanisms (Kimmerer 1998). First, flow conditions in the estuary set up by tides and freshwater input, and in some cases by export flows, may alter the retention of some species in the estuary, thereby affecting population size. Second, the amount of physical habitat may change with freshwater flow through such effects as inundation of floodplains or expansion of low-salinity shallow water habitat.

Now consider how potential management interventions are affected by these three scenarios. If the mechanism is stimulation at the base of the food chain, appropriate management actions include addition of nutrients or organic matter to the estuary. If retention is the issue, flows could be manipulated to lengthen or shorten the period of retention in the estuary. If habitat is the issue, physical restoration of habitat or judicious use of flow to increase the amount of habitat at critical times might be in order.

Thus, a very simple model illustrates how critically the management options depend on the assumed cause-and-effect mechanism as well as how various kinds of management interventions can be suggested by a conceptual model. To provide further detail, we use part of the Estuarine Ecology Team's report on the Fish-X2 relationships (Estuarine Ecology Team 1997). That report included a matrix (Figure 3-3) that summarized knowledge about each of the potential mechanisms underlying the Fish-X2 relationships. For each mechanism and each species, the importance of the mechanism is denoted by the size of the symbol. In addition, open symbols denote mechanism for which there is some scientific information, and closed symbols denote mechanisms about which virtually nothing is known.

Each of the mechanisms has a precise definition (Estuarine Ecology Team 1997), but we consider only a few of them here. First, examine the row labeled "Reduced Entrainment (CVP-SWP)." In addition to a number of smaller symbols, large open symbols are given for all the anadromous species except for splittail. Thus, the Estuarine Ecology Team believed that for these species, entrainment could explain at least part of the observed Fish-X2 relationships. Now examine the row labeled "Gravitational Circulation Strength." There are six large filled circles, including those for species that recruit from the ocean as well as several for those that move down-estuary during development and then reside primarily in Suisun or San Pablo Bay and the Delta. In this case, the



Note: The labels "trophic" and "physical" indicate that causative pathways on the left side of the diagram are more biological, based on feeding relationships, whereas those on the right side describe mechanisms that arise through interactions with physical conditions and abundances of species of interest. Tides, freshwater flow, and exports influence organic and nutrient inputs, stratification and gravitational circulation, and the extent of physical habitat with various characteristics. Organic and nutrient input can stimulate growth at the bottom of the food web, which may progress to higher trophic levels, such as fish. Export flow, together with residual and tidal circulation in the estuary, may interact with behavior to affect losses from the estuary or, alternatively, retention. Thus, fish may benefit from increased flow through increased food supply, improved retention in their habitat, or an increase in the quantity or availability of physical habitat.

Figure 3-2: Schematic Diagram Showing Potential Causative Pathways Underlying the "Fish-X2" Relationships

Species

X_2 Mechanisms	CF	PH	SF	WS	AS	SB	LF	DS	ST	CS	NM
Spawning habitat space		◯		○	◯	◯	●	⬤	◯	◯	
Spawning habitat access				○	○	○			◯	◯	
Cooccurrence of food		⬤		●	●	⬤	⬤	⬤	⬤	●	●
Rearing habitat space	◯	⬤	⬤	⬤	⬤	◯	◯	⬤	⬤	●	●
Predation avoidance: turbidity		●			●	○	●	●	●	○	⬤
Predation avoidance: shallow	●	●	●						●	○	
Predation avoidance: encounter	●						●	⬤	●	●	
Reduced entrainment (CVP-SWP)			●	○	◯	◯	◯	◯	●	◯	○
Reduced entrainment (PG&E)	●		●		○	○	⬤	⬤	●	○	●
Reduced entrainment (agricultural)			●		●	◯	●	⬤	●	●	●
Toxic dilution	●	●	●	●	●	○	●	●	⬤	●	●
Transport	●			◯	◯	◯	◯	●	●		
Gravitational circulation strength	⬤	○	⬤			⬤	⬤	⬤			⬤
Entrapment zone residence time						⬤	⬤	⬤			⬤
Temperature (as affected by flow)					●	●				◯	●
Strong migratory cues	●	●	●	◯	◯	●			●	◯	
Higher production of food	●	●			⬤	⬤	⬤	⬤	●		⬤

Relative Uncertainty

● Higher

○ Lower

Importance

⬤ High

● Low

◯ Upstream effect

Note: Symbols indicate a potential mechanism according to the key at right. Several minor mechanisms have been eliminated to simplify the diagram. "Upstream" effects refer to flow effects that occur entirely upstream of the Delta. The species abbreviations are defined as follows:

CF = bay shrimp, *Crangon franciscorum*
PH = Pacific herring
SF = starry flounder
WS = white sturgeon
AS = American shad
SB = striped bass
LF = longfin smelt
DS = delta smelt
ST = splittail
CS = Chinook salmon (note: few major effects are in the Delta)
NM = *Neomysis* and other mysids

Figure 3-3: Estuarine Ecology Team's Summary of Potential Causes Underlying "Fish-X2" Relationships team believed gravitational circulation to be an important mechanism although there was virtually no specific information on its effects. Similarly, "Rearing Habitat Space" was considered an important probable mechanism for the largest number of species although knowledge of this topic is limited. In these latter two examples, the Estuarine Ecology Team was exercising professional judgment in the absence of hard scientific information. Similar kinds of judgments will have to be made in decisions about ecological restoration. However, by employing adaptive management, we will be able to design restoration and management actions that allow us to learn about the mechanisms governing ecological function and species abundance while restoration is proceeding.

Defining Restoration Actions

Conceptual models help to shape the character of restoration actions by identifying key uncertainties or by revealing the level of confidence that a particular action will achieve a given objective. Three types of management actions can be selected for implementation (Figure 3-1). **Targeted Research** may be necessary to resolve critical issues about ecosystem structure and function that preclude us from even defining problems adequately. **Pilot or Demonstration Projects** can help to determine the practicality or effectiveness of restoration actions, allowing resource managers to evaluate alternative actions or build confidence in the ability of a particular action to achieve an objective. For those restoration actions about which we are reasonably confident will achieve an objective, we can begin **Full-Scale Implementation.**

These three types of actions are not mutually exclusive, and all might be used to address a particular problem. Furthermore, they are a set of options and not necessarily progressive.

Monitoring Restoration Actions

It is critical to monitor the implementation of restoration actions to gauge how the ecosystem responds to management interventions. Monitoring provides the data necessary for tracking ecosystem health, for evaluating progress toward restoration goals and objectives, and for evaluating and updating problems, goals and objectives, conceptual models, and restoration actions. Monitoring requires measuring the abundance distribution, change or status of ecological indicators.

Ecological indicators are measures of ecological attributes, populations, or processes that can be measured. Indicators include:

- response variables, such as abundance of important species, used to assess trends and measure progress;
- input variables that can be manipulated directly, such as salinity and temperature;
- summaries of habitat characteristics, such as dimensions of river meanders or area of tidal marsh habitat, that indicate progress toward a goal;
- other variables, such as birth, survival, or migration rates, that can be used to interpret the other data and assess the effects of particular manipulations; and
- intermediate variables that may help to understand the trajectory of response variables and some of which might eventually serve to indicate ecosystem condition (e.g., primary or secondary production, inputs or turnover rate of organic carbon or nutrients, or aspects of foodweb structure).

Ecological indicators should based on goals and objectives, and on important elements of conceptual models. Indicators will need to be reevaluated as the system develops and as models change.

Evaluating and Revising Problems, Conceptual Models, and Restoration Goals, Objectives, Targets and Actions

As we learn more about the ecosystem, it is important that this new information feed back into the planning and management process. Problems, conceptual models, goals, objectives, quantified targets, and the restoration actions that flow from them must be re-evaluated and, if needed, revised to reflect the most current information. Such re-evaluation and revision is essential to ensure that the restoration program is achieving its objectives efficiently and to prevent wasting resources upon restoration actions that do not contribute toward achieving objectives.

To better define restoration objectives, the ERP should specify quantitative restoration targets, as best as possible. The ERP has yet to complete this important task. A process for setting, evaluating, and revising restoration targets needs to be developed. This process should be science-based, using the best available scientific information and judgement through the CALFED Science Program and the independent scientific review process.

Proposed ERP Target Setting, Evaluation, and Revision Process

The process proposed here would be used to evaluate and refine existing targets, set targets for program objectives and elements without quantitative targets, and future target evaluation and refinement through the adaptive management process.

Step 1: Initial evaluation of existing ERP targets for strategic objectives and ecosystem elements.

- Step 1A: Proposed ERP Science Board, or an equivalent independent scientific review panel, evaluates existing quantified targets in the ERPP and classifies them into three categories: (1) stated target has sufficient scientific basis and stated justification or rationale is sufficient; (2) stated target has sufficient scientific basis but stated justification insufficient; (3) stated targets needing revision (i.e., insufficient scientific basis). Steps 1A and 1B conducted concurrently.

- Step 1B: Staff (CALFED or combined CALFED/agency/stakeholder staff) identify strategic objectives and ecosystem elements without quantified targets. Steps 1A and 1B conducted concurrently.

- Step 1C: Science Board develops priority list of strategic objectives and ecosystem elements for target setting (i.e., those without targets), target revision, and additional target justification (based on information from Steps 1A and 1B). Identifying objectives and elements for which there is currently insufficient scientific information to establish targets, and the required information needs (and perhaps actions to provide needed information), would be included in this step.

Step 2: Provide additional scientific justification for targets with sufficient scientific basis.

For targets determined by the Science Board to be scientifically sound (i.e., sufficient scientific basis) but lacking sufficient justification, staff (CALFED or combined CALFED/agency/stakeholder staff) and/or consultants would write scientific justification. Step 2 would be performed concurrent with Step 3.

Step 3: Establish and revise targets by topic area.

For objectives and elements without existing quantitative targets or with existing targets needing revision, small technical teams would establish or revise targets and provide justifications for sets of objectives and elements by topic area (e.g., fish species, fluvial geomorphic processes, Delta wetland and aquatic habitats). Technical team composition: A team for each topic area or category composed of three to five environmental scientists and managers with expertise in the that topic. The Science Board, in consultation with ERP, agency, and stakeholder staff, would establish topic areas and select team members. The Science Board would provide scientific guidance and oversight for the teams. Staff would provide team administrative support and day-to-day management. For each objective/ element topic area, the product of this step would be proposed targets based on best current scientific information (i.e., report presenting proposed targets and scientific justification). For targets that can not be determined because sufficient scientific information is currently lacking, identify scientific information needs and related actions (research, modeling, monitoring). Step 3 would be performed concurrent with Step 2.

STEP 4: Scientific review of proposed targets.

Step 3 products (proposed targets and scientific justifications) would be reviewed by the Science Board and made available for review and comment by agency and stakeholder environmental scientists and managers. These reviews could be sequential with revisions after the Science Board and before broader review, or concurrent with revisions after all comments.

STEP 5: Policy level review and establishment of targets.

- Step 5A: Ecosystem Roundtable review, comment, and recommendations on proposed scientifically based targets. Recommendations should include policy justification.

- Step 5B: CALFED Management Team and Policy Group (or future CALFED/ERP governing entity) consideration of proposed scientifically based targets and Ecosystem Roundtable recommendations. Final policy review, revision, and establishment of targets.

DECISION NODES

Adaptive management includes several crucial decision nodes (Figure 3-1) that have the potential to be bottlenecks. Decisions about which projects to implement and which to postpone, when to gather more information and when to proceed with large-scale restoration, when to terminate projects and when to change direction, and when to declare the success or failure of a particular intervention are difficult and contentious. Although rigorous data analysis and modeling can help with these decisions, they cannot determine the decisions. Efficient progress in adaptive ecological restoration will depend on having institutional arrangements that facilitate effective communication and decision making. A significant element of subjectivity in decisions about whether to proceed will always exist. Open discussion may help to resolve many contentious issues and decisions; nevertheless, in such a large, complex public program there will always be a need for a formal dispute resolution process.

The bottleneck in decision nodes is also important for regulatory compliance. Many of the decision points in the adaptive management system will require state and federal agency approvals for actions recommended by the adaptive management process. Early identification of the decision points requiring public agency approvals can reduce the potential for delays resulting from a disconnect between the adaptive management process and applicable regulatory requirements. Adaptive management decisions made within a regulatory context also will be less vulnerable to challenges.

♦ Chapter 4. Goals and Objectives

Development of CALFED Program Mission and Objectives

In the scoping phase of the CALFED Program in 1996, stakeholders and agency staff developed a mission statement, objectives for four problem areas (ecosystem quality, water quality, water supply reliability and levee system integrity) and solution principles to guide the development and implementation of the Program (Figure 4-1). A series of sub-objectives were developed for CALFED's ecosystem quality objective. These sub-objectives guided the development of implementation objectives that were incorporated into the 1997 version of the ERPP. As the ERP became more specific in its approach and proposed actions, it became apparent that the CALFED objective for ecosystem quality and the implementation objectives did not provide enough specificity or direction.

In 1998, CALFED Program and agency staff, the BDAC Ecosystem Restoration Work Group and the Core Team developed the six goals which were presented in the June 1999 version of the Strategic Plan for Ecosystem Restoration. The six goals were reviewed by the Ecosystem Restoration Program Focus Group and minor revisions made in June 2000. The goals are considered final and are not intended to change. For each goal, the Core Team also developed a draft set of objectives. In revising the goals, the ERP Focus Group also revised the objectives to be consistent with the Multi-Species Conservation Strategy. The ERP Focus Group also added rationales that clarified the objectives. Some of the rationales had been prepared originally by the Core Team, but some were created by the Focus Group.

CALFED Ecosystem Restoration Goals

This document is a guide for achieving a reasonable level of *ecosystem quality* for the Bay-Delta system in a way that reduces conflicts among beneficial uses of California's water. The key term "ecosystem quality" is not well defined but it presumed to equate to "ecosystem health" and "ecosystem integrity" (e.g., Woodley et al. 1993). All of these terms imply the desirability of ecosystems that not only will maintain themselves through natural processes with the minimal human interference possible but also will be aesthetically attractive and produce goods and services in abundance for humans.

The ERP goal statements below provide the basis for a vision of a desired future condition of the Bay-Delta system. Basically, they lead to a definition of what is meant by "ecosystem quality" as applied to the Bay-Delta system. CALFED's goals for ecosystem restoration (referred to in the ERPP as "Strategic Goals"), developed by a diverse group of representatives from CALFED agencies, academia and the stakeholder community, are as follows:

1 Achieve recovery of at-risk native species dependent on the Delta and Suisun Bay as the first step toward establishing large, self-sustaining populations of these species; support similar recovery of at-risk native species in the Bay-Delta estuary and the watershed above the estuary; and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed.

2 Rehabilitate natural processes in the Bay-Delta estuary and its watershed to fully support, with minimal ongoing

RELATIONSHIP OF CALFED MISSION, OBJECTIVES AND SOLUTION PRINCIPLES TO ERP GOALS AND OBJECTIVES

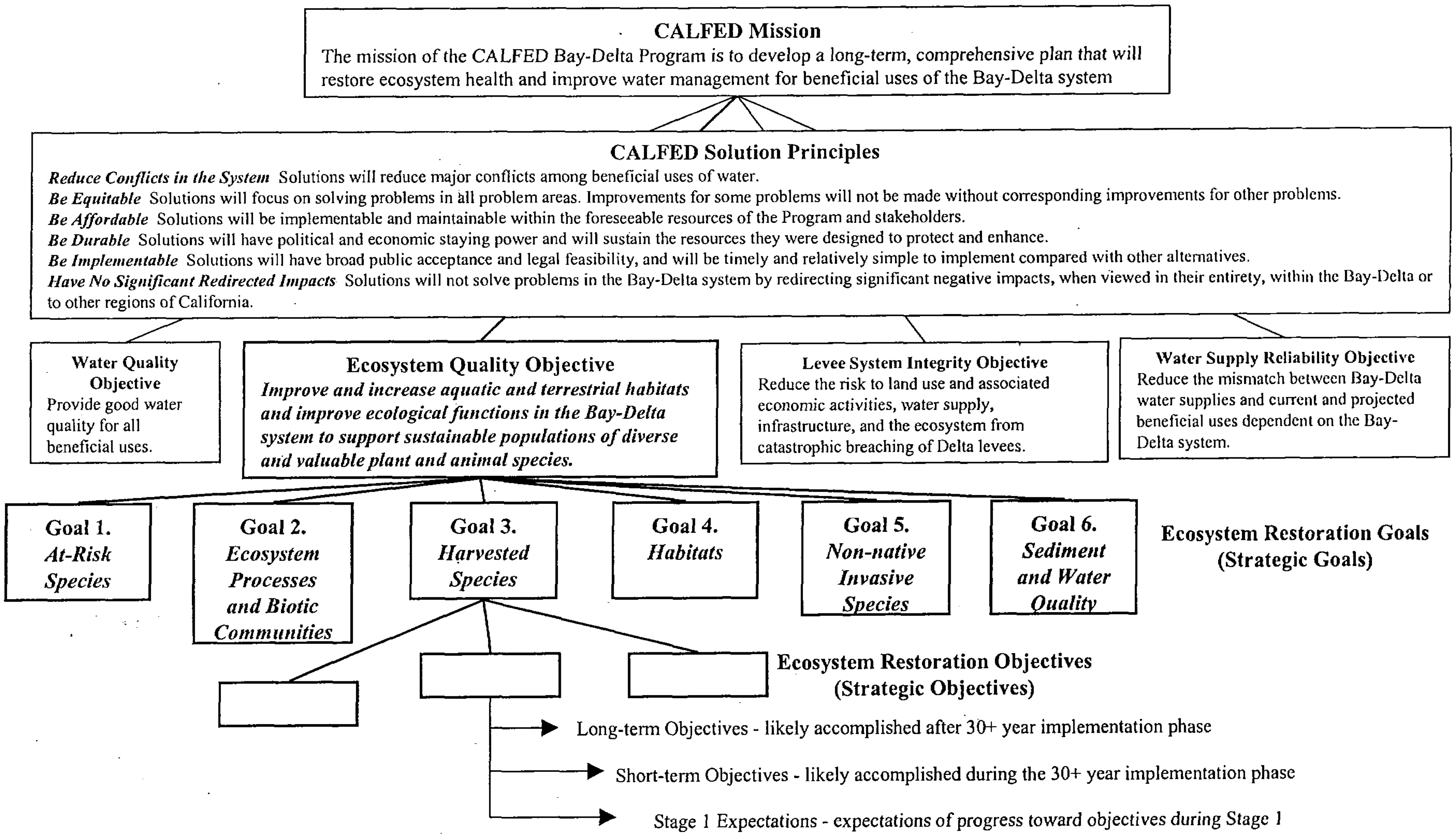


Figure 4-1: Relationship of CALFED Mission, Objectives and Solution Principles to ERP Goals and Objectives

human intervention, natural aquatic and associated terrestrial biotic communities and habitats, in ways that favor native members of those communities.

3 Maintain and/or enhance populations of selected species for sustainable commercial and recreational harvest, consistent with the other ERP strategic goals.

4 Protect and/or restore functional habitat types in the Bay-Delta estuary and its watershed for ecological and public values such as supporting species and biotic communities, ecological processes, recreation, scientific research, and aesthetics.

5 Prevent the establishment of additional non-native invasive species and reduce the negative ecological and economic impacts of established non-native species in the Bay-Delta estuary and its watershed.

6 Improve and/or maintain water and sediment quality conditions that fully support healthy and diverse aquatic ecosystems in the Bay-Delta estuary and watershed; and eliminate, to the extent possible, toxic impacts to aquatic organisms, wildlife, and people.

What Are the Goals Designed to Achieve?

First, the goals reflect a desire for ecosystems that are not continually being disrupted by unpredictable events, such as the invasion of non-native species capable of altering ecosystem processes, massive levee failures, or the collapse of populations of native species. The ecosystems should be dynamic but function within known limits, be resilient in the face of severe natural conditions, and be capable of changing in a more or less predictable fashion in response to global climate change.

Second, the goals reflect the desire for ecosystems that incorporate humans as integral parts of them, as managers, participants, and beneficiaries. According to this description, the ecosystems under the purview of CALFED are not "natural" ecosystems in which humans are primarily observers. Instead, they are systems that continue to be altered by human activity, but in a less harmful way; they include people who live and make a living in them; and they produce products that benefit the larger society, such as water, power, and food.

Third, the goals reflect a desire for ecosystems that maintain substantial self-sustaining populations of the remaining native species and some high-value non-native species (e.g., striped bass, crayfish), with large numbers of species with high cultural, symbolic, or economic value (e.g., salmon, raptors, tules).

Fourth, the goals reflect a desire for a landscape that is aesthetically pleasing and that contains large-scale reminders of the original "primeval" ecosystem, such as salt marshes, tidal sloughs, and expanses of clean, open water.

Fifth, the goals recognize that the ecosystems that will result from CALFED actions will be unlike any ecosystems that have previously existed. They will be made up of mixtures of native and non-native species that will interact in an environment in which many of the basic processes have been permanently altered by human activity and will continue to be regulated by humans. At the same time, the templates for the new ecosystems are the tattered remnants of the original systems and the natural processes that made these systems work.

Goal 1: At-Risk Species

Achieve recovery of at-risk native species dependent on the Delta and Suisun Bay as the first step toward establishing large, self-sustaining populations of these species; support similar recovery of at-risk native species in the Bay-Delta estuary and its watershed; and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed.

The conflict between protecting endangered species and providing reliable supplies of water for urban and agricultural uses was a major factor leading to the formation of CALFED. "At-risk species" are those native species that are either formally listed as threatened or endangered under state and federal laws or have been proposed for listing. The goal places highest priority on restoring populations of at-risk species that most strongly affect the operation of the State Water Project and Central Valley Project diversions in the south Delta, such as Delta smelt, all runs of chinook salmon, steelhead trout, and Sacramento splittail. The goal gives highest priority to the legal recovery of species formally listed under the federal and California Endangered Species Acts (ESAs) because of the high degree of legal protection given the species, especially under federal law.

The ERP also supports actions that will lead to the restoration of large, self-sustaining populations of these endangered species and encourages and supports restoration of populations of species whose listing has less direct impacts on water diversions from the estuary, such as salt marsh harvest mouse (marshes in San Francisco Bay) and yellow-billed cuckoo (riparian areas along the Sacramento River). Because many other native species, especially aquatic species, are also in long-term decline, the ERP overall seeks to create conditions in the estuary and watershed that increase the distribution and abundance of native species or at least stabilize populations so that trends toward endangerment and extinction are halted.

Although the overall goal of the ERP is ecosystem rehabilitation, it is highly appropriate that native species be a major focus of the rehabilitation efforts for the following reasons:

- The federal and State ESAs mandate recovery of species, but because there are often multiple at-risk species in a region, ecosystem recovery is usually necessary for achieving recovery of all the species.

- The habitats that make up the ecosystem contain mixtures of native and non-native species, and often the non-native species are part of the reason for declines of the native species (see goal 5).

- Although ecosystem recovery can be difficult to assess, the abundance and distribution of multiple sensitive native species are easier to determine and can indicate whether or not ecosystem processes have recovered.

GOAL 2: ECOSYSTEM PROCESSES AND BIOTIC COMMUNITIES

Rehabilitate natural processes in the Bay-Delta estuary and its watershed to fully support, with minimal ongoing human intervention, natural aquatic and associated terrestrial biotic communities and habitats, in ways that favor native members of those communities.

This goal recognizes that an ecosystem restoration plan must include restoration and maintenance of ecosystem processes, such as seasonal fluctuations in flow of streams and salinity of the estuary, cycling of nutrients and predator-prey dynamics, to support natural aquatic and associated terrestrial biotic communities. Biotic communities are dynamic assemblages of interacting species that occupy a common environment and share similar physiological tolerances. Ecosystem processes in natural biotic communities vary within predictable bounds. Excessive variation beyond these bounds is a symptom of poor ecosystem "health," often caused by disruptions such as introduction of exotic species or shifts in flow patterns. Particular assemblages of organisms within defined sets of conditions (the biotic communities) therefore become indicators that the ecosystem is functioning in ways regarded as desirable. For example, if the system is managed to sustain high-flow events in March and April, conditions may favor a suite of native fishes (e.g., splittail, hitch, chinook salmon) that respond positively to the increase in shallow-water habitat by flooding. Two key aspects of this goal are (1) to have self-sustaining biotic communities that will persist without continual high levels of human manipulation of ecosystem processes and species abundances and (2) to have communities in which the dominant species, as much as possible, are native species.

This goal emphasizes rehabilitation rather than restoration because so many of the physical and chemical processes in the watershed have been fundamentally altered by human activity. Dams, diversions, levees, and changing patterns of land use have altered the way water, sediments, nutrients, and energy cycle through the system. These changes, largely irreversible within human time scales, set constraints on the nature of the biotic communities that can be maintained. They will allow rehabilitation of ecosystem functioning in ways we find desirable but not restoration of the communities to some pristine state.

GOAL 3: HARVESTED SPECIES

Maintain and/or enhance populations of selected species for sustainable commercial and recreational harvest, consistent with the other ERP strategic goals.

This goal recognizes that maintaining some species in numbers large enough to sustain harvest by humans is important, even if the species are non-native. For native species such as chinook salmon, steelhead, and splittail this means maintaining populations at levels considerably higher than those required to keep them from going extinct. For non-native species such as striped bass, signal crayfish, and channel catfish, this means managing populations at harvestable levels but only as long as such management does not interfere with the restoration of large populations of endangered native fishes or disrupt the structure and function of established, desirable biotic communities.

This goal neither precludes nor encourages hatchery programs to enhance populations of sport and commercial fishes. However, hatchery programs that enhance populations of top predators in the Bay-Delta system are likely to have negative effects on other species. The goal refers to "selected" species because some species that may be harvested (e.g., *Corbicula* clams) are also nuisance species whose populations should be reduced. The species selected for harvest management must be chosen in ways that recognize that the species regarded as harvestable vary considerably among ethnic groups and can change with time. For example, most native cyprinids (e.g., splittail, blackfish, hitch) are held in high regard by many people of Chinese heritage even though they are disdained by many anglers of European heritage.

GOAL 4: HABITATS

Protect and/or restore functional habitat types in the Bay-Delta estuary and its watershed for ecological and public values such as supporting species and biotic communities, ecological processes, recreation, scientific research, and aesthetics.

Habitats are usually defined through some combination of physical features and conspicuous or dominant organisms, usually plants (e.g., salt marsh and riparian forest). Plants are often highly visible natural features and have important roles in the function of the ecosystems of which they are part (e.g., salt marshes can fix large amounts of carbon, which may cycle through the entire system). The ERPP (Volume I) identifies major habitat types in the estuary and watershed, and Moyle and Ellison (1991) identify, at a finer scale, freshwater habitat types. By definition, different habitats support different species or combinations of species and play different roles (usually poorly understood) in the dynamics of the Bay-Delta system. It therefore becomes important to protect and restore large expanses of the major habitat types identified in the ERPP and at least representative "samples" of other habitat types as identified by Moyle and Ellison (1991) and others.

Many direct benefits arise from protecting a wide array of habitats, including the recovery of endangered species and the production of economically important wild species (e.g., fish and ducks). Equally important are the aesthetic values of natural landscapes containing mosaics of habitats. Less appreciated, but also important, are the ecosystem services provided by natural habitats, such as purification of water and air and delivery of nutrients to systems producing fish and other economically important aquatic organisms (Daily 1997).

GOAL 5: NON-NATIVE INVASIVE SPECIES

Prevent the establishment of additional non-native invasive species and reduce the negative ecological and economic impacts of established non-native species in the Bay-Delta estuary and its watershed.

This goal is arguably part of the first four goals because protecting and enhancing species, communities, and habitats in an estuary and its watershed implicitly includes reducing the impact of non-native invasive species. However, the introduction of new species into the system is still occurring so frequently, and the potential for ecological damage by further invasions is so high, that the necessity for halting (not just reducing) further introductions needs to be emphasized. Hobbs and Mooney (1998) document how invasions by non-native species are a major ecological force for change in California. Cohen and Carlton (1998) have labeled the San Francisco estuary as the most invaded estuarine ecosystem in the world and document the accelerating rate at which new species continue to become established, mostly as the result of their deliberate release through the dumping of ballast water of ships. Other sources include illicit introductions by anglers (e.g., northern pike) and aquarists (e.g., *Hydrilla*). This problem needs to be dealt with quickly and directly because new invading species can negate the effects of millions of dollars spent on habitat or ecosystem restoration. Likewise, already established non-native species, such as water hyacinth and the Asian clam (*Potamocorbula*), continue to have major negative impacts on more desirable species in the system, and methods of control have to be devised. However, control methods must be less harmful to native species than the ecological disruption caused by invading species.

CALFED Nonnative Invasive Species Program

The CALFED Nonnative Invasive Species Program is a new program managed by the US Fish and Wildlife Service with the support of numerous agencies, universities and stakeholder groups. The NIS Program is developing a Strategic Plan for managing nonnative invasive species in the Bay-Delta. The NIS Program has adopted CALFED ERP's Goal 5 as its mission statement and has also identified three goals:

Goal I: Prevent new introductions of NIS into the ecosystems of the San Francisco Bay-Delta, the Sacramento/San Joaquin rivers and their watersheds.

Goal II: Limit the spread or, when possible and appropriate, eliminating populations of NIS through management.

Goal III: Reduce the harmful ecological, economic, social and public health impacts resulting from infestation of NIS through appropriate management.

Please refer to Appendices E and F of this volume for additional information on the NIS Program.

GOAL 6: SEDIMENT AND WATER QUALITY

Improve and/or maintain water and sediment quality conditions that fully support healthy and diverse aquatic ecosystems in the Bay-Delta estuary and watershed; and eliminate, to the extent possible, toxic impacts to aquatic organisms, wildlife, and people.

Similar to the difficulty in solving the problem of introduced species, solving the problems associated with aquatic toxicity could be considered part of the first four goals. However, because toxic effects are pervasive and incompletely understood, developing the needed understanding has been identified as a distinct CALFED goal. This goal is being addressed through the CALFED Water Quality Program in close coordination with the ERP.

Problems associated with toxic substances in the aquatic environment include the following:

- Persistent toxicants such as methyl mercury and PCBs can accumulate and concentrate in the aquatic food web creating health problems for carnivorous fish and for other predator organisms such as raptors and humans. (Most of the organo-chlorine compounds responsible for these effects, such as DDT and PCBs, are now banned, but residues remain in sediments and tissues of organisms.)

- As older organo-chlorine pesticides and PCBs were banned because of their persistence, ability to concentrate in the food web, and harmful biological effects, they were replaced by non-persistent chemicals, some of which are acutely toxic. Residues of these materials from agricultural applications and residential use can enter watercourses and cause temporary toxicity to resident organisms, including those upon which other organisms must depend for food. Though temporary toxicity might have important effect on the aquatic ecosystem, the effects may be too subtle to be easily observed.

- Naturally occurring toxic substances, such as extracellular algal metabolites, can also cause toxic effects that may complicate the ability to distinguish toxicity due to activities of humans.

- Considerable potential exists for ecological disasters caused by large, sudden influxes of toxic materials, such as might be caused by flood-released toxic mine wastes (e.g., Iron Mountain Mine) or by spills of a pesticide carrier (e.g., the Cantara spill on the upper Sacramento River).

- Some toxic materials can accumulate in sediments where they can negatively affect benthic organisms directly and indirectly, the food webs they support. This is an important mechanism for the continuing entry of DDT and related water-insoluble compounds into aquatic food webs, despite many having been outlawed since the 1970s. Some toxicants, such as some metals, cause relatively little environmental damage when left undisturbed in sediment beds but, when disturbed, can undergo chemical transformation into forms that cause toxicity in the aquatic ecosystem.

- Substances once thought to be harmless or not previously identified in the aquatic environment can have harmful effects in subtle ways, such as the potential for chronic, low-level stress resulting in increased susceptibility to disease or predation and reduced growth rates or fecundity (e.g., carcinogens or hormone disrupters). The impact of toxic substances is also an area in which there is high public awareness. Considerable concern exists regarding the risks of consuming harvested organisms or of drinking water from the system.

CALFED Ecosystem Restoration Objectives

Associated with each of the six goals for the ERP is a series of objectives (referred to in the ERPP as "Strategic Objectives") (See Figure 4-2). The strategic objectives are intended to assess progress toward achieving the associated goal. The objectives are stated primarily in terms of management actions designed to have a favorable impact on the Bay-Delta system. However, some are also stated in terms of studies that will teach us how the ecosystem behaves so that principles of adaptive management can be better employed. For either purpose, the objectives must be tangible and measurable (e.g., a net increase in the abundance of a species or a successfully completed experimental study).

Individual objectives in the Strategic Plan and ERPP are (or will be) linked to conceptual models that indicate how they fit into the bigger picture of ecosystem restoration. Implicit in all the long-term objectives (and many of the short-term objectives) is the idea they will be achieved and may be changed through adaptive management. For example, several long-term objectives are designed to achieve numbers or densities of spawning salmon equivalent to those of some time in the past. However, we will not know if such numerical objectives are realistic until one or more regulated rivers have been manipulated on a fairly large scale. One way that the success of achieving objectives may be determined is through the use of indicators that are fairly easy to measure. According to the CALFED Ecological Indicators Work Group, "Ecological indicators translate program goals and objectives into a series of specific measurements that can be used to determine whether the goal and objectives have been met." Some potential indicators are implied or given in the objectives and Stage 1 expectations, but most will have to be developed.

Relationship of ERP Goals, Objectives, Targets and Actions with Simplified Example for Upper Sacramento River Floodplain and Meander Restoration

Strategic Goals (6 presented in the Strategic Plan)

Goals provide the basis for a vision of a desired future condition of the Bay-Delta system

Strategic Objectives (32 presented in ERPP Volume I)

Objectives are specific measures of progress toward meeting the goals. The objectives are based on the best available science, and are not intended to change over time except with new information. Objectives help develop and organize targets and programmatic actions. Objectives are presented for three time frames:

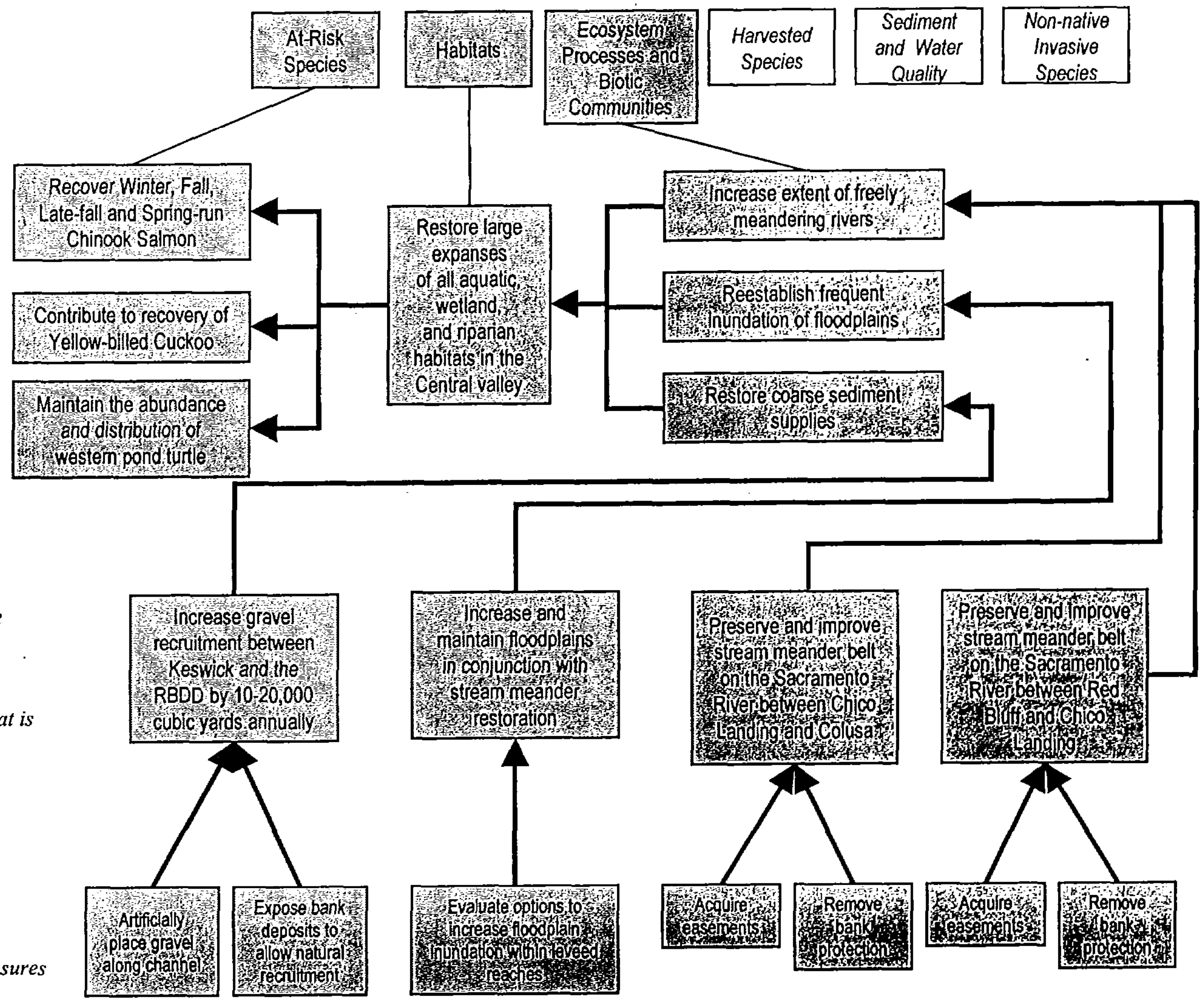
- *Long-term objectives: likely accomplished after 30+ year implementation phase*
- *Short-term objectives: likely accomplished during the 30+ year implementation phase*
- *Stage 1 Expectations: expectations of progress toward objectives during Stage 1*

Targets (over 300 presented in ERPP Volume II)

Targets are quantitative (e.g., a range of numbers) or qualitative (e.g., a narrative description) statements of what is needed in terms of the quality or quantity of desirable ecosystem attributes to meet the objectives. Targets are something to strive for but may change over the life of the program.

Programmatic Actions (over 600 presented in ERPP Volume II)

Programmatic actions are the specific implementation measures required to meet the targets.



This example is described in detail in ERPP Volume II, *Sacramento River Ecological Management Zone Vision.*

Figure 4-2: Relationship of ERP Goals, Objectives, Targets and Actions With Simplified Example for Upper Sacramento River Floodplain and Meander Restoration

The objectives under the six goals often overlap each other broadly or are closely linked. Some may even seem contradictory. Such problems (if they are indeed problems) are inherent in any program designed to make major changes at the ecosystem level. They provide yet another argument for the use of adaptive management as a basic principle to use in implementing restoration programs.

RELATIONSHIP OF GOALS, OBJECTIVES, TARGETS AND ACTIONS

Ecosystem Restoration Goals and Objectives help develop and organize the numerous components of the ERP. Goals provide the basis for a vision of a desired future condition of the Bay-Delta system. Objectives are specific measures of progress toward meeting the goals. Neither the goals nor objectives are intended to change over time except with significant a change in policy direction or new scientific information. In ERPP Volume II, one or more Targets are identified for each objective. Targets are quantitative (e.g., a range of numbers) or qualitative (e.g., a narrative description) statements of what is needed in terms of the quality or quantity of desirable ecosystem attributes to meet the objectives. Targets are something to strive for but may change over the life of the program. Programmatic actions are the specific implementation measures required to meet the targets. Figure 4-2 graphically depicts the relationship of these components.

ERP STRATEGIC GOALS, OBJECTIVES, AND RATIONALES

GOAL 1: ENDANGERED AND OTHER AT-RISK SPECIES, AND NATIVE BIOTIC COMMUNITIES

Achieve recovery of at-risk native species dependent on the Delta and Suisun Bay as the first step toward establishing large, self-sustaining populations of these species; support similar recover of at-risk native species in San Francisco Bay and the watershed above the estuary; and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed.

OBJECTIVE 1: Achieve, first, recovery and then large self-sustaining populations of the following at-risk native species dependent on the Delta, Suisun Bay, and Suisun Marsh: Central Valley winter-, spring- and fall/late fall-run chinook salmon ESUs, Central Valley steelhead ESU, delta smelt, longfin smelt, Sacramento splittail, green sturgeon, valley elderberry longhorn beetle, Suisun ornate shrew, Suisun song sparrow, soft bird's-beak, Suisun thistle, Mason's lilaeopsis, San Pablo song sparrow, Lange's metalmark butterfly, Antioch Dunes evening primrose, Contra Costa wallflower, and Suisun marsh aster.

RATIONALE: This objective addresses species whose populations are likely to further decline if present trends continue and corresponds to the list of species designated "R" (recovery) in the Multi-Species Conservation Strategy. Most of the species designated "R" are either formally listed as threatened or endangered under State and federal laws or have been proposed for listing and their recovery is dependent on improved habitat conditions and restoration of the Delta and Suisun Marsh and Suisun Bay. These are also species for which CALFED could reasonably be expected to undertake all or most of the actions necessary to recover the species. For species with a recovery plan CALFED will implement all necessary recovery actions within the ERP ecological management zones.

This objective places highest priority on restoring at-risk native fish species that are greatly affected by, and in turn strongly affect, the operation of the State Water Project and Central Valley Project. Anadromous and estuarine fish species populations are especially vulnerable to SWP and CVP export diversions in the south Delta. This objective also accentuates the need to recover at-risk native plants and other wildlife species that would likely be affected by CALFED Program actions.

In the early stages of CALFED implementation it is critical to make significant progress towards improving the population health of the at-risk native species addressed in this strategic objective. Without improved species health it is possible that some CALFED Program actions would not be able to move forward because of the uncertain effects to listed-species populations and the associated regulatory constraints.

This objective also addresses the need for progressive restoration by first working toward recovery of at-risk species dependent on the Delta, Suisun Bay, and Suisun Marsh so that they would no longer need to be listed in order to avoid their extinction. The next step is restoring populations to levels that can be sustained without significant human intervention or the risk of listing in the future. Large self-sustaining populations of species such as chinook salmon would also ensure the concurrent support of healthy commercial and sport fisheries.

OBJECTIVE 2: Contribute to the recovery of the following at-risk native species in the Bay-Delta estuary and its watershed: Sacramento perch, delta green ground beetle, giant garter snake, salt marsh harvest mouse, riparian brush rabbit, San Pablo California vole, San Joaquin Valley woodrat, least Bell's vireo, California clapper rail, California black rail, little willow flycatcher, bank swallow, western yellow-billed cuckoo, greater sandhill crane, Swainson's hawk, California yellow warbler, salt marsh common yellowthroat, Crampton's tuctoria, Northern California black walnut, delta tule pea, delta mudwort, bristly sedge, delta coyote thistle, alkali milkvetch, and Point Reyes bird's-beak.

RATIONALE: This objective corresponds to the list of species designated "r" (contribute to recovery) in the Multi-species Conservation Strategy. For species designated "r", CALFED will make specific contributions toward the recovery of the species for which CALFED actions affect only a limited portion of the species' range and/or CALFED actions have limited effects on the species.

The objective of contributing to a species' recovery implies that CALFED will undertake some of the actions under its control and within its scope that are necessary to recover the species. When a species has a recovery plan, CALFED may implement plan measures that are within the CALFED Problem area, and measures that are outside the Problem Area. For species without a recovery plan, CALFED will need to implement specific conservation measures that will benefit the species.

OBJECTIVE 3: Enhance and/or conserve native biotic communities in the Bay-Delta estuary and its watershed, including the abundance and distribution of the following biotic assemblages and communities: native resident estuarine and freshwater fish assemblages, anadromous lampreys, neotropical migratory birds, wading birds, shore birds, waterfowl, native anuran amphibians, estuarine plankton assemblages, estuarine and freshwater marsh plant communities, riparian plant communities, seasonal wetland plant communities, vernal pool communities, aquatic plant communities, and terrestrial biotic assemblages associated with aquatic and wetland habitats.

RATIONALE: This objective accentuates the importance of conserving all native species assemblages and biotic communities in the Bay-Delta estuary and its watershed. CALFED will undertake actions to conserve and enhance the diversity, abundance and distribution of these biotic assemblages and communities in a manner that contributes to their long-term sustainability, without precluding opportunities to improve conditions for at-risk native species.

OBJECTIVE 4: Maintain the abundance and distribution of the following species: hardhead, western least bittern, California tiger salamander, western spadefoot toad, California red-legged frog, western pond turtle, California freshwater shrimp, recurved larkspur, mad-dog skullcap, rose-mallow, eel-grass pondweed, Colusa grass, Boggs Lake hedge-hyssop, Contra Costa goldfields, Greene's legenere, heartscale, and other species designated "maintain" in the Multi-Species Conservation Strategy.

RATIONALE: This objective includes all of the species designated "m" (maintain) in the Multi-Species Conservation Strategy. These are species that are expected to be minimally affected by CALFED actions. CALFED will ensure that any adverse effects on "m" species are offset commensurate with the level of effect on the species thereby maintaining the condition of the species. At a minimum, CALFED actions will not contribute to the need to list a species or degrade the status of a listed species.

GOAL 2: ECOLOGICAL PROCESSES

Rehabilitate natural processes in the Bay-Delta estuary and its watershed to fully support, with minimal ongoing human intervention, natural aquatic and associated terrestrial biotic communities and habitats, in ways that favor native members of those communities.

OBJECTIVE 1: Establish and maintain hydrologic and hydrodynamic regimes for the Bay and Delta that support the recovery and restoration of native species and biotic communities, support the restoration and maintenance of functional natural habitats, and maintain harvested species.

RATIONALE: The restoration of most, if not all, of the native species and habitats in the Bay-Delta estuary depends on having dynamic hydrologic and hydrodynamic regimes (freshwater inflow, salinity, and Delta water circulation patterns) that approximate the historic regimes in order to create conditions favorable for all phases of the life cycles of the "key" fish species (listed in goals 1 and 3). The principal measure in place today of the suitability of the hydrologic and hydrodynamic regime for key fish species is X2, which indicates the position of the salinity gradient in the estuary.

One area in which the hydrologic regime could be altered to favor native species is the Delta. Before the development of water projects, the Delta was less saline in the spring and more saline in the summer during severe droughts than it is now. Highly variable flow and salinity conditions, including infrequent high-salinity events in the Delta, would therefore presumably favor native over introduced species.

As more is learned about the hydrodynamics of the estuary, especially the importance of the low-salinity zone and restoring flow patterns in Delta channels that support estuarine processes related to the food web and fish spawning, rearing, and migration, direct and indirect modifications of estuarine hydrodynamic and hydrologic regimes (in an adaptive management context) should continue.

OBJECTIVE 2: Increase estuarine productivity and rehabilitate estuarine food web processes to support the recovery and restoration of native estuarine species and biotic communities.

RATIONALE: The abundance of many species in the estuary may be limited by low productivity at the base of the food web in the estuarine ecosystem. The causes of this are complex and not well understood, but may include a shortage of productive shallow-water regions such as marshes, high turbidity in open-water regions of the estuary, and consumption and sequestering of available organic carbon by the Asiatic clam. Solving the problem directly is difficult but presumably other actions taken as part of the ERP, such as increasing the acreage of tidal marshlands, will contribute to the solution. A major obstacle to solving problems of estuarine productivity is our poor understanding, so solutions will have to come from research and monitoring of effects of various ecosystem restoration projects.

OBJECTIVE 3: Rehabilitate natural processes to create and maintain complex channel morphology, in-channel islands, and shallow water habitat in the Delta and Suisun Marsh.

RATIONALE: There is widespread agreement that more shallow water habitat needs to be created in the Delta and that existing shallow water habitat needs to be maintained. However, opinions differ on whether creating more habitat will actually increase abundance of desirable species. Ecosystem-based restoration is predicated on this assumption, but adaptive management demands that it be rigorously tested. Staged implementation will allow an increase in confidence in whether or not habitat restoration in the estuary will result in higher abundance of desirable species. Initially this shallow water habitat will be along Delta and Suisun Marsh channels or on small islands in the channels. Ultimately, much of this shallow water habitat would be associated with the restoration of large expanses of tidal emergent wetland, tidal channels, and tidal perennial wetlands in the Delta and Suisun Marsh (recreating large contiguous blocks of the original channel-marsh system). The desirable physical and biotic characteristics of these habitats may be created artificially at first, but the expectation is that they will be maintained by natural processes (e.g., tidal flux, sediment inputs from upstream).

OBJECTIVE 4: Create and/or maintain flow and temperature regimes in rivers that support the recovery and restoration of native aquatic species.

RATIONALE: Virtually all streams in the region are regulated or otherwise modified to some degree, and the altered flow regimes frequently favor non-native fishes. The native fish assemblages (including those with anadromous fishes) are increasingly uncommon. Recent studies in Putah Creek, the Stanislaus River, and the Tuolumne River demonstrate that native fish assemblages can be restored to sections of streams if flow (and temperature) regimes are manipulated in ways that favor their spawning and survival, usually by having flow regimes that mimic natural patterns in winter and spring but that increase flows during summer and fall months (to make up for loss of upstream summer habitats). Native invertebrates and riparian plants may also respond positively to these flow regimes. Similarly, flow regimes in unregulated (naturally flowing) streams that support the restoration and sustenance of native species must be maintained.

OBJECTIVE 5: Establish hydrologic regimes in streams, including sufficient flow timing, magnitude, duration, and high flow frequency, to maintain channel and sediment conditions supporting the recovery and restoration of native aquatic and riparian species and biotic communities.

RATIONALE: Native aquatic and riparian organisms in the Central Valley evolved under a flow regime with pronounced seasonal and year-to-year variability in magnitude, duration, and timing. Frequent (annual or longer term) high flows mobilized gravel beds, drove channel migration, inundated floodplains, maintained sediment quality for native fishes and invertebrates, and maintained complex channel and floodplain habitats. This objective addresses the rehabilitation of at least some of these ecological processes. A strategy of high-flow releases, in conjunction with natural high-flow events, lends itself well to adaptive management because the flows can easily be adjusted to the level needed to achieve specific objectives. However, it should be recognized that channel adjustments may lag behind hydrologic changes by years or decades, requiring long-term monitoring. Also, on most rivers, reservoirs are not large enough to eliminate extremely large, infrequent events so these will continue to affect channel form at irregular, often long, intervals; artificial high-flow events may be needed to maintain desirable channel configurations created during the natural events. This objective is similar to the previous one but differs in its focus on flows that are likely to be higher than those needed to maintain most native fish species but that are important for maintaining in-channel and riparian habitats for fish as well as other species (e.g., invertebrates, birds, mammals). Experimental flow releases also will have to be carefully monitored for negative effects, such as encouraging the invasion of unwanted non-native species. Natural flow regimes, including high flow frequency, in unregulated streams that support the restoration and sustenance of in-channel and riparian habitats should be maintained.

OBJECTIVE 6: Reestablish floodplain inundation and channel-floodplain connectivity of sufficient frequency, timing, duration, and magnitude to support the restoration and maintenance of functional natural floodplain, riparian, and riverine habitats.

RATIONALE: Frequent (often annual) floodplain inundation was an important attribute of the original aquatic systems in the Central Valley and was important for maintaining diverse riverine and riparian habitats. Important interactions between channel and floodplain include overflow onto the floodplain, which (1) reduces the cutting down of the channel, (2) acts as a "pressure relief valve", permitting a larger range of sediment grain sizes to remain on the channel bed, (3) increases the complexity and diversity of instream and riparian habitats, and (4) stores flood water (thereby decreasing flooding downstream). The floodplain also provides shading, food organisms, and large woody debris to the channel. Floodplain forests serve as filters to improve the quality of water reaching the stream channel by both surface flow and groundwater. This objective addresses the reestablishment of active floodplain inundation needed to support these ecological functions.

OBJECTIVE 7: Restore coarse sediment supplies to sediment-starved rivers downstream of reservoirs to support the restoration and maintenance of functional natural riverine habitats.

RATIONALE: One of the major negative effects of dams is the capture of coarse sediments that naturally would pass on to downstream areas. As a result, the downstream reaches can become sediment starved, producing "armoring" of streambeds in many (but not all) rivers to the point where they provide greatly reduced habitat for fish and aquatic organisms and are largely unsuitable for spawning salmon and other anadromous fish.

OBJECTIVE 8: Increase the extent of freely meandering reaches and other pre-1850 river channel forms to support the restoration and maintenance of functional natural riverine, riparian, and floodplain habitats.

RATIONALE: Freely meandering rivers have the highest riparian and aquatic habitat diversity of all riverine systems. Through the process of meandering, eroding concave banks and building convex banks, the channel creates and maintains a diversity of surfaces that support a diversity of habitats, from pioneer riparian plants on newly deposited point bars to gallery riparian forest on high banks built of overbank silt deposits. Similarly, wandering or braided rivers support distinct habitat types and thus are beneficial to aquatic biota. Floodplain restoration can also increase flood protection for urban areas and increase the reliability of stored water supplies in reservoirs (because reservoirs can be maintained at higher levels because of reduced need to catch flood waters).

GOAL 3: HARVESTED SPECIES

Maintain and/or enhance populations of selected species for sustainable commercial and recreational harvest, consistent with the other ERP strategic goals.

OBJECTIVE 1: Enhance fisheries for salmonids, white sturgeon, pacific herring, and native cyprinid fishes.

RATIONALE: Historically the chinook salmon fishery was one of the most economically valuable and the most culturally significant in California. Central Valley salmon and steelhead stocks have been greatly reduced due to dams and other barriers blocking access to spawning habitat, direct mortality from water diversions, altered stream hydrology and Delta hydrodynamics, direct habitat destruction and degradation, harvest pressure, and other stressors. Enhancing salmon and steelhead fisheries will require a coordinated approach of restoring key habitats and ecological processes and reducing or eliminating stressors. Enhancing the fisheries, especially the inland sport fishery, for winter and spring-run chinook salmon and steelhead will be challenging because available habitat is so limited.

White sturgeon represent an unusual situation: a success story in the management of the fishery for a native species. Numbers of sturgeon today are probably nearly as high as they were in the nineteenth century before they were devastated by commercial fisheries. The longevity and high fecundity of the sturgeon, combined with good management practices of the California Department of Fish and Game (CDFG), have allowed it to sustain a substantial fishery since the 1950s, without a major decline in numbers. Numbers of white sturgeon could presumably be increased if the San Joaquin River once again contained suitable habitat for spawning and rearing.

Pacific herring support the most valuable commercial fishery in San Francisco Bay. An important connection to the ERP is that highest survival of herring embryos (which are attached to eel grass and other substrates) occurs during years of high outflow during the spawning period; the developing fish seem to require a relatively low-salinity environment. There is also some indication that populations have been lower since the invasion of the Asiatic clam into the estuary, with the subsequent reduction in planktonic food organisms. Given the frequent collapse of commercial fisheries (including those for herring) in the modern world, it is best to manage this fishery very cautiously to make sure it can continue indefinitely.

Sacramento blackfish, hitch, and splittail support small commercial or sport fisheries. The commercial fisheries are largely unstudied and lightly regulated. Likewise, there is little information on the recreational fishery for splittail in the Delta. Because the ERP seeks to increase populations of native fishes, finding ways to make sure the native cyprinids can support fisheries for specialty markets seems very compatible with the other objectives.

OBJECTIVE 2: Maintain, to the extent consistent with ERP goals, fisheries for striped bass, American shad, signal crayfish, grass shrimp, and nonnative warmwater gamefishes.

RATIONALE: This objective addresses maintaining the popular fisheries provided by these species in a manner that does not conflict with other ERP objectives such as recovery of at-risk native species. The Delta, for instance, has been noted in the past for its productive striped bass and American shad fisheries. Currently these fisheries are depressed while the largemouth bass fishery is in excellent condition. In the absence of a comprehensive restoration effort, increasing the abundance of nonnative fishery species has the potential to limit the recovery of native species, such as chinook salmon and steelhead. Therefore, the management of these species must balance the objective of providing opportunities for harvest while not jeopardizing recovery of native species.

OBJECTIVE 3: Enhance, to the extent consistent with ERP goals, populations of waterfowl and upland game for harvest by hunting and for non-consumptive recreation.

RATIONALE: The Central Valley, Delta, Suisun Marsh, and the rest of the estuary provide important habitat for migratory and resident waterfowl. Public and private seasonal and permanent wetlands and agricultural lands managed to benefit these species following harvest support the impressive flocks of ducks and geese from the Pacific Flyway. While a significant motivation for managing these wetlands has been to support waterfowl hunting, the large associated waterfowl concentrations have become major attractions for large numbers of wildlife viewers, helping to make wetland restoration a much more publicly-supported activity. Much of the primary natural habitats for waterfowl, seasonal wetlands, permanent wetlands, riparian, and grasslands, has been lost or degraded. This has resulted in declines in suitable waterfowl nesting habitat and reductions in the amount of wintering waterfowl habitat. Areas restored to managed seasonal and permanent wetlands and agricultural croplands support increased populations of wintering waterfowl. Management of these habitats with a multi-species perspective will support goals to recover some endangered species.

The upland game guild includes resident and migratory game birds and small mammal game species defined by CDFG hunting regulations. These species are of high interest to recreational hunters in the Bay-Delta watershed. Much of the primary natural habitats for upland game, riparian, oak woodlands, and grasslands, has been lost or degraded. This has resulted in declines in native game species abundances. Agricultural croplands also support upland game. This objective addresses the need to maintain these species by restoring and maintaining the habitats on which they depend.

OBJECTIVE 4: Ensure that chinook salmon, steelhead, trout, and striped bass hatchery, rearing, and planting programs do not have detrimental effects on wild populations of native fish species and ERP actions.

RATIONALE: The salmon, steelhead, trout, and striped bass hatchery, rearing and planting programs in the Bay-Delta watershed were developed to maintain fisheries for these species that would otherwise have ceased or been severely reduced because of habitat loss and degradation, such as dams and diversions blocking access to spawning habitat. To a certain extent, these programs have succeeded by maintaining the commercial and sport fishery for some of these species. Hatcheries and planting programs have not been able to reverse the decline and degradation of wild populations of salmon, steelhead, trout, and other aquatic species. Salmon, steelhead, and trout originating from hatcheries may have aggravated this problem by interacting negatively with wild fish, introducing disease and genetic impacts, and by encouraging high harvest levels in ocean fisheries. Striped bass prey on native fish species, including salmon. There is thus a need to closely evaluate and manage all hatchery and stocking programs that take place in the CALFED area to make sure they are compatible with ERP goals and actions.

A major emphasis of the ERP is to restore wild runs of salmon and steelhead by improving habitat conditions for them and by augmenting flows in spawning streams. The role that state, federal, or private hatcheries can play in this recovery is uncertain. For severely depleted stocks (e.g., winter run chinook) hatchery rearing can provide temporary insurance against extinction due to major natural and unnatural events. For more abundant stocks, however, hatcheries producing large numbers of salmon have the potential to confuse and contravene efforts to restore salmon and steelhead using natural means. Clearly the role of hatcheries on every run of salmon and steelhead needs to be carefully evaluated to determine if and how hatchery practices should be changed or if artificial propagation of some stocks should be halted completely.

GOAL 4: HABITATS

Protect and/or restore functional habitat types in the Bay-Delta estuary and its watershed for ecological and public values such as supporting species and biotic communities, ecological processes, recreation, scientific research, and aesthetics.

OBJECTIVE 1: Restore large expanses of all major habitat types, and sufficient connectivity among habitats, in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay to support recovery and restoration of native species and biotic communities and rehabilitation of ecological processes. These habitat types include tidal marsh (fresh, brackish, and saline), tidal perennial aquatic (including shallow water and tide flats), nontidal perennial aquatic, tidal sloughs, midchannel island and shoal, seasonal wetlands, riparian and shaded riverine aquatic, inland dune scrub, upland scrub, and perennial grasslands.

RATIONALE: All major natural habitat types in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay have been reduced to a small fraction of the area they once occupied, resulting in a large number of at-risk plant and animal species and an increased susceptibility of the remaining areas to irreversible degradation (e.g., invasion by non-native species). The reduction trend is continuing and will have to be reversed if self-sustaining examples of these habitats, and the diverse organisms they support, are to persist into the future. The major habitat types to be restored are stated above in the objective. Within these broad habitat types are more narrowly defined habitats that also need special attention. For example, among the tidal shallow water habitats are intertidal mudflats which are major foraging and resting habitat for migratory and resident shorebirds and waterfowl. Ideally, the mudflats should be dynamic, changing in area and composition in response to freshwater flow and tides. Many are being invaded by non-native cordgrasses which turns mudflat into marsh with relatively low biodiversity. The tendency of this habitat to disappear needs to be reversed through active programs such as cordgrass control. In order to make restoration actions systematic and cost-effective, specific implementation objectives need to be established for each of the habitat types, as well as subhabitats that have distinctive ecological characteristics, and then priorities set within each objective for protection and restoration activities.

OBJECTIVE 2: Restore large expanses of all major aquatic, wetland, and riparian habitats, and sufficient connectivity among habitats, in the Central Valley and its rivers to support recovery and restoration of native species and biotic communities and rehabilitation of ecological processes. These habitat types include riparian and shaded riverine aquatic, instream, fresh emergent wetlands, seasonal wetlands, other floodplain habitats, lacustrine, and other freshwater fish habitats.

RATIONALE: The diversity and spatial extent of aquatic, wetland, and riparian habitats are declining in Central Valley watersheds, especially in lowland areas. Each habitat supports a different assemblage of organisms, and quite likely many of the invertebrates and plants are still unrecognized as endemic forms. Thus, systematic restoration of large expanses of the entire array of major aquatic, wetland, and riparian habitats in the region, with sufficient connectivity among habitats, provides some assurances that essential ecological processes will be rehabilitated and maintained and native biota will be protected, preventing future species listings.

OBJECTIVE 3: Protect tracts of existing high quality major aquatic, wetland, and riparian habitat types, and sufficient connectivity among habitats, in the Bay-Delta estuary and its watershed to support recovery and restoration of native species and biotic communities, rehabilitation of ecological processes, and public value functions.

RATIONALE: A widely accepted principle of ecosystem management is that protecting and maintaining tracts of existing viable, high quality habitat is usually more ecologically efficient, effective, and economical, than restoring degraded or lost habitat. Parcels of high quality aquatic, wetland, and riparian habitats that support native biodiversity and natural processes exist in the Bay-Delta estuary and its watershed. Protecting and maintaining tracts of existing high quality habitat to anchor larger scale habitat restoration actions is a crucial step to improving the ecological health of the Bay-Delta estuary and a top ERP priority along with restoring and/or maintaining sufficient connectivity among habitats.

OBJECTIVE 4: Minimize the conversion of agricultural land to urban and suburban uses and maintain open space buffers in areas adjacent to existing and future restored aquatic, riparian, and wetland habitats, and manage agricultural lands in ways that are favorable to birds and other wildlife.

RATIONALE: The CALFED region is one of the most productive agricultural areas in the world, so agricultural lands and practices will continue to have a significant influence on natural habitats in the area. Agricultural land is important as winter feeding grounds for sandhill cranes, various species of geese, and many ducks. It is also frequently important for foraging raptors, such as Swainson's hawk, and other birds. These benefits are lost if the land becomes urbanized and intense land use disturbs or alters adjacent wetlands or aquatic systems. The negative aspects of modern agriculture from an ecological perspective include its heavy use of pesticides and fertilizers, its efficiency of crop harvest (leaving little for wildlife), its capacity to change land use quickly (e.g., from row crops to vineyards) and its ability to efficiently use each acre of land leaving very little permanent habitat at field margins. This objective addresses the need for "open space" buffers or buffer zones of agricultural land that are farmed in environmentally friendly ways between natural habitats and more industrial agriculture lands or urban areas.

OBJECTIVE 5: Manage the Yolo and Sutter Bypasses as major areas of seasonal shallow water habitat to enhance native fish and wildlife, consistent with CALFED Program objectives and solution principles.

RATIONALE: The Yolo and Sutter bypasses are artificial floodplains constructed in the 1920s to reduce or eliminate flooding of Sacramento and other towns. When not flooded, these immense areas are devoted largely to agriculture. When flooded (mostly during wet winters), the Yolo Bypass alone doubles the wetted surface area of the Delta. Recent studies indicate that the bypasses are potentially important spawning areas for splittail and rearing areas for juvenile chinook salmon, as well as for other species. Their potential as seasonal floodplain habitat is just beginning to be appreciated. A major wildlife area has just been established in the Yolo Bypass. Managing the bypasses at least in part for fish and wildlife therefore has considerable potential and is worth investigating closely. Major problems to overcome are making improvements for fish and wildlife compatible with flood control and with agriculture. Because additional bypasses are being planned, the lessons learned in managing the Yolo and Sutter Bypasses may have broad implications.

GOAL 5: NONNATIVE INVASIVE SPECIES

Prevent the establishment of additional non-native invasive species and reduce the negative ecological and economic impacts of established non-native species in the Bay-Delta estuary and its watershed.

OBJECTIVE 1: Eliminate further introductions of new species from the ballast water of ships into the Bay-Delta estuary.

RATIONALE: The introduction of nonnative species in the ballast water of ships has made the estuary the most invaded estuary in the world; a new species is being added about every 14 weeks. New nonnative invasive species can greatly increase the expense and difficulty of restoring the estuary, and potential reduce the value of a restoration project. Aquatic invasions in various locations in the United States and the world also have harmed public health, decimated fisheries, and impeded or blocked water deliveries. Substantial reductions in the number of organisms released via ballast water are readily achievable. Around the world, restrictions and regulations governing management of ballast water and other ballast materials are being promulgated to reduce the introduction of non-native species by this means. Strict controls on ballast water exchange can be an effective strategy for addressing this objective.

OBJECTIVE 2: Eliminate further introductions of new species from imported marine and freshwater baits into the Bay-Delta estuary and its watershed.

RATIONALE: Many kinds of marine and freshwater nonnative organisms are used for bait in the Bay-Delta estuary and its watershed. Presently, polychaete worms are shipped live from New England and southeast Asia to the San Francisco Bay Area for use as bait in marine sport fisheries. The New England worms are packed in seaweed which contains many non-native organisms, some of which have been established in San Francisco Bay as a result. This is thus an example of small activity that has the potential for large-scale economic damage (see ballast water rationale). Freshwater bait fishes like the red shiner have been spreading rapidly and now dominate many streams, with unknown impacts on native fishes and on fisheries. They continue to be spread by anglers releasing unused bait. Like marine baits, other new organisms may be brought in as "hitch-hikers" in shipments of bait fishes.

OBJECTIVE 3: Halt the unauthorized introduction and spread of potentially harmful non-native introduced species of fish or other aquatic organisms in the Bay-Delta and Central Valley.

RATIONALE: CDFG has long had a policy of not bringing new aquatic species into California to improve fishing. However, illegal introductions continue, such as that of northern pike into Lake Davis. If the highly predatory pike become established in the Sacramento River and Delta, it is quite likely it would have had devastating impact on salmon and native fish populations. There is a need to develop stronger prevention strategies for illegal introductions. The conflict that developed around the necessary elimination of pike from Lake Davis demonstrates the need for developing better public understanding of the need to halt invasions. Education is also needed to make the point that any movement of fish and aquatic organisms by humans to new habitats is potentially harmful, even if the species is already established nearby. Brook trout introduced into a fishless mountain lake, for example, can eliminate the population of mountain yellow-legged frog that lives there, pushing the species further towards endangered species listing.

OBJECTIVE 4: Halt the release of non-native introduced fish and other aquatic organisms from private aquaculture operations and the aquarium and pet trades into the Bay-Delta estuary, its watershed, and other California waters.

RATIONALE: Stocks of fishes and invertebrates are imported from other regions for rearing in aquaculture facilities in the Bay-Delta system, and permits are occasionally approved to bring in new species for aquaculture. Numerous examples exist of organisms escaping from aquaculture facilities and becoming established outside of their range. These include, or potentially could include, fish, crayfish and other shellfish that could compete with or prey on native California fish and aquatic organisms, including sport and commercial species. Of greater concern is the potential for the introduction of parasites and diseases to native fish and shellfish, again including fishery species.

Many kinds of aquatic organisms are sold in aquarium and pet stores. It is likely that some species of nuisance aquatic plants (e.g., *Hydrilla*) became established through aquarists dumping them in local waterways. Nonnative turtles originating in pet stores are frequently present in ponds and have the potential to displace and spread diseases to native pond turtles. Although many organisms sold in aquarium stores are tropical and unlikely to survive in Central California (with some surprising exceptions), the industry is constantly searching for and bringing in new species from a variety of habitats. As indicated in the ballast water rationale, new species can have unexpected and sometimes large-scale negative impacts on aquatic ecosystems and can make restoration much more expensive and difficult.

OBJECTIVE 5: Halt the introduction of non-native invasive aquatic and terrestrial plants into the Bay-Delta estuary, its watershed, and other central California waters.

RATIONALE: Many areas of the Central California landscape are dominated by non-native plant species (e.g., annual grasslands, eucalyptus forests) that have displaced native species and have unexpected negative impacts. Parrot's feather, for example, is an ornamental aquatic plant that is now widespread, clogging ponds and ditches in the CALFED area, thereby creating breeding habitat for mosquitoes. Many harmful species (e.g., water hyacinth) can easily be purchased in plant nurseries and so continue to be spread into natural systems. New species and varieties of plants from all over the world are constantly being brought into California with little evaluation of their invasive qualities. Some species (e.g., Atlantic and English cordgrass) have even been imported for marsh restoration projects.

OBJECTIVE 6: Reduce the impact of non-native mammals on native birds, mammals, and other organisms.

RATIONALE: Probably few issues are as potentially contentious to the public as programs to control the numbers of house cats (both tame and feral), red fox (introduced in the Central Valley and spread to marshes throughout the Bay-Delta system), and domestic dogs in natural areas. The fact remains that such predators can have a major impact on the ability of natural areas to support wildlife, including threatened native species such as clapper rails, salt marsh harvest mice, and salt marsh song sparrows. Likewise, non-native rats and mice can impact populations of native rodents and songbirds. Thus there is a major need to educate the public about the tradeoffs in protecting abundant and conspicuous predators that prey on native species, as well as programs to rid areas of other non-native mammals.

OBJECTIVE 7: Limit the spread or, when possible and appropriate, eradicate populations of non-native invasive species through focused management efforts.

RATIONALE: Nonnative invasive species (NIS) are now part of most aquatic, riparian, and terrestrial ecosystems in California. It is usually difficult to control or reduce the spread of NIS. Preventing new introductions is the most practical, economical, and environmentally safe strategy for dealing with NIS. However, in some instances, control and/or eradication of invasive species is needed (and feasible) to protect the remaining native elements or to support human uses. Four factors should be considered in focusing control efforts. First, an introduced species is often not recognized as a problem by society until it has become widespread and abundant. At that point, control efforts are likely to be difficult, expensive, and relatively ineffective, while producing substantial environmental side effects or risks, including public health risks. Second, some organisms, by nature or circumstance, are more susceptible to control than others. Rooted plants are in general more controllable than mobile animals, and organisms restricted to smaller, isolated water bodies are in general more controllable than organisms free to roam throughout large, hydrologically connected systems. Third, although biological control is conceptually very appealing, it is rarely successful and always carries some risk of unexpected side effects, such as an introduced control agent "controlling" desirable native species. And fourth, physical or chemical control methods used in maintenance control rather than eradication require an indefinite commitment to ongoing environmental disturbance, expense, and possibly public health risks. Overall, the most efficient, cost-effective, and environmentally beneficial control programs may be those that target the most susceptible species, and species that are not yet widespread and abundant. This suggests a need to (1) assess the array of introduced species and focus on those that are most amenable to containment and eradication, rather than focusing just on those that are currently making headlines, and (2) responding rapidly to eradicate new introductions rather than waiting until they spread and become difficult or impossible to eradicate.

An example of an introduced species with currently limited distribution needing eradication that is only beginning to be dealt with is Atlantic smooth cordgrass (*Spartina alterniflora*) in San Francisco Bay. Replacing open mudflats and native cordgrass communities with monospecific stands, smooth cordgrass is a substantial threat to aquatic organisms, wildlife, and fisheries in Pacific estuaries. For example, it densely covers about 30% of the intertidal area of Willapa Bay, Washington. Its introduction into San Francisco Bay has resulted in rapid colonization of the south end of the bay. It has the potential to spread throughout the estuary. However, because of its present relatively limited distribution and abundance, smooth cordgrass can readily be eradicated using appropriate methods.

An example of an abundant species needing immediate attention is the water weed *Egeria densa*. This plant has been spreading rapidly through the Delta, where it clogs sloughs and channels with its dense growth, creating problems for navigation. From a biological perspective, it is undesirable because *E. densa* beds appear to exclude native fishes and favor introduced species.

OBJECTIVE 8: Prevent the invasion of the zebra mussel into California.

RATIONALE: The zebra mussel has done enormous damage to water supply infrastructure and to natural ecosystems in the eastern United States, through which they are spreading rapidly. It is likely that at some point a live population of zebra mussels will appear in California waters through any one of several means. Studies have already demonstrated that it will likely thrive in many parts of the California water system. Therefore, it is highly desirable to have in place a strategy to deal with a localized invasion, along with a commitment of resources from agencies so that rapid action is possible.

GOAL 6: WATER AND SEDIMENT QUALITY

Improve and/or maintain water and sediment quality conditions that fully support healthy and diverse aquatic ecosystems in the Bay-Delta estuary and watershed; and eliminate, to the extent possible, toxic impacts to aquatic organisms, wildlife, and people.

OBJECTIVE 1: Reduce the loadings and concentrations of toxic contaminants in all aquatic environments in the Bay-Delta estuary and watershed to levels that do not adversely affect aquatic organisms, wildlife, and human health.

RATIONALE: Many fish, invertebrates, and wildlife, including at-risk species in Goal 1 and harvested species in Goal 3, contain high levels of heavy metals, pesticides, and other contaminants. There is good reason to think that these toxic compounds may be having negative effects on these organisms, both acute and chronic, including affecting their ability to reproduce, feed, navigate, avoid predation, and/or fight off disease. These same compounds can affect human health through the consumption of harvested species. Systematic reduction in contaminant loads from point and nonpoint sources into the aquatic ecosystems should have positive ecological and human health benefits. In some cases, such as mercury, reduction of concentrations to safe levels may be difficult because of deposits in sediments, but strategies to reduce loads and concentrations are still necessary. This objective addresses CALFED environmental water quality parameters of concern identified by the CALFED Water Quality Technical Group including mercury, pesticides, selenium, trace metals, and toxicity of unknown origin.

OBJECTIVE 2: Reduce loadings of oxygen-depleting substances from human activities into aquatic ecosystems in the Bay-Delta estuary and watershed to levels that do not cause adverse ecological effects.

RATIONALE: As a result of the Clean Water Act, local, regional, state and federal agencies have greatly decreased the amount of contamination of California's waters by sewage, animal wastes, and other substances that deplete oxygen in the water. These organic materials and ambient river conditions cause rapid eutrophication, resulting in dominance by undesirable organisms. Such contamination, although diminished, is still common and needs to be reduced further, from both point and non-point sources. For example, low dissolved oxygen levels in the lower San Joaquin River are often a barrier to the upstream movement of adult salmon and other fish. It is worth noting, however, that release of organic nutrients into aquatic systems is not necessarily always harmful, especially if the nutrients derived from human sources essentially replace those no longer entering the system from natural sources.

OBJECTIVE 3: Reduce fine sediment loadings from human activities into rivers and streams to levels that do not cause adverse ecological effects.

RATIONALE: Fine sediment loads from human activities can and has degraded stream and river habitat in the Sacramento River watershed, the San Joaquin River watershed, and tributaries to San Pablo Bay. Sedimentation and turbidity adversely affect the quality and quantity of fish spawning habitat and other benthic stream habitat and organisms. Erosional soil discharges from agricultural lands, road construction and repair, mining sites, and urban/suburban lands in stormwater runoff and in-channel mining and dredging activities are the major anthropogenic sources of fine sediment loads into streams.

TABLE 4-1. STRATEGIC GOALS AND OBJECTIVES.

GOAL 1: ENDANGERED AND OTHER AT-RISK SPECIES AND NATIVE BIOTIC COMMUNITIES *Achieve recovery of at-risk native species dependent on the Delta and Suisun Bay as the first step toward establishing large, self-sustaining populations of these species; support similar recover of at-risk native species in San Francisco Bay and the watershed above the estuary; and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed.*	
	OBJECTIVE 1: Achieve, first, recovery and then large self-sustaining populations of the following at-risk n beetle, Suisun ornate shrew, Suisun song sparrow, soft bird's-beak, Suisun thistle, Mason's lilaeopsis, San Pablo song sparrow, Lange's metalmark butterfly, Antioch Dunes evening primrose, Contra Costa wallflower, and Suisun marsh aster.
	OBJECTIVE 2: Contribute to the recovery of the following at-risk native species in the Bay-Delta estuary and its watershed: Sacramento perch, delta green ground beetle, giant garter snake, salt marsh harvest mouse, riparian brush rabbit, San Pablo California vole, San Joaquin Valley woodrat, least Bell's vireo, California clapper rail, California black rail, little willow flycatcher, bank swallow, western yellow-billed cuckoo, greater sandhill crane, Swainson's hawk, California yellow warbler, salt marsh common yellowthroat, Crampton's tuctoria, Northern California black walnut, delta tule pea, delta mudwort, bristly sedge, delta coyote thistle, alkali milkvetch, and Point Reyes bird's-beak.
	OBJECTIVE 3: Enhance and/or conserve native biotic communities in the Bay-Delta estuary and its watershed, including the abundance and distribution of the following biotic assemblages and communities: native resident estuarine and freshwater fish assemblages, anadromous lampreys, neotropical migratory birds, wading birds, shore birds, waterfowl, native anuran amphibians, estuarine plankton assemblages, estuarine and freshwater marsh plant communities, riparian plant communities, seasonal wetland plant communities, vernal pool communities, aquatic plant communities, and terrestrial biotic assemblages associated with aquatic and wetland habitats.
	OBJECTIVE 4: Maintain the abundance and distribution of the following species: hardhead, western least bittern, California tiger salamander, western spadefoot toad, California red-legged frog, western pond turtle, California freshwater shrimp, recurved larkspur, mad-dog skullcap, rose-mallow, eel-grass pondweed, Colusa grass, Boggs Lake hedge-hyssop, Contra Costa goldfields, Greene's legenere, heartscale, and other species designated "maintain" in the Multi-Species Conservation Strategy.
GOAL 2: ECOLOGICAL PROCESSES *Rehabilitate natural processes in the Bay-Delta estuary and its watershed to fully support, with minimal ongoing human intervention, natural aquatic and associated terrestrial biotic communities and habitats, in ways that favor native members of those communities.*	
	OBJECTIVE 1: Establish and maintain hydrologic and hydrodynamic regimes for the Bay and Delta that support the recovery and restoration of native species and biotic communities, support the restoration and maintenance of functional natural habitats, and maintain harvested species.
	OBJECTIVE 2: Increase estuarine productivity and rehabilitate estuarine food web processes to support the recovery and restoration of native estuarine species and biotic communities.
	OBJECTIVE 3: Rehabilitate natural processes to create and maintain complex channel morphology, in-channel islands, and shallow water habitat in the Delta and Suisun Marsh.
	OBJECTIVE 4: Create and/or maintain flow and temperature regimes in rivers that support the recovery and restoration of native aquatic species.
	OBJECTIVE 5: Establish hydrologic regimes in streams, including sufficient flow timing, magnitude, duration, and high flow frequency, to maintain channel and sediment conditions supporting the recovery and restoration of native aquatic and riparian species and biotic communities.
	OBJECTIVE 6: Reestablish floodplain inundation and channel-floodplain connectivity of sufficient frequency, timing, duration, and magnitude to support the restoration and maintenance of functional natural floodplain, riparian, and riverine habitats.

	OBJECTIVE 7: Restore coarse sediment supplies to sediment-starved rivers downstream of reservoirs to support the restoration and maintenance of functional natural riverine habitats.
	OBJECTIVE 8: Increase the extent of freely meandering reaches and other pre-1850 river channel forms to support the restoration and maintenance of functional natural riverine, riparian, and floodplain habitats.
GOAL 3: HARVESTED SPECIES *Maintain and/or enhance populations of selected species for sustainable commercial and recreational harvest, consistent with the other ERP strategic goals.*	
	OBJECTIVE 1: Enhance fisheries for salmonids, white sturgeon, pacific herring, and native cyprinid fishes.
	OBJECTIVE 2: Maintain, to the extent consistent with ERP goals, fisheries for striped bass, American shad, signal crayfish, grass shrimp, and nonnative warmwater gamefishes.
	OBJECTIVE 3: Enhance, to the extent consistent with ERP goals, populations of waterfowl and upland game for harvest by hunting and for non-consumptive recreation.
	OBJECTIVE 4: Ensure that chinook salmon, steelhead, trout, and striped bass hatchery, rearing, and planting programs do not have detrimental effects on wild populations of native fish species and ERP actions.
GOAL 4: HABITATS *Protect and/or restore functional habitat types in the Bay-Delta estuary and its watershed for ecological and public values such as supporting species and biotic communities, ecological processes, recreation, scientific research, and aesthetics.*	
	OBJECTIVE 1: Restore large expanses of all major habitat types, and sufficient connectivity among habitats, in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay to support recovery and restoration of native species and biotic communities and rehabilitation of ecological processes. These habitat types include tidal marsh (fresh, brackish, and saline), tidal perennial aquatic (including shallow water and tide flats), nontidal perennial aquatic, tidal sloughs, midchannel island and shoal, seasonal wetlands, riparian and shaded riverine aquatic, inland dune scrub, upland scrub, and perennial grasslands.
	OBJECTIVE 2: Restore large expanses of all major aquatic, wetland, and riparian habitats, and sufficient connectivity among habitats, in the Central Valley and its rivers to support recovery and restoration of native species and biotic communities and rehabilitation of ecological processes. These habitat types include riparian and shaded riverine aquatic, instream, fresh emergent wetlands, seasonal wetlands, other floodplain habitats, lacustrine, and other freshwater fish habitats.
	OBJECTIVE 3: Protect tracts of existing high quality major aquatic, wetland, and riparian habitat types, and sufficient connectivity among habitats, in the Bay-Delta estuary and its watershed to support recovery and restoration of native species and biotic communities, rehabilitation of ecological processes, and public value functions.
	OBJECTIVE 4: Minimize the conversion of agricultural land to urban and suburban uses and maintain open space buffers in areas adjacent to existing and future restored aquatic, riparian, and wetland habitats, and manage agricultural lands in ways that are favorable to birds and other wildlife.
	OBJECTIVE 5: Manage the Yolo and Sutter Bypasses as major areas of seasonal shallow water habitat to enhance native fish and wildlife, consistent with CALFED Program objectives and solution principles.
GOAL 5: NONNATIVE INVASIVE SPECIES *Prevent the establishment of additional non-native invasive species and reduce the negative ecological and economic impacts of established non-native species in the Bay-Delta estuary and its watershed.*	
	OBJECTIVE 1: Eliminate further introductions of new species from the ballast water of ships into the Bay-Delta estuary.
	OBJECTIVE 2: Eliminate further introductions of new species from imported marine and freshwater baits into the Bay-Delta estuary and its watershed.
	OBJECTIVE 3: Halt the unauthorized introduction and spread of potentially harmful non-native introduced species of fish or other aquatic organisms in the Bay-Delta and Central Valley.

	OBJECTIVE 4: Halt the release of non-native introduced fish and other aquatic organisms from private aquaculture operations and the aquarium and pet trades into the Bay-Delta estuary, its watershed, and other California waters.
	OBJECTIVE 5: Halt the introduction of non-native invasive aquatic and terrestrial plants into the Bay-Delta estuary, its watershed, and other central California waters.
	OBJECTIVE 6: Reduce the impact of non-native mammals on native birds, mammals, and other organisms.
	OBJECTIVE 7: Limit the spread or, when possible and appropriate, eradicate populations of non-native invasive species through focused management efforts.
	OBJECTIVE 8: Prevent the invasion of the zebra mussel into California.
GOAL 6: WATER AND SEDIMENT QUALITY *Improve and/or maintain water and sediment quality conditions that fully support healthy and diverse aquatic ecosystems in the Bay-Delta estuary and watershed; and eliminate, to the extent possible, toxic impacts to aquatic organisms, wildlife, and people.*	
	OBJECTIVE 1: Reduce the loadings and concentrations of toxic contaminants in all aquatic environments in the Bay-Delta estuary and watershed to levels that do not adversely affect aquatic organisms, wildlife, and human health.
	OBJECTIVE 2: Reduce loadings of oxygen-depleting substances from human activities into aquatic ecosystems in the Bay-Delta estuary and watershed to levels that do not cause adverse ecological effects.
	OBJECTIVE 3: Reduce fine sediment loadings from human activities into rivers and streams to levels that do not cause adverse ecological effects.

♦ Chapter 5. Implementing the ERP

Introduction

The ERP contains hundreds of programmatic actions that, after being refined and evaluated, will be implemented and monitored throughout the ERP focus area over the 30 or more year implementation phase of the CALFED program. Because of the large scope of the ERP, both in the number of restoration actions and the area within which they will be implemented, restoration of the Bay-Delta ecosystem will occur in stages. Staged implementation will also facilitate an adaptive management approach to ecosystem restoration, since it is difficult to know how the Bay-Delta ecosystem will respond to implementation of proposed ERP actions, as well as the implementation of other CALFED Program components. Later stages of ERP implementation will thus be more responsive to future Bay-Delta conditions, and they will benefit from the knowledge gained from restoration actions implemented in earlier stages. Staged implementation will also allow the costs of restoration to be spread over multiple years.

The CALFED Bay-Delta Program has defined the initial stage of implementation, Stage 1, as the first 7 years following a Record of Decision (ROD) and certification of the Final Programmatic EIS/EIR. The focus of Stage 1 is to implement the six common programs while feasibility studies, planning and design, impact evaluation, and permit acquisition on potential new storage and conveyance facilities are completed. In this manner, storage and conveyance facilities may be ready for construction at the beginning of Stage 2 if they are required, while implementation of the common programs during Stage 1 may obviate the need for, or reduce the scope of, new facilities required.

The Stage 1 action plan for the ERP will include restoration actions that are technically, economically, and politically feasible to implement in the first 7 years of the restoration program, and actions for which environmental documentation can be prepared and required permits can be acquired during the early years of Stage 1. Within these parameters, the focus of the ERP in Stage 1 is to implement those restoration actions that, based upon current assumptions and hypotheses about ecosystem structure and dynamics, will provide the greatest ecological benefits within existing constraints (such as large water supply and flood control dams), thereby improving the environmental baseline for future stages of restoration. In Stage 1, the ERP also aims to resolve critical uncertainties about ecosystem structure and function that currently hamper our ability to adequately define problems or design restoration actions. Twelve critical issues and potential restoration opportunities to address the issues are described later in this chapter. ERP implementation in Stage 1 also focuses on reducing conflicts among beneficial uses of Bay-Delta resources and building public support for long-term ecosystem restoration and management. Appendix D contains a draft list of ERP actions to be implemented in Stage 1.

Appendix D contains a draft list of ERP actions for Stage 1 implementation. The draft Stage 1 actions are a subset of programmatic actions described in Volume II of the ERPP that are feasible to implement in the first 7 years and that address key stressors for high-priority watersheds and areas of the Bay and Delta. The proposed actions in Appendix D are provisional. Continuing work efforts will help to refine the draft Stage 1 actions by articulating assumptions about ecosystem structure and function, and by applying a set of project selection/prioritization criteria.

Guiding Principles for Priority Setting

The following is a list of five consensus principles developed by the ERP Focus Group to guide prioritization of ecosystem restoration activities. These guiding principles are intended to establish fundamental ground rules for ongoing and future priority setting and funding decisions related to ERP implementation. The principles specifically address the following:

- The process for developing near- and long-term ERP actions;
- The role of science-based adaptive management; and
- Parameters for determining the balance of funding priorities and allocation.

These guiding principles will be used in combination with project selection criteria (as described later in the Strategic Plan) to determine priorities. The principles will apply in moving from programmatic actions to regional implementation plans (or Ecological Management Zone Or Ecological Management Unit Plans), as well as in moving from regional implementation plans to project-specific actions. The principles, in and of themselves, do not establish implementation strategies or priorities, but rather are intended to be used in concert with more detailed selection criteria and statutory responsibilities to facilitate an integrated and transparent decision making process for program implementation.

Decisions related to selecting/prioritizing ERP actions and ensuring compliance with state and federal endangered species laws will be integrated to the maximum extent possible to promote one consistent and efficient approach to ecosystem restoration, in accordance with a single blueprint.

Consensus Principles

1. **Basis for ERP Implementation Priorities:** The development of annual, near-term and long-term ERP implementation priorities and strategies will be based on the goals and objectives of the ERP Strategic Plan, MSCS, ESA recovery plans, and implementation plans developed for specific ecological management zones, and informed by a science based adaptive management process.

2. **Role of Science:** A science based adaptive management process will be used to review and advise on ERP strategies and priorities. This process will include adequate monitoring, research, and performance assessment activities, and an independent Ecosystem Science Board. CALFED is committed to using the best available science for ERP implementation in accordance with a single blueprint.

3. **Setting Priorities:** Final decisions regarding ERP implementation strategies, priorities, and funding allocations will be made by the CALFED Policy Group or its successor entity, based on recommendations developed through a collaborative effort involving the CALFED Science Program (including an Ecosystem Science Board), CALFED agencies, stakeholders, and the public.

4. **Funding Priorities:** ERP implementation will include strategies to address the immediate needs of species and other ecosystem components at highest risk; and comprehensive measures to protect and restore habitats, rehabilitate ecological processes, and reduce stressor impacts. The initial funding allocation between these strategies is intended by CALFED to be balanced so that the total allocation provides for a comprehensive restoration approach. Adequate funding will be provided to fully support the science-based adaptive management process and the administration and management of the ERP.

5. **Use of ERP Funds:** ERP funds will be used to implement management measures identified in the ERPP, non-mitigation measures identified in the MSCS, and/or measures developed under the ERP adaptive management process.

REFINING THE LIST OF ERP ACTIONS FOR STAGE 1 IMPLEMENTATION

A series of continuing work efforts will help refine the Draft ERP Actions for Stage 1 Implementation. CALFED is developing a series of scientific white papers that will succinctly describe assumptions about ecosystem structure and function and identify information gaps to be addressed by further analysis, research and monitoring. The white papers are designed to

- Develop conceptual models that describe the key inter-relationships among ecosystem components, system dynamics, and limiting factors relevant to the white paper topic. The white papers will also indicate the degree of confidence and consensus about our understanding of the interrelationships, dynamics, and limiting factors. These conceptual models will be composed of both written description and diagrams.

- Identify uncertainties or scientific disagreements about key interrelationships among ecosystem components, system dynamics, and limiting factors that prevent us from defining or selecting management actions with sufficient confidence or consensus of being effective. The white papers will suggest adaptive management interventions, targeted research, and expanded regional monitoring for addressing these uncertainties.

- Identify general opportunities for, and constraints to, applying restoration/ management strategies and adaptive management experiments.

The current list of white paper topics include:

- Fluvial Geomorphology
- Riparian Habitat and Avifauna
- Tidal Wetlands
- Aquatic Contaminants
- Salmonids
- Delta Smelt
- Splittail
- Open Water Processes
- Diversion Effects on Fish/Environmental Water Account

The ERP has begun developing tributary assessments to help clarify the relative staging of ERP actions, and help identify packages of ERP actions to fulfill restoration objectives for specific Bay-Delta tributaries. The general objectives of the tributary assessments include:

- Identifying additional actions for potential inclusion in the ERPP;

- Refining ERP actions and targets;

- Discussing local factors limiting salmonid production, fluvial processes, and riparian regeneration processes;

- Identifying local restoration opportunities and constraints;

- Identifying potential threats to proposed ERP actions from permitted or planned human activities;

- Refining the general restoration objectives for the tributary;

- Packaging ERP actions in terms of the general restoration objectives; and

- Identifying potential adaptive management experiments.

DECISION ANALYSIS MODEL

The ERP has commissioned the development of a decision analysis model to help define and evaluate alternative management options for a restoration issue that is central to the ERP. A decision analysis model defines and evaluates alternative management options by characterizing: the ecological and biological benefits associated with each option; the ecological, social, and economic tradeoffs associated with each option; and the information value to be gained for each management option. The general objectives of the modeling project are to test the applicability of decision analysis modeling to CALFED restoration issues and to refine CALFED's adaptive management approach by defining experimental management options for a central restoration issue.

Taken together, the white papers and the reconnaissance-level technical analysis will help identify a subset of ERP actions that will be prioritized and evaluated using the action selection criteria described in the next section.

PROJECT SELECTION CRITERIA

The following is a draft list of criteria that will be used to prioritize and select ERP actions for implementation in Stage 1. The application of these criteria to candidate ERP actions will make the selection of Stage 1 actions more transparent.

ECOLOGICAL BENEFIT

- **PROVIDE BENEFIT FOR SPECIAL-STATUS FISH SPECIES.** While the goal of the long-term Ecosystem Restoration Program is to recover and maintain stable, self-sustaining populations of all plant and animal species that rely upon the Delta for part or all of their life history needs, Stage 1 actions will focus primarily upon restoring processes and habitats that benefit endangered and threatened fish species and fish species that are candidates for listing under the state or federal ESA. For instance, numerous Stage 1 actions focus on restoring spawning and rearing habitat and reducing stressors that affect various races of chinook salmon, steelhead trout, delta smelt, and splittail. These special-status fish species are at the center of the most strident conflicts among beneficial uses of Bay-Delta resources. Protecting the survival of special-status fish species will not only preserve integral components of the Bay-Delta ecosystem, but also helps to reduce conflict among beneficial uses of Bay-Delta resources.

- **RESTORES ECOLOGICAL PROCESSES /IS SELF-SUSTAINING.** Actions that restore the dynamic flows of water, sediment, nutrients, woody debris and biota—the building blocks of habitat—are generally preferable to restoration actions that physically reconstruct habitat. Restoring habitats by restoring ecological processes can recreate subtle elements of ecosystem structure and function that likely improve the quality of restored habitat. Restoring ecological processes can also reduce the amount of human intervention required to maintain the value of restored habitat. For example, an area of physically reconstructed salmonid spawning habitat may wash out during high flows, necessitating the continual reconstruction of habitat following high flow events. In contrast, restoring flows of water and sediment can create and maintain spawning habitat with less human intervention, such that the high flow events transport and distribute restored sediments, allowing the system to organize its own spawning habitat.

- **PROVIDE BENEFIT FOR MULTIPLE SPECIES.** The design and location of a restoration action can determine the plant and animal species that it benefits. In terms of project design, restoration actions that restore ecological processes generally benefit multiple species by recreating or mimicking the habitat conditions under which native species evolved. The location of a restoration action also helps

Selection Criteria

Ecological benefit:
- Provide benefit for special-status fish species
- Restores ecological processes/is self-sustaining
- Provide benefit for multiple species
- Provide greatest benefit-cost ratio for native species
- Are complementary

Information value:
- Improve understanding of ecosystem structure and function
- Offer information richness
- Provide results in a short time-frame and inform decisions about potential storage and conveyance facilities

Public Support/Implementability:
- Contribute to multiple Program objectives and minimize conflicts among Program components
- Have high public support and visibility
- Ability to attain Regulatory Compliance

determine the number and types of plant and animal species that will benefit. For example, the inundation of a floodplain in one part of the ecosystem may provide important rearing habitat for a particular species of fish, while the inundation of a floodplain in another location may provide not only rearing habitat for that same species of fish, but also spawning habitat for other fish species, and foraging habitat for multiple bird species. Project locations that will benefit multiple species will generally receive more favorable consideration.

- **PROVIDE THE BENEFIT-COST RATIO FOR NATIVE SPECIES.** Restoration actions will require water, land/easements, material, and financial resources for implementation. The expenditure of resources for the implementation of any action reduces the resources available for other actions. Consequently, it is important to implement actions that will optimize the ecological benefit and/or the information value gained for the resources expended. Actions with the greatest potential to improve ecological conditions or our understanding of the ecosystem for the amount of resources required to implement the action will be good candidates for Stage 1 implementation.

- **ARE COMPLEMENTARY.** Many of the restoration actions described in Volume II of the ERPP must be implemented in concert or in sequence. For example, the addition of spawning-sized gravel to a tributary deprived of its historical coarse sediment load by a dam will need to be accompanied by flow releases sufficient to mobilize and distribute the introduced sediments. Similarly, efforts to restore salmonid spawning habitat may need to be accompanied by restoration of rearing habitat to accommodate an increase in the production of juvenile fish. Actions that can be bundled together to achieve complementary effects will be better candidates for Stage 1 implementation, since they can help ensure more comprehensive restoration and speed progress toward achieving restoration objectives.

INFORMATION VALUE

- **IMPROVE UNDERSTANDING OF ECOSYSTEM STRUCTURE AND FUNCTION.** While much is known about the Bay-Delta ecosystem, there are still gaps in our knowledge about how the ecosystem is structured and how it functions. This uncertainty hampers our ability to adequately define problems are to design effective restoration actions with sufficient confidence. Improving our understanding of the ecosystem can provide a more solid foundation for the long-term ERP, by allowing resource managers to design future restoration actions to be more effective in achieving restoration objectives. Thus, projects with greater potential to improve our understanding of important ecosystem elements and dynamics will generally be good candidates for Stage 1 implementation.

- **OFFER INFORMATION RICHNESS.** The location of restoration actions can determine the value of the information that the action yields. For example, projects underlain by historical and baseline data, such as stream gauge records and baseline biological monitoring, can generally provide more valuable information by placing the results of the restoration action within a larger ecological context. Similarly, certain projects may provide unique opportunities to limit the number of confounding variables, such that the monitored response of the ecosystem to a management action can be attributed more directly to the action rather than factors beyond control.

- **PROVIDE RESULTS IN A SHORT TIME-FRAME AND INFORM DECISIONS ABOUT POTENTIAL STORAGE AND CONVEYANCE FACILITIES.** Restoration actions that yield ecological benefits and information in a short time-frame are good candidates for Stage 1 implementation since they can both build public support for the restoration program and inform the selection and design of future restoration actions. At the end of Stage 1, the Program will determine the new storage and conveyance facilities that may be needed to meet Program objectives, so restoration actions will be selected and designed for implementation in Stage 1 to help inform such decisions at the end of Stage 1.

PUBLIC SUPPORT/ IMPLEMENTABILITY

- **CONTRIBUTE TO MULTIPLE PROGRAM OBJECTIVES AND MINIMIZE CONFLICTS AMONG PROGRAM COMPONENTS.** The ERP is inextricably linked to other CALFED Program components, such as water quality, levee system integrity, and water supply reliability. Ecosystem restoration actions that also contribute to other Program components are good candidates for Stage 1 implementation since they can help ensure that progress toward multiple Program objectives is balanced--an assurance mechanism. Care in the design and location of ecosystem restoration actions will also help to minimize conflicts with other Program components.

- **HIGH PUBLIC SUPPORT AND VISIBILITY.** The public will play in important role in the types and location of restoration actions to be implemented, as well as the overall scope of restoration to be achieved. Actions that enjoy broad public support are better candidates for Stage 1 implementation since they are less likely to be mired in controversy that can delay or undermine their implementation. Pilot projects can also help build public confidence in restoration actions, thereby laying a foundation for the long-term public support that will be necessary to implement the long-term restoration program.

- **ABILITY TO ATTAIN REGULATORY COMPLIANCE.** ERP actions that can be covered adequately by the Programmatic EIS/EIR and do not require additional, site-specific documentation will be good candidates for Stage 1 implementation. However, most proposed ERP actions will require additional environmental documentation and the acquisition of regulatory permits to ensure compliance with laws and regulations. Since the preparation of environmental documents can be a lengthy process, it will be important to ensure that the proposed Stage 1 actions will be ripe for implementation in the first 7 years by identifying the permitting and environmental documentation requirements for each action and estimating the time required to complete them.

IMPLEMENTABILITY CRITERIA

The ERP Strategic Plan describes a conceptual framework and process for refining, evaluating, prioritizing, implementing, monitoring, and revising ERP actions. This conceptual framework includes the identification and application of selection criteria for screening, refining, and prioritizing ERP actions for implementation. The ERP Strategic Plan identifies three primary categories of selection criteria for refining and prioritizing ERP actions:

1. Ecological Benefit;
2. Information Value; and
3. Implementability/Public Support.

Using this conceptual framework and selection criteria as a starting point, the ERP Focus Group has examined the concept of the third suggested criteria (implementability/public support) in more detail, including how such criteria should be defined and when and how they should be applied within an overall priority setting process, including how they should be balanced with other important considerations/criteria (such as ecological benefit and information value criteria). With regard to specific criterion, the ERP Focus Group focused only on implementability criteria. The group did not review or discuss specific ecological benefit or information value criteria. A list of proposed implementability criteria developed by the ERP Focus Group for use in setting priorities and selecting projects for ERP implementation is presented below.

The purpose of implementability criteria is to ensure that issues related to the overall implementability of a proposed action are considered and evaluated in the prioritization and project selection process. The criteria themselves are meant to be screens; they are not intended to function as "on-off" switches. Rather these criteria are intended to represent important factors for evaluating the relative merits of various options. For example, one suggested implementability criterion at the project selection level is "ease of implementation." It is applied not to eliminate projects that are more challenging to undertake, but rather to rank one project characteristic against numerous other criteria that assess implementability. Furthermore, "ease of implementation" in and of itself is not necessarily an overall preferred criterion, given the adaptive management approach embedded in the ERP.

Implementability criteria for selection of ERP actions be applied both at a regional level, where a number of activities must be planned and coordinated, and at the local, project-specific level with outreach and involvement of local officials in affected areas including, but not limited to, watershed groups, local conservancies, local planning groups, property owners, and native American tribes. At the regional level of planning in particular, multiple opportunities exist for achieving multiple CALFED objectives and minimizing conflicts across Program actions, one of the key factors identified in the ERP Strategic Plan.

Regional Implementability Criteria

At the regional level, implementability criteria should be used as screens that on a broad-brush scale can help determine whether or not a project or action is implementable. These criteria should be applied early in the regional planning process in order to ensure that projects and actions are physically implementable and that coordination to enhance achievement of overall CALFED Program objectives is considered. Local interests including, but not limited to, watershed groups, local conservancies, environmental justice groups, local planning groups, property owners, and Native American tribes are to be involved in application of these criteria, to ensure that decisions are fully informed by local consideration prior to decision-making.

The following broad regional implementability criteria will be used:

- **Infrastructure Criteria:** Areas proposed for restoration should be assessed for presence of heavy development or significant existing infrastructure (e.g., large subdivisions, industrial complexes, major interstate and state highways). Areas proposed for restoration should be investigated to determine the potential for imminent or likely land use conflicts.

- **Landscape Resistance Criteria:** Projects and actions should be investigated to determine, from an ecosystem restoration perspective, their relative feasibility based on key landscape conditions such as elevation or topography.

- **Sustainability Criteria:** Proposed actions or projects should be screened for their sustainability given existing ecological processes such as floods, tides, sea level rise, wind or wave erosion, etc.

- **MSCS Consistency Criteria:** Actions or projects should be screened for their consistency with the MSCS.

- **Program Integration/Multiple Program Objectives:** These criteria assess the extent to which proposed actions foster the CALFED Program as a whole and are well integrated with other program elements, both within CALFED and with other related programs.

- **Public Outreach and Local Involvement:** This criterion ensures public outreach and opportunities for local involvement, input, and advice at the regional planning level has occurred.

Potential Conflicts at the Regional Level

In the process of setting ERP priorities at the regional level, one or more CALFED agencies, or local stakeholders, may disagree regarding the advisability of proceeding on a certain type of project proposed in a regional plan. In its proposed single blueprint for ERP implementation, the ERP Focus Group recommends a conflict resolution process to resolve differences of scientific opinion regarding ERP priorities or the implementability of a particular project or type of projects. In the event that conflict resolution efforts are unsuccessful at resolving the disagreement at the regional level, the conflict may be elevated to the CALFED Policy Group, or the proposed ERP governing entity, for resolution.

PROJECT LEVEL IMPLEMENTABILITY

At the project selection level, implementability criteria are applied to help reviewers select among competing proposals or among alternatives in the same proposal category. The Focus Group endorses the implementability criteria that have been developed for the 2001 Proposal Solicitation Package (PSP). Some of the project evaluation criteria identified in the 2001 PSP include: scientific merit of a proposal; clearly stated objectives and hypotheses; sound approach for conceptual model, project design, study methods, and analyses techniques; adaptive management approach; adequacy of proposed monitoring, information assessment, and reporting; technical feasibility of proposal; and proponent qualifications. The Focus Group encourages the Restoration Program to adopt the two additional implementability criteria, as follows:

- **CONTRIBUTION TO MULTIPLE OBJECTIVES:** These criteria should be applied at both the regional and the action-specific level. ERP actions should, when possible, interact with other CALFED actions and other related program actions to maximize achievement of synergistic benefits. Examples include ERP actions that benefit Levee Program objectives, or are consistent with the objectives of the AFRP or the Comprehensive Flood Management Study.

- **CONSISTENCY WITH REGIONAL IMPLEMENTATION PLANS:** A proposed ERP project should be consistent with the appropriate ERP regional plans, with regard to habitat types and quantities proposed for restoration. They should also be consistent with the proposed geographic area in the regional plan.

Additionally, planning and action implementation described in the ERP includes three distinct levels of planning: (1) programmatic, (2) regional, and (3) site specific. The programmatic level of planning is presented in Volume II of the ERP. The regional planning process is discussed later in this section. Site specific planning occurs immediately prior to implementation and has been in progress during the CALFED's early implementation of ecosystem restoration projects.

REGIONAL PLAN DEVELOPMENT

The purposes of Regional Ecosystem Implementation Plans are to clearly articulate an integrated planning, implementation, and scientific framework by which to successfully implement and evaluate restoration of the EMAs and EMUs which collectively constitute the Bay-Delta ecosystem. The Regional Plans will provide comprehensive plans of action that will guide proposed restoration actions during development, revision, implementation, and post-implementation periods. The urgency to rehabilitate the ecosystem can be met by addressing scientific uncertainty and proceeding with scientifically defensible Regional Plans and Implementation Strategies.

One of the primary criticisms of the draft ERP is that the plan did not present a clear restoration strategy integrated across the proposed implementation objectives and programmatic actions. The overall Strategic Plan and Regional Plans are designed to rectify this inadequacy by providing clear restoration and implementation strategies that are strongly supported at the local level.

The five important elements of Regional Plans are the what, why, when, who, and how. CALFED and agency staff can assist in the identification of restoration actions and provide a scientific basis for the actions. Other stakeholders may participate and will given the opportunity to assist in the development of actions and the scientific justification for watershed and site specific projects.

CALFED will have a greater role in determining when funding under its purview will be provided for specific projects and will have to judge the merits of numerous individual projects over the entire ERPP study area.

Local watershed groups and conservancies will have a major role in determining who will implement the actions and the manner in which the actions will be implemented. All implementation will have to comply with State and Federal law and which ever contract law (State or Federal) applies to the specific project. CALFED or its participating agencies may be able to enter in direct cooperative agreements or contracts with watershed groups or conservancies that have legal "non-profit" status as a means by which to receive funding and implement restoration actions.

A broad spectrum of participants is required in the development, evaluation, and implementation of the Regional Plans. Local watershed groups, conservancies, individuals, local governments, and State and Federal agencies will be the primary group developing these implementation plans. Other stakeholders will be invited to participate in reviewing intermediate work products. There will also be issue- specific technical workshops closely linked to the overall Strategic Plan which will have a strong link with the development of the local implementation plans.

Development of Regional Plans will require resolution of many issues related to the selection and implementation of restoration actions presented in the ERP. The major issues and areas of concern follow:

- Local participation and empowerment
- Coordination with other restoration programs
- Conceptual ecosystem models
- Implementation management
- Setting priorities
- Establishing measurable success standards
- Accountability

LOCAL PARTICIPATION AND EMPOWERMENT

Successful implementation of restoration programs and projects is composed of many building blocks. The blocks will be placed on a strong foundation of local support and involvement and science. To ensure that the foundation of the restoration program is sound, it is imperative that local groups have not only the desire to participate but also the wherewithal to assist CALFED in designing and implementing restoration actions within clearly defined areas such as an ecological management unit or watershed. In addition, the development, evaluation, and selection of restoration projects must be based on the best available science. Implementation must also be closely linked to monitoring and the collection of scientific data by which to fairly judge the outcomes of restoration efforts.

To accomplish these tasks, CALFED is looking for a consistent approach between ecological management units in developing standards and procedures. Because much of the potential success of the program depends on local support, CALFED must identify ways in which to foster local participation, and ways in which to empower local groups in the decision-making processes and implementation phase.

COORDINATION WITH OTHER RESTORATION PROGRAMS

One of the important values of an effective Local Implementation Strategy is the opportunity in incorporate coordination as one of the key planning elements. The CALFED Program offers new sources of funding and a new approach to restoration that augments and supports many of the existing restoration programs. Major programs that need to be included in the coordination aspect of the Regional Plans include close coordination with the Department of Fish and Game, National Marine Fisheries Service, and the U.S. Fish and Wildlife Service. Each of these agencies has regulatory authorities for implementing programs to protect, enhance, or restore a wide variety of fish, wildlife, and plant species. The Department of Fish and Game is required under provisions of the Salmon, Steelhead Trout and Anadromous Fisheries Program Act (SB 2261) to implement programs and actions to contribute to the doubling of anadromous fish populations over the level that was present when the act became law. The U.S. Fish and Wildlife Service (and the Bureau of Reclamation), under authority of the Secretary of the Interior, are required to implement provisions of the Central Valley Project Improvement Act, many of which address anadromous fish and riparian habitats. All agencies have major responsibilities under the State and Federal Endangered Species Acts to develop and implement recovery programs for listed species.

To improve coordination and project development the Department of Fish and Game and the U.S. Fish and Wildlife Service have independently and cooperatively established field level restoration coordinator positions to assist the agencies, local watershed groups, and conservancies in identifying, developing, funding, and implementing restoration actions. These restoration positions are critical resources than need to be fully integrated into the Regional Plans.

CONCEPTUAL ECOSYSTEM MODELS

The ERP Indicators Work Group has developed draft conceptual models and ecological attributes pursuant to the recommendations of the Scientific Review Panel. Ecological attributes for the Bay-Delta-River System are organized by broad ecological zone designations which include: upland river-riparian systems, lowland river-floodplain systems, Delta, and Greater San Francisco Bay. General categories of attributes were identified (hydrologic, geomorphic, habitat, biological community, and community energetics) which reflect essential aspects of ecosystem structure and function. Understanding the ecological attributes of the Bay-Delta-River system provides a basis for developing conceptual models.

The conceptual models are designed to provide as much consistency across both ecological hierarchy and geography as possible so that information can be aggregated in a variety of ways. Input by technical experts will be more easily integrated using a common format. The next step is to apply these models to individual ecological management areas and units. This will require a critical review of the ecological interrelationships within individual watersheds.

Ultimately, these models, when fine-tuned for individual ecological management units, will provide a further basis by which to evaluate restoration needs, proposed actions, and in refining a process by which to establish restoration priorities.

ECOSYSTEM-SCALE CONCEPTUAL MODELS

Regional Plans need to incorporate conceptual models in the planning process. Ecosystem-scale models include the Upland River-Riparian Systems, Lowland River-Floodplain Systems, and Bay-Delta Conceptual models. The attributes for the Greater San Francisco Bay and Delta have been incorporated by CALFED staff into one model called the Bay-Delta Conceptual Model. As the iterative review process unfolds it may be necessary to develop separate conceptual models for the Greater San Francisco Bay and Delta.

The ecosystem-scale models are based on distinctive geomorphic and hydrologic features which warrant the development of separate conceptual models. For example, upland river-riparian systems are characterized by steep confining topography with bedrock-controlled stream channels in a narrow floodplain. These systems generally occur in upper elevation watersheds above major dams in both the Sacramento and San Joaquin Valley. Hydrologically these areas are characterized by seasonal shifts in stream levels with periodic flooding. The lowland river- floodplain systems are characterized by flat, non- confining topography with a wide floodplain area which allows for active channel migration and floodplain development. These systems have seasonal shifts in stream levels with periodic flooding but also have greater hydrodynamic complexity and large groundwater basins, particularly in the Sacramento Valley.

For undammed tributaries the 300 foot contour was chosen as the dividing line between upland-river riparian and lowland- river floodplain systems. This is the approximate boundary where alluvial soils begin. Often, the location of dams and reservoirs coincides with this boundary. The difference in hydrologic attributes above and below dams warrant using this as a boundary. The uppermost extent of tidal influence was chosen as the boundary between lowland-river floodplain systems and the Delta. Finally, Chipps Island, to coordinate with the legal definition of the Delta, was selected as the boundary between the Delta and the Greater San Francisco Bay.

HABITAT-SCALE CONCEPTUAL MODELS

Conceptual models of habitats need to be developed to depict our current understanding of habitat structure and function. Habitat models could be used to assess technical feasibility and desirability of proposed restoration projects and to evaluate the results of restoration and management actions. A detailed riparian forest habitat model might include such attributes as hydrologic and sedimentation regime; plant composition, diversity and cover; faunal diversity; and reproduction of neotropical migrant birds. Such a model could be used to construct alternative hypotheses regarding, for example, the ecological effects of a levee setback.

SPECIALIZED CONCEPTUAL MODELS

Specialized conceptual models include models of individual tributaries, stream reaches, sections of rivers, biological communities, species populations and ecological processes. The Lower American River Conceptual Model is an example of a tributary model that could be used to track local system health and demonstrate the contribution of a particular waterway to landscape-level ecological integrity. The lower American River is essential to the migration, spawning, rearing and outmigration of chinook salmon. Conceptual models and indicators for the lower American River will be developed with the assistance of technical specialists having expertise on this system. For example, the Department of Fish and Game's Stream Evaluation Program, the Water Forum, and Sacramento Area Flood Control Agency technical specialists will likely be contributors to this process. While the general ecological attributes of tributaries in a particular geographic area may be the same, the individual tributary indicators and stressors will likely vary to reflect the different areas of concern for each tributary.

The Interagency Ecological Program's Salmon Project Work Team (PWT) is developing a life history model for Central Valley fall-run chinook salmon and a Steelhead PWT is being formed to assist in the development of a steelhead life history model. Quantitative models of hydrology, sediment transport, and carbon budget are examples of specialized conceptual models of ecological processes. Many other conceptual models have been developed (e.g., oak regeneration, vernal pools, perennial grasslands) that are useful in understanding the dynamic character of watersheds and can contribute to the scientific basis for site-specific project development.

IMPLEMENTATION MANAGEMENT

One of the most difficult challenges in the administration of the ERP is the potential design of the necessary institutional arrangements to ensure implementation of a large program in a large geographic area over a long time period (30 years). Although the nature of the implementation entity for the ERP is not a focal point in developing this Strategic Plan, it remains an important activity occurring outside of the ERP. Some of the important issues to be addressed include fostering a regional perspective, utilizing a "Problemshed" orientation, clearly defining the function of the implementation entity which will then define its structure, integrating strong mechanisms for full accountability of the program, and avoiding a fixed approach to implementation by promoting flexibility and creativity.

Some of the issues that need to be resolved include the overall assurances for implementing the CALFED program. Assurances are the mechanisms necessary to assure that the long-term Bay-Delta solution will be implemented and operated as agreed.

Setting Priorities

Phased implementation is an approach to implement actions identified in the ERPP. Phased implementation is comprised of a multistage priority strategy which assists in identifying and sequencing the implementation of the ERPP restoration actions over time and among the 52 EMUs.

Phased implementation within annual implementation programs will be modified on a recurrent basis as a result of adaptive management and the collection and evaluation of new or improved information. The shorter-term implementation programs developed within the framework of adaptive management may vary significantly from the programmatic snapshot of implementation. This is consistent with the theme of adaptive management and reflects the feedback and evaluation loops needed to refine and adjust the implementation program in the short-term.

Funding

The total for implementing the ERPP has been very roughly estimated at $2.5 billion. About half of that is available through Proposition 204 bond and expected federal appropriations. These funds will be used to provide the initial infusion of capital to move the implementation program forward. In later years, the magnitude of the annual implementation program may be constrained by the annual availability of funding. Phasing, and the overall adaptive management program, is ultimately influenced by the availability of restoration funds throughout the duration of the program, individual and cumulative costs to implement the ERPP, and priority strategies that select for specific actions to reach specific targets.

Establishing Measurable Success Standards

The success of the Ecosystem Restoration Program will be measured at various ecological scales. Generally, the scales will include the landscape (entire ERP study area), ecological zone (four distinct ecological areas), ecological management units (watersheds), abundance trend data for certain species, status of ecological processes, recolonization of restored habitat areas, and the ecological effects of site-specific projects.

The Indicators Work Group will play a major role in defining the measures of success by which to evaluate the progress of the ERP. The measures of success have not been developed at this time, and their development hinges on the refinement and critical review of the conceptual models for important aspects of the ecological processes, habitats, and species within the ERP study area.

Accountability

Because of the large size of the proposed restoration program and the estimated overall financial commitment, a strong program to track expenditures and successes is imperative. The shape of the accountability programs has not been developed but will likely include elements that address financial and environmental aspects of the restoration program.

Demonstration Watersheds

ERP Stage 1 actions will focus on restoring the critical ecological process and reducing or eliminating the primary stressors that degrade ecological health and limit threatened fish populations in several key watersheds of the ERP focus area. Improving the health of the constituent watersheds by restoring ecological processes and reducing or eliminating principal stressors will help to improve the health of the overall Bay-Delta ecosystem.

Stage 1 of the ERP will also include comprehensive, full-scale implementation of restoration actions in selected demonstration watersheds tributary to the Sacramento and San Joaquin rivers. The objective for each of the demonstration watersheds is to create healthy, resilient havens of riparian and aquatic habitat to provide refugia during prolonged droughts or other periods of extreme environmental stress. The approach in the demonstration watersheds is to fully restore the stream corridor within existing constraints (such as large dams) by using a more holistic approach that considers the entire watershed, not just the riparian corridor. Because of the comprehensive nature of restoration actions in demonstration watersheds, the Program will work with local conservancies and stakeholders to help select demonstration watersheds that provide significant potential for large-scale restoration that enjoys local support. Restoring these tributaries into healthy riparian corridors during Stage 1 will also help to recover and maintain large populations of fish species to endure severe ecological conditions such as droughts.

The demonstration watersheds will also serve as laboratories in which resource managers and scientists can test assumptions and hypotheses about ecosystem structure and dynamics and the complex interplay of stressors and how they affect ecological health. The knowledge gained from restoration in the demonstration streams will help to strategically focus restoration actions on primary stressors in other tributaries, as well as clarify how multiple stressors interact to intensify their impacts upon the ecosystem.

ADDRESSING CRITICAL UNCERTAINTIES AND IMPEDIMENTS TO RESTORATION

Decades of scientific study about the Bay-Delta ecosystem have yielded considerable knowledge about ecological relationships and functions. However, significant uncertainties about Bay-Delta ecosystem dynamics still remain, and they hamper our ability to adequately define some ecological problems or to design effective restoration actions for known problems. The following list of issues indicates substantial uncertainties about Bay-Delta ecosystem dynamics that can be addressed by designing Stage 1 actions to test current assumptions and competing hypotheses about ecosystem structure and function. Many of the following issues deal with uncertainty resulting from incomplete information and unverified conceptual models, sampling variability, and highly variable system dynamics. Developing a better understanding of how these factors affect the ecosystem early in the program will help resource managers to design later restoration actions with greater confidence in their ability to produce desired effects.

The twelve issues described below are listed in approximately increasing order of specificity but not ordered by importance. These issues are not the only ones to consider but must be taken into account to help ensure a successful program.

1. NON-NATIVE INVASIVE SPECIES

Non-native invasive species (NIS) have produced immense ecological changes throughout the Bay-Delta ecosystem, and they represent one of the biggest impediments to restoring populations of native species. We generally do not understand the mechanisms and pathways by which non-native invasive species affect Bay-Delta ecology, or the underlying mechanisms that give non-native or native species a competitive advantage. Consequently, it is difficult to select, bundle, and design habitat restoration projects so that they favor native species. Nor do we know the basic life history requirements for several non-native invasive species, which complicates the development of control and/or eradication strategies. In order to minimize the risk of potentially massive ecological and biological disruptions associated with non-native species that threaten to negate the benefits of restoration efforts, it is important to initiate an early program that meets the following goals:

- Prevent new introductions and establishment of NIS into the ecosystems of the Bay-Delta, the Sacramento/San Joaquin rivers and their watersheds.
- Limit the spread or, when possible and appropriate, eliminate populations of NIS through management.
- Reduce the harmful ecological, economic, social, and public health impacts resulting from infestations of NIS through appropriate mitigation.
- Increase our understanding of the invasion

process and the role of established NIS in ecosystems in the CALFED region through research and monitoring.

CALFED established the Non-Native Invasive Species program in 1998, which developed both a Strategic Plan (See Appendix E) and an Implementation Plan (See Appendix F) for addressing non-native invasive species in the Bay-Delta ecosystem.

2. Natural Flow Regimes

Human activities have fundamentally, and irreversibly, altered hydrologic processes in the Bay-Delta ecosystem. For example, changes in land use have affected how and when water drains from the land into stream channels; water diversions have changed the amount of water flowing through tributaries and the Delta; and dam development has profoundly altered the timing, frequency, and magnitude of flows. Extensive water development has generally affected the flow regime by reducing the seasonal and inter-annual variability of flows, as reservoirs capture and store stormwater and snowmelt runoff for later release as water supply. Such changes to the flow regime stress native habitats and species that evolved in the context of a variable flow regime. Restoring variability to the flow regime will be an important component of restoring ecological function and supporting native habitats and species in the Bay-Delta ecosystem.

Restoring variability to flow does not imply restoring a pre-disturbance, natural flow regime, which would be impossible considering the human reliance upon the water supply infrastructure that most affects the character of flow in the Bay-Delta ecosystem. Rather, restoring flow variability will generally mean mimicking the natural hydrograph—imitating the relative timing, magnitude, and duration of pre-disturbance flows.

There will likely be limited opportunities for mimicking naturally low base flows since human water supply and quality needs are so reliant upon the water releases that generally increase base flows. Also, in many reaches, re-creating low base flows may not be desirable from an ecological standpoint. For example, dams have prevented sensitive anadromous species from accessing historical holding and spawning habitats in upper watersheds, but cold water releases from the dams have permitted these fish to survive in reaches downstream of dams. Limited opportunities for re-creating low base flows should not preclude experimental management actions that examine how low-flow conditions affect native and non-native species.

Restoring flow variability will likely focus on mimicking historical peak flows to restore some measure of ecological function and to better create and maintain habitats. However, defining a flow schedule to best achieve ecological restoration objectives on streams regulated by dams is a complex task that must account for the fundamental changes that dams create, including trapping sediments and organic material from upper watersheds, as well as downstream channel adjustments to the post-dam flow regime. Historical reference conditions are instructive, but alone are insufficient to define the flow patterns that will best achieve ecological objectives. Defining ecologically functional flow schedules will also require analyzing current downstream channel and habitat conditions, and developing and testing hypotheses regarding flow requirements for various geomorphic and ecological functions. Research, monitoring, and implementation projects designed to develop a better understanding of geomorphic flow thresholds and hydrologic-biologic relationships will facilitate estimating environmental flow needs, so that environmental dedications of water are effective and efficient in achieving restoration objectives, thereby minimizing potential impacts upon water supply and hydropower generation.

To better define the extent to which rivers regulated by dams can be restored to provide some measure of ecological function, early restoration efforts will need to be accompanied by appropriate research, monitoring, modeling, planning, and feasibility studies. Examples of such projects include:

- Monitoring projects to better estimate geomorphic thresholds, such as the placement and monitoring of tracer gravels and monitoring of water surface elevations to better estimate bed mobility thresholds and gravel routing.

- Historical analysis and modeling to define or refine the non-linear relationships between flow and bank erosion;
- Monitoring to refine stage-discharge relationships and the availability, quality, and use of resultant microhabitats;
- Monitoring and modeling to determine fish passage flows past flow-related barriers;
- Monitoring and modeling to develop or refine flow-temperature relationships;
- Support studies such as an examination of sources of sediment for restoration purposes;
- Research projects that examine the mechanisms underlying native and exotic species responses to flow;
- Simulation and operational modeling to evaluate options for obtaining water to meet environmental needs;
- Monitoring and modeling to develop or refine relationships between flow and contaminant concentrations, bioavailability, and resultant dose and exposure to biota.

Several of the topics noted above can be incorporated into implementation projects. For example, the placement and monitoring of tracer gravels should be a part of any gravel augmentation project implemented to compensate for historical gravel depletion. Similarly, any riparian re-vegetation project should be structured and monitored to enhance our understanding of how native and/or non-native species of riparian vegetation respond to flow components.

3. Channel Dynamics, Sediment Transport, and Riparian Vegetation

Rivers are naturally dynamic. They migrate across valley floors as flows erode banks and deposit sediment on point bars; they occupy different channel alignments through channel avulsion; they periodically inundate floodplains; they recruit and transport sediment; and they drive the establishment and succession of diverse riparian plant communities. These physical processes provide the energy and material necessary to create and maintain healthy and diverse riverine habitats that support native populations of plants, fish, and wildlife. There is a growing recognition that the preservation of existing habitat, and the physical creation of new habitat, must be accompanied by the restoration of physical processes, not only because they help create and maintain these habitats, but also because they are fundamental determinants of habitat conditions in themselves. Restoring ecological processes as a means of restoring habitat conditions is a signature feature of an ecosystem-based management approach.

Human activities have generally reduced the dynamic processes of Central Valley tributaries, with a resultant loss of riverine habitat. Dams have reduced the peak flows essential for shaping and re-shaping channel forms and for connecting river channels with their floodplains. Dams also trap sediment and woody debris from upstream reaches, depriving downstream reaches of the fundamental building blocks for habitat. Levees and bank protection have also prevented channel migration and reduced connectivity between channels and floodplains.

It is generally infeasible to restore fully dynamic rivers because of irreversible historical changes and continued human uses. However, river channels and floodplains may be dynamic on a smaller scale so as to restore some measure of ecological function. For example, rivers can be scaled down by providing space for its meanders to migrate, though not the full floodplain width that it historically meandered across. Similarly, we can introduce coarse sediment and large woody debris into a channel to compensate for the material trapped by dams, but without attempting to match the historical scale of such material inputs. Channel-floodplain connectivity can be increased without restoring the full extent of historical floodplain inundation. While we may be able to restore ecosystem function by restoring riverine processes at a reduced scale, we cannot scale down a river indefinitely, as there are basic thresholds below which a river will cease to function. For example, there are minimum threshold flows required to initiate important geomorphic functions such as bed mobility, bank erosion, and overbank flooding.

We generally do not know the scale and balance of inputs--flow, sediment, organic material--and channel modifications that will restore riverine ecosystem function. Nor do we know how channels and habitats downstream of dams have adjusted to the post-dam flow regime and how, therefore, the re-invigoration of dynamic riverine processes will affect overall habitat. Restoring geomorphic processes so as to optimize ecosystem benefits will be a matter of both analysis and experimentation. It is also important to identify locations in the Bay-Delta ecosystem that still have, or can have, adequate flows to inundate floodplains and sufficient energy to drive channel migration.

4. FLOOD MANAGEMENT AS ECOSYSTEM TOOL

River-floodplain interaction is a vital component of riverine health. When inundated, floodplains provide valuable habitat for a multitude of species. They can also supply sediment, nutrients, and large woody debris to river channels, and provide a place for fine sediment deposition, which is an important function in light of flushing flows designed to cleanse spawning gravels. Inundation of floodplains also contributes to diverse structure of riparian vegetation. Human activities have aggressively and deliberately isolated floodplains from river channels, most clearly through levees designed to confine flows in channels. Dams have also contributed to floodplain isolation by reducing peak flows necessary to inundate floodplains.

Floodplains also provide storage of floodwaters, and there is growing interest in reconnecting rivers with their floodplains as part of a comprehensive flood management strategy. Large floods in the Mississippi River Valley and Central Valley in the last decade have exposed weaknesses in a purely structural approach to flood management and nurtured a growing recognition that we can never eliminate floods. For example, levees pulse floodwaters downstream more quickly, which provides local flood protection by transporting flood burden and risk downstream. In contrast, floodplains can actually store floodwaters and generally reduce overall flood risk by gradually metering flow back into the channel over time. For example, an analysis of hydrologic data for some Central Valley tributaries during the '97 floods indicates rising flows beginning to plateau as upstream levees were breached. The plateau effect demonstrates the ability of the floodplain to absorb part of the discharge, thereby attenuating the peak flow and reducing flood pressure on downstream reaches.

The Army Corps of Engineers, the Department of Water Resources, and the Reclamation Board are engaged in a Comprehensive Study of the Sacramento and San Joaquin River systems to examine opportunities for improving flood management through both structural and non-structural options. The Comprehensive Study and CALFED represent an important opportunity to integrate flood management and ecosystem benefits by reconnecting rivers with their floodplains.

Flood management can also provide ecosystem benefits through the evacuation of reservoir space for flood reservations. Many dams in the Central Valley reserve a certain portion of reservoir capacity to capture floodwaters, so as the rainy season approaches, dams must often release flows to evacuate water that occupies flood reservation space. Such flood management releases have the potential to provide significant ecosystem benefits if they are released to mimic the peak flows that are essential for restoring geomorphic processes.

Integrating and balancing flood management and ecosystem benefits will require several activities and adaptive management experiments. Some of the activities and actions include:

- Identifying and acquiring floodplain land or easements to provide opportunities for restoring channel-floodplain connectivity and testing flood management and ecosystem benefits;

- Quantifying the flood management benefits of floodplain storage;
- Examining opportunities for restoring river-floodplain connectivity without compromising development, such as protective ring levees, setback levees, or floodproofing;
- Re-grading existing floodplains on regulated streams so that they inundate more frequently in the context of post-dam flow regime, to facilitate testing flood management and ecosystem benefits;
- Clarifying how ecosystem restoration efforts, such as riparian re-vegetation, gravel augmentation, and channel reconstruction projects, affect flood conveyance capacity;
- Identifying hydraulic constrictions/choke points that prevent managed flow releases to inundate floodplains, and exploring options for addressing them; and
- Exploring opportunities to re-construct levees to provide some measure of habitat without reducing levee strength or reducing conveyance capacity.

5. BYPASSES AS HABITAT

The Yolo and Sutter Bypasses along the Sacramento River provide important flood management benefits in the Sacramento Valley and downstream urban areas. The realization of their relatively low-cost benefits to flood control is leading to the consideration of additional bypasses, especially in the San Joaquin Valley. The bypasses accommodate multiple uses; during the dry season, they are important areas for farming, and when flooded they provide important habitat for waterfowl, fish spawning and rearing, and possibly as sources of food and nutrients for estuarine foodwebs. For example, when the Yolo Bypass is flooded, it effectively doubles the wetted surface area of the Delta, mostly in shallow-water habitat. More frequent inundation of existing flood bypasses and the creation of new bypasses could expand the ecosystem benefits that they provide, but managing the bypasses for the benefit of fish and wildlife must be balanced with their use for flood control and farming. Achieving this balance of flood management, land use, and ecosystem benefits will require activities such as:

- Evaluating structural alternatives for directing water into bypasses so that they inundate more frequently;
- Experimenting with different inundation scenarios to study fish and wildlife preferences and benefits;
- Identifying opportunities for new flood bypasses and how they can be designed to benefit fish and wildlife;
- Examining how ecosystem habitats affect flood conveyance of bypasses;
- Evaluating the relative importance of flood bypass contributions to estuarine foodweb productivity;
- Studying what multiples uses are compatible in flood bypasses (e.g., what types of agricultural practices used in the bypasses and what types of fish and wildlife use are and are not compatible)

Recent studies of flooded bypasses demonstrate their importance for several sensitive fish species. There is some question, however, if the bypasses can be used as models for floodplain restoration actions along Bay-Delta tributaries, or if the bypasses constitute unique habitats.

6. SHALLOW-WATER TIDAL AND FRESHWATER MARSH HABITAT

Both tidal and freshwater wetlands (marsh habitats) represent critical areas for many key species, including species that are threatened or endangered or that have commercial and/or sport value. A significant portion of historical wetlands have been lost to human uses, so the ERP will restore wetland habitats throughout the Bay-Delta ecosystem as part of an ecosystem-based management approach. The underlying rationale of wetlands restoration is that rehabilitating the appropriate physical-chemical habitat in priority locations will contribute to the recovery of sustainable populations of the species of concern. The loss of these wetland habitat types is assumed to be causally linked to declines in these key species. These causal links have not been well established and habitat manipulations, designed as careful experiments on differing spatial and temporal scales, hold promise for determining the relationships that can help guide restoration efforts. However, a major concern remains that the restored habitat will be successfully colonized by non-native rather than native species.

Additional information is needed about life history and species needs relative to inundation (water depth) and salinity regimes in tidal wetlands, required by key native or non-native wetland species. The growth and reproduction of selected species of concern and their linkage to inundation-salinity (in tidal marshes) regimes in given wetland plant communities needs to be better understood to facilitate successful wetland restoration projects. Identification of limiting factors which determine the distribution and abundance of selected wetland species of concern for various inundation-salinity regimes will also facilitate increased success of restoration efforts. Evaluation of spatial characteristics (size, shape, and connectivity) for their effect on the population dynamics of selected freshwater or tidal wetland species, especially their colonization or extinction rates, should be conducted or included as part of physical interventions. This uncertainty might be addressed by making multi-year observations of arrays of habitats that differ in size, shape, and/or connectivity (nearest neighbor characteristics) or by creating such an array of habitats by planting and/or removing selected habitat patches.

Because of the complexity of wetland habitats it will be important to identify and justify animal species that can be used as indicators of acceptable wetland conditions. For example, the sustainable presence of species with long life cycles that are sessile and/or have poor dispersal habit could be good indicators of acceptable stable conditions.

7. Contaminants in the Central Valley

The Bay-Delta ecosystem receives a large variety of potential toxicants (Gunther et al., 1987; Davis et al., 1992). These include significant quantities of selenium from agricultural practices, mercury from historical gold mining and refining activities, pesticides from a variety of agricultural and home uses, polynuclear aromatic hydrocarbons from automobiles, and other metals from a variety of geochemical cycles accelerated by human activities. Moreover, there is a legacy of persistent chlorinated hydrocarbons whose effects appear to be as potentially as serious as those from any current practices. High exposures of aquatic organisms to many of these compounds occurs in the late winter and spring, when water runoff from land is greatest and many aquatic species reproduce (Adams et al., 1996) and whose eggs, larvae and juveniles are the most susceptible stages to contaminants.

Many uncertainties remain about contamination in the Delta. It is known that contaminants enter the Delta: selenium from the Western San Joaquin Valley, pesticides from both the Sacramento and San Joaquin watersheds, mercury from mines and other sources, copper used as an algaecide, PAHs, MTBE and perhaps TBT from heavy boat traffic, and metals from mining. Temperature effects on habitat suitability is also in need of study. Yet not one of these has been studied systematically or in detail in any Delta environment. Although the last several years have seen great advances in our understanding of the distribution and abundance of contaminants in the estuary (e.g., SFEI, 1995), there has not been as much emphasis on defining contaminant exposures in the Sacramento and San Joaquin Rivers and the Delta. Moreover, we have no comprehensive understanding of the risk that contaminants might pose to the health of individuals and populations in the estuary or upstream of the tidal portion of the ecosystem. To improve our understanding, we must determine the degree of contaminant exposure to aquatic organisms, if there is link between exposure and sublethal and chronic toxicity, and then use the exposure-effect relationships to determine the risks to aquatic populations in the catchment of the Bay-Delta.

It is also unclear how restored habitats, such as wetlands, will affect the transport, conversion, and bioavailability of contaminants (e.g., mercury). Examining the relationships between contaminant exposure and effects on organisms is critical to our understanding the links between the two. Actions in one area may have profound effects in another. There is also need to go beyond traditional toxicity tests and examine the overall survival and reproductive potential of organisms. Each contaminant is associated with specific target organisms and possibly target impacts on the organism. Synergistic effects upon biota of the multiple contaminants entering the system need to be evaluated. Such studies will provide insight on effectively restoring an organisms' health.

8. BEYOND THE RIPARIAN CORRIDOR

Efforts made to acquire or manage lands beyond the riparian zone can have multiple benefits. Not only can they be used to expand functional floodplain to allow natural flooding and stream meander, but they can also be managed or enhanced to provide habitat for a number of native species at risk or in decline. Habitat types found beyond the riparian corridor that support species of concern include a variety of wetland types, including: seasonal wetlands (such as vernal pools and flooded fields), perennial grasslands, and inland dune communities. A number of native species in these "upland" areas—such as waterfowl and game birds, Swainson's hawk, greater sandhill crane, California tiger salamander and western pond turtle--appear to thrive in certain agricultural lands managed to benefit wildlife species. Other species exhibit greater habitat specificity and many have suffered population declines or extirpations from past disturbances and conversion of valley bottom areas adjacent to stream channels and riparian zones. Included are such species as salt marsh harvest mouse, valley elderberry longhorn beetle, giant garter snake, and Lange's metalmark butterfly.

It is often difficult to determine the extent to which the status and trends of particular species populations are controlled by natural variability, and to what extent they are the product of human disturbances. Consequently, it is difficult to know if observed changes in the ecosystem are attributable to restoration and management actions or if they are driven by conditions beyond human control. Developing a better understanding of species-habitat interactions, species-species interactions, and species responses to variable ecosystem conditions is essential to make efforts to recover sensitive species more effective.

It is also important that progress is made toward improving and quantifying the understanding of how areas adjacent to riparian zones, in particular agricultural lands, influence ecological health. It is currently unknown how most species respond individually to disturbances common in landscape areas adjacent to riverine systems, including crop and dryland agriculture, land development, and invasion of non-native species. In California, ecosystem restoration actions are most often the neighbor to agricultural areas. Important questions remain about how agricultural practices can be enhanced or modified to improve ecological conditions and species health. Alternative pest management and fertilizer practices, cropping patterns, the use of no-till agriculture or winter flooding, and the establishment of buffer zones around cropped areas are all areas where pilot scale projects could yield information about how to best implement these types of practices on a large scale and the quantify the benefits associated with them.

There are also agricultural lands and other open space which are considered to be important in their current condition adjoining habitat areas or which have potential for future ecosystem restoration that are at risk of urban development. These areas would benefit from conservation or agricultural easements to preserve the current land use. Another significant concern remains over the potential third party impacts to areas adjoining restoration lands. Rural and agricultural communities have the greatest potential to be influenced by large-scale restoration actions, and there are concerns regarding the potential for adverse economic and regulatory effects from converting agricultural lands to ecosystem restoration areas.

9. X2 RELATIONSHIPS

Current management of the Bay-Delta system is based in part on a salinity standard known as the "X2" standard. This standard is based on empirical relationships between various species of fish and invertebrates and X2 (or freshwater flow in the estuary). Positive relationships with flow (negative with X2) have been observed for several estuarine-dependent species as well as some anadromous species during their migration through the Delta. As with all empirical relationships, these are not very useful to predict how the system will respond after it has been altered by various actions in the Delta, including altered conveyance facilities. This uncertainty illustrates a broader issue: a lack of predictive capability for determining how the ecosystem might respond to changes in its flow regime. This predictive capability will need to be developed to the point where it can support critical decisions about future restoration actions. This implies a need to determine the underlying mechanisms of the X2 relationships so that the effectiveness of various actions in the Delta can be put in context with this ecosystem-level restorative measure.

10. DECLINE IN PRODUCTIVITY

Productivity at the base of the foodweb has declined throughout the Delta and northern San Francisco Bay. Although some of this decline can be attributed to the introduced clam *Potamocorbula amurensis*, or Asiatic clam, not all of the decline is explained. The decline at the base of the foodweb has been accompanied by declines in several species and trophic groups, including mysids and longfin smelt. The long-term implications of this suggest a potential reduction in the capacity of the system to support higher trophic levels, which could limit the extent to which Bay-Delta fish populations can be restored unless creative solutions can be found to increase foodweb productivity.

It is also unclear how actions in the watershed influence estuarine foodweb productivity. For example, more frequent inundation of floodplains and bypasses may stimulate estuarine, as well as riverine, productivity by supplying larger loads of carbon and nutrients to the estuary.

Because we know little about the different sources of decline in productivity at the base of the foodweb, and how non-native species have changed, and are changing, foodweb dynamics, early efforts to address this uncertainty will likely emphasize monitoring, research, and modeling projects that address the issue of decline in foodweb productivity. Examples of projects include:

- Research to examine how introduced species have changed foodweb dynamics, and how efforts to control or eradicate introduced species may affect foodwebs;

- Monitoring and research to identify and examine other potential sources affecting productivity at the base of the foodweb, such as contaminants;

- Monitoring, research, and modeling to examine the role of carbon and nutrients introduced from bypasses and rivers in stimulating estuarine productivity;

- Monitoring and research to understand how the restoration of geomorphic processes (such as bed mobility) and riparian vegetation stimulates aquatic invertebrate production, and how this in turn affect fish survival and growth.

Several types of implementation projects can also be structured and monitored to address uncertainties about foodweb productivity. For example, gravel augmentation projects can include monitoring of aquatic invertebrates. Riparian re-vegetation projects can include complementary monitoring to assess the relative role of insect drop and aquatic invertebrates in fish growth. Projects that create shallow-water habitat can monitor the exchange of carbon between open water environments and the restored wetlands.

11. DIVERSION EFFECTS OF PUMPS

Both the State Water Project (SWP) and the Central Valley Project (CVP) have large-capacity pumping facilities located in the southern Delta, where they divert water into the California Aqueduct and the Delta-Mendota Canal for delivery to the San Joaquin Valley and Southern California. Pump operations can affect the circulation of water, and therefore biota, in interior Delta channels and sloughs. The pumps are a source of mortality for several species, including protected fish species. However, it is unclear to what extent pump operations affect the population size of any one species of fish or other biota, or by what mechanisms the pumps most affect fish and biota. For example, the pumps can be a source of direct morality through diversion, impingement upon fish screens, or handling mortality associated with fish salvage operations. The pumps can also have indirect affects upon fish and other biota. For example, the pumps can expose fish to higher rates of predation by drawing them into Clifton Court Forebay, which provides habitat for non-native warm-water fish species that prey upon native fish species. Similarly, the pumps can affect the survival of fish and other biota by drawing them toward the southern Delta, where there is generally less habitat available to support them. By altering the normal circulation patterns of water in the Delta, the pumps can also affect fish survival by altering migrational cues. Because the mechanisms underlying entrainment are not clear, it is unclear which restoration strategy, or mix of strategies, will most reduce the effects of pump operations on sensitive fish species.

It is also unclear to what extent other sources of Delta mortality affect the population of any given species, which has a bearing upon the relative importance of entrainment in the SWP and CVP pumps as a source of mortality. For example, there are thousands of agricultural diversions located in the Delta, and it is unclear how important they are, both individually and cumulatively, as a source of mortality for any given species of fish. Similarly, it is unclear to what extent water quality in the Delta affects the survival of biota or the population dynamics of any given species.

More information on the ecological and biological effects of entrainment and altered hydrodynamics will be pivotal for CALFED in choosing a water conveyance method, because it will help determine to what extent an isolated conveyance facility can be expected to alleviate conflicts between sensitive fish species and Delta exports. Reducing this uncertainty is also essential to ensure that the expenditure of restoration funds is well targeted.

Implementation projects conducted as adaptive management experiments will be necessary to better understand the relative importance of entrainment in the SWP and CVP pumps as a source of mortality for individual species, as well as the underlying mechanisms. Such implementation projects will require advance planning to manage risks to important resources, such as protected fish species and water supplies, and since the expense of such implementation projects will likely be significant. Such advance planning will include the development of conceptual models, simulation modeling, and decision modeling to guide the selection and design of adaptive management experiments, expanded monitoring, and targeted research. The use of an Environmental Water Account (EWA) will provide an early opportunity for adaptive management experiments designed to study the mechanisms underlying the diversion effects upon Delta ecology and biology.

12. THE IMPORTANCE OF THE DELTA FOR SALMON

Scientific opinion varies on the suitability and use of the Delta for rearing by juvenile salmon and steelhead. Although chinook salmon use other estuaries for rearing, most research on salmon in the Delta, and resulting protective measures, focus on smolt passage. However, if substantial numbers of salmon fry rear in the Delta and these fish contribute substantial recruitment to the adult population, then current actions to protect migrating smolts (e.g., pulse flows) might be modified or supplemented by actions designed to protect resident fry (e.g., extended high flows to flood shallow areas).

Early efforts to address this uncertainty will likely emphasize monitoring, targeted research, modeling, and pilot projects. Examples of such projects include:

- Expanded monitoring and research to better determine what fraction of salmon fry rear in the delta for different salmonid species, and which tributaries contribute larger fractions of salmon fry;

- Research to evaluate the survival of salmon fry that rear in the Delta versus the survival of fry that rear in tributaries;
- Research and monitoring to determine if Delta fry rearing is a life history strategy, a function of lack of rearing habitat in tributaries, and/or a function of tributary flow patterns;
- Population modeling to evaluate actions that emphasize Delta rearing and actions that emphasize smolt passage through the Delta; and
- Pilot projects that provide Delta rearing habitats for salmon fry and monitor their use.

SEIZING UPON RESTORATION OPPORTUNITIES

There are many opportunities to build upon existing restoration efforts in the Bay-Delta ecosystem, including ongoing and recent restoration projects funded by Category III, CVPIA, and CALFED's Restoration Coordination programs. Several local and regional watershed groups have also completed or are conducting restoration planning efforts that will facilitate the selection and implementation of restoration actions. For example, the Upper Sacramento River Fisheries and Riparian Habitat Plan (SB 1086) can help guide restoration of the Upper Sacramento River. There are also opportunities to implement large-scale restoration projects in the Bay-Delta ecosystem that will enable resource managers to test different hypotheses and to refine restoration methods, thereby contributing not only to the long-term Ecosystem Restoration Program, but also to restoration science in general.

This section identifies some promising opportunities for initiating large-scale ecological restoration in Stage 1 of the ERP. These are only a sample of the opportunities for ecological restoration that would potentially benefit endangered species, as well as other native species. The restoration activities described below have not been subjected to the adaptive management process described earlier in this chapter. A more rigorous assessment of the costs and benefits of the following activities might indicate that some of these projects are less promising than imagined. This list of opportunities is illustrative; it is meant to demonstrate the types of restoration activities available in the ERP.

The choice of specific examples was guided by the principles that were established in the strategic plan: that restoration of endangered species is best approached through restoration of the ecological structures and processes on which the species depend and that habitat restoration and maintenance is a dynamic, not a static, process. In light of these principles, opportunities have been identified that focus on ecological processes and that could be implemented in ways that would be largely self-sustaining. For example, opportunities identified for Bay-Delta tributaries emphasize the restoration of physical and ecological processes, rather than artificial measures to maintain populations, such as hatcheries or creation of habitats that will not be sustained by ongoing processes. Examples have also been selected that would generate results within the short timeframe of Stage 1.

OPPORTUNITIES IN THE BAY-DELTA

1. **REDUCE THE INTRODUCTION OF BALLAST-WATER ORGANISMS FROM SHIPS TO 5% OF 1998 LEVELS.** The shipping industry can greatly reduce and eventually eliminate the introduction of organisms through ballast water using existing technology. Significant progress could also be made in reducing the introduction of non-native species from other sources as well. This is a preventative rather than a restorative activity. Given the impacts that introduced invasive species have already had on the ecology of the Bay-Delta ecosystem, however, the eventual elimination of all additional species introductions is crucial to the ultimate success of the ERP.

2. **EXPAND OR ENHANCE SEASONAL SHALLOW-WATER HABITAT IN THE BYPASSES (E.G., YOLO BYPASS) AND NEAR-**

Delta floodplains. The bypasses and other "artificial" floodplains that flood during wet years are demonstrably productive places for juvenile salmon and splittail, as well as waterfowl. By re-engineering the weirs that release water into the bypasses, the bypasses presumably can be flooded (at least partially) on a more regular basis and could therefore be productive in most years. Habitat creation in flood bypasses presents one of the best opportunities for ecosystem restoration because large areas of habitat can probably be created at small cost while retaining the flood management functions of the bypasses.

3. **Initiate several large-scale - pilot projects using different approaches to restoring tidal marshes in the North Delta (around Prospect Island), Suisun Marsh, and the North Bay.** These projects could be designed as experiments to assess the benefits for marsh-dependent species and the most effective techniques of restoration, as well as providing an opportunity to evaluate options for minimizing or controlling invasive plant species. Note also that this kind of project represents an implementation of the three levels of adaptive management action: targeted research, pilot testing of techniques, and large-scale restoration.

4. **Develop means to control invasive aquatic plants in the Delta.** Invasive plants, such as water hyacinth and *Egeria densa* (Brazilian water weed), are clogging many sloughs and waterways of the Delta, not only impeding boat traffic, but also creating environments that are unfavorable for native fishes. The California Department of Boating and Waterways has an Egeria control program, but has not yet received CEQA approval for use of chemical controls. There is an immediate need to develop ways by which to control these plants that are not, in themselves, environmentally harmful. An opportunity exists for the ERP to join forces implementing ambitious eradication and control measures with agencies, organizations, and water districts concerned with the deleterious effects of these water weeds on navigation in the Delta, clogging of water intakes and fish screens, and diminished recreational uses.

5. **Initiate targeted research on major restoration issues, such as: (1) how to control problem invasive species such as the Asian clam (*Potamocorbula amurensis*) which has a negative effect on foodweb dynamics in the estuary; (2) factors limiting the abundance of high-priority endangered species; and (3) design of habitats for shallow-water tidal marsh and bypasses.** Use such research to begin addressing issues raised in the twelve issues above. Ultimately, the limited funds available for restoration will be much more effectively spent if there is a clear understanding of the relative seriousness of the diverse problems facing the estuarine and riverine ecosystems and of the ability to solve those problems. Where the research can be linked to pilot or large-scale restoration projects, the benefits will be multiplied.

6. **Coordinate with the various levee and flood control state, local, and federal programs to establish design criteria and standards that ensure that levee rehabilitation projects incorporate features beneficial to the aquatic and riparian environments of the Delta.** The majority of the approximately 50 Delta islands are hydrologically disconnected by levees from the primary channel, open-water estuarine environment. Most of these levees are likely to remain in future years and to be reinforced with rock riprap, raised and widened, or rehabilitated in other ways to prevent levee failure. Potentially beneficial projects that could be incorporated into these programs include levee setbacks and creation of broad submerged benches, as well as the construction of broader levees to support riparian vegetation. Developing contingency plans for responses to major and multiple levee failures in different parts of the Delta can also provide ecosystem benefits and minimize disturbances associated with levee repair.

7. **Establish large-scale pilot projects on both leveed Delta islands and on submerged islands (e.g. Frank's Tract) to test and monitor techniques for returning subsided Delta islands to shallow-water and marsh habitats.** On leveed islands, areas could be diked off, partially flooded, and planted with tules to examine the potential for natural deposition of organic matter to raise island levels. On submerged islands, dredge spoils and other materials could be used to create shallow-water habitats. One potential benefit of a project to convert parts of Frank's Tract to shallow-water habitat would be reduction of wave erosion affecting Delta island levees surrounding the tract.

8. **Develop large-scale pilot projects that examine the relationship between variable salinity and the maintenance of native species in the Delta, especially in shallow-water habitats.** Historically, the Delta and other parts of the estuary had salinity regimes that fluctuated from year to year as well as from month to month and, often, daily with tides. The native organisms presumably evolved in such variable conditions and should be favored by them. Many of the non-native species (e.g., freshwater aquatic plants, freshwater and marine clams), in contrast, may be favored by the more stable conditions now present as the result of regulation of freshwater inflows into the Delta. Opportunities exist to restore large tracts of former tidal shallow-water habitat in the north Delta, lower Yolo Basin, and along river channels and sloughs in the vicinity of Sherman Island. Once these shallow-water habitats are in place, it may be possible to vary the position of the salinity gradient in these areas, thereby testing the effects of variable salinity on native and introduced organisms in the shallow-water habitats. This action would provide valuable information on such things as: (1) the extent to which physical habitat may be limiting native and introduced species, (2) how salinity gradients and variability affect conditions and species within the shallow-water habitats, and (3) calibration of models to evaluate the changes in the hydraulics of the Delta that would result from having more extensive tidelands and more breached Delta islands.

Opportunities for Rivers

1. **Mimic natural flow regimes through innovative methods to manage reservoir releases.** There is underutilized potential to modify reservoir operations rules to create more dynamic, natural high-flow regimes in regulated rivers without seriously impinging on the water storage purposes for which the reservoir was constructed. Water release operating rules could be changed to ensure greater variability of flow, provide adequate spring flows for riparian vegetation establishment, simulate effects of natural floods in scouring riverbeds and creating point bars, and increase the frequency and duration of overflow onto adjacent floodplains. In some cases, downstream infrastructure of river floodways may require upgrading to safely accommodate a more desirable natural variability and peak discharge magnitude associated with moderate floodflows (e.g., strengthen or set levees back).

2. **Mimic natural flows of sediment and large woody debris.** Dams disrupt the continuity of sediment and organic-debris transport through rivers, with consequent loss of habitat, and commonly, river incision, downstream. In some cases, such as Englebright Dam on the Yuba River, dam removal can be considered as a potential solution to reestablishing continuity of sediment and debris transport, as well as opening access to important spawning and rearing areas. Most dams, however, cannot be removed, so methods must be sought to reestablish continuity of sediment and wood transport with the dam in place. Coarse sediment can be artificially added below dams to at least partially mitigate for sediment trapping by the dam and ameliorate the impacts of sediment-starved flows. This approach has been successfully used in Europe, using sediment from natural (landslide) and artificial sources (injected from barges). On

the River Rhine, enough gravel and sand are added below the lowest dam to satisfy the present sediment transport capacity of the Rhine to prevent further incision of the bed (an average of over 200,000 cubic yards annually). On the Sacramento River, gravels have been added at a rate much below the river's transport capacity so they are vulnerable to washout at high flows. A more sustainable approach would be to add gravel (and sand) on a regular basis and at a much larger scale to better mimic natural sediment loads and therefore provide the sediment from which the river would naturally create and maintain spawning riffles. This latter approach requires a large commitment of resources and should be undertaken only in rivers where other factors (e.g., temperature regime) are favorable (or can be made favorable) for recovery of species (such as the upper Sacramento). Such opportunities will be more economical where sources of dredger tailings or reservoir Delta deposits are available nearby.

While recognizing the navigation and flood safety issues associated with large woody debris in rivers, the importance of this debris to the foodweb and structural habitat for fish should not be overlooked. There is an opportunity to investigate ways by which to pass debris safely through dams and bridges. This may require replacing some existing bridges with those less prone to trapping woody debris.

3. **IDENTIFY AND CONSERVE REMAINING UNREGULATED RIVERS AND STREAMS AND TAKE ACTIONS TO RESTORE NATURAL PROCESSES OF SEDIMENT AND LARGE WOODY DEBRIS FLUX, OVERBANK FLOODING, AND UNIMPAIRED CHANNEL MIGRATION.** Most rivers in the Central Valley are regulated by large reservoirs and therefore require considerable investment to recreate the natural processes needed to sustain true ecosystem restoration; however, a few large unregulated rivers still exist, such as the Cosumnes River and Cottonwood Creek. Lowland alluvial rivers and streams with relatively intact natural hydrology should be identified and made a high priority for acquisition of conservation and flooding easements, setting back of levees, and other restoration actions because such actions on these rivers are likely to yield high returns in restoration of natural processes and habitats and, ultimately, fish populations.

4. **UNDERTAKE FLUVIOGEOMORPHIC-ECOLOGICAL STUDIES OF EACH RIVER BEFORE MAKING LARGE INVESTMENTS IN RESTORATION PROJECTS.** River ecosystem health depends not only on the flow of water, but on the flow of sediment, nutrients, and coarse woody debris and on interactions between channels and riparian vegetation, variability in flow regime, and dynamic channel changes. It is only through interdisciplinary, watershed, and historical scale studies that the constraints and opportunities particular to each river can be understood. For example, it was only after a fluviogeomorphic study of Deer Creek that the impact of flood control actions on aquatic and riparian habitat was recognized, a recognition that has lead to a proposal for an alternative flood management approach designed to permit natural river processes to restore habitats along Lower Deer Creek.

5. **UNDERTAKE FLOODPLAIN RESTORATION ON A BROAD SCALE, WHERE LAND OR EASEMENTS CAN BE ACQUIRED AND WHERE THE RIVER HYDROLOGY INCLUDES (OR CAN BE MADE TO INCLUDE) SUFFICIENTLY HIGH FLOWS TO INUNDATE FLOODPLAIN SURFACES.** Restoration of floodplain function can produce many benefits, such as reducing stress on remaining levees, reducing excessive channel scour, and encouraging establishment of riparian vegetation over a larger area within the adjacent floodplain. A range of possible measures will need to be employed to fit local conditions, such as widening flood bypasses or creating new ones; setting levees back, creating backup levee systems, or deauthorizing specific levee reaches; constructing armored notch weirs in levees and purchasing flood easements to restore floodbasin storage functions; or implementing measures described in item two above to increase the frequency and duration of overbank flow onto existing floodplains. Reactivating the historical floodplain can

provide effective, reliable and cost effective flood storage while restoring important ecological processes.

6. **Reduce or eradicate invasive non-native shrubs and trees from riparian corridors.** Of particular importance is the control of the spread of tamarisk and giant reed, two introduced species that displace native flora, offer marginal value to fish and wildlife, and cause channel instability and reduced floodway capacity. Some rivers, such as Stony Creek and Cache Creek and the lower San Joaquin River, have undergone large expansions of these non-native species, even in the past 10-15 years. A combination of large-scale eradication pilot projects and targeted research on several streams will help to temporarily reduce the rate of expansion of their range, identify the most vulnerable stream environments, and determine whether valley-wide eradication or suppression measures are warranted or feasible.

7. **Remove barriers to anadromous fish migration where feasible.** Significant progress has been made in recent years to improve salmon passage on several spawning streams (e.g., Butte Creek, Battle Creek) by removing barriers, consolidating diversion weirs, or constructing state-of-the-art fish passage structures. Existing and potential spawning areas in the ERP focus area that are not obstructed by major reservoir dams, but are currently obstructed by other barriers, should be identified and action taken to restore anadromous fish spawning upstream.

8. **Develop a partnership with the Army Corps of Engineers, Reclamation Board and DWR to fully integrate river and floodplain ecological restoration with flood management measures being considered in the 4-year Comprehensive Study underway for the Sacramento and San Joaquin River basins.** Many of the ecological approaches to river restoration listed above are feasible only if and when the overall capacity of the Valley flood control system is expanded and the risk of flooding farms and cities has been significantly reduced. In other words, more room within the managed floodways must be made available for the "roughness" of habitats and the ecologically desirable tendency of alluvial river channels to migrate by eroding of banks or spread high flows onto natural floodplains. Pilot projects and studies should be initiated that test innovative solutions to improve floodplain management with significant ecosystem benefits, such as the proposed floodplain restoration projects under evaluation along the lower San Joaquin and Cosumnes Rivers.

9. **Promote and support river-based conservancies and broad coalitions to resolve conflicts and achieve local consensus over the restoration and management of river corridors.** Local coalitions with technical and financial support from CALFED, CVPIA, and other state and federal programs have been successful at reaching broad agreement on solutions and implementing projects to restore river habitats and recover threatened fish populations. Expanding financial and technical assistance throughout the ERP focus area can yield similar benefits in other ecological management units.

Regulatory Compliance

The proposed Stage 1 actions will also need to be reviewed to determine which can be covered adequately by the Programmatic EIS/EIR and which will require additional, site-specific (second tier) environmental documentation and the acquisition of regulatory permits. Most proposed ERP actions will require additional documentation, so it will be important to ensure that the proposed Stage 1 actions will be ripe for implementation by identifying the permitting and environmental documentation requirements for each action and estimating the time required to complete them. Since the acquisition of regulatory permits and preparation of environmental documents can delay the implementation of the program, it is important to streamline the regulatory compliance process. Two mechanisms to facilitate compliance include bundling actions and building off of permits and documentation from other actions. It is possible to bundle multiple ERP and related non-ERP CALFED actions so that they are covered by a single document or permit, thereby saving time and the cumulative impacts of the actions are more adequately described. It may also be possible to build off of permits or reference environmental documents prepared for restoration actions already underway through CVPIA, Category III, and CALFED Restoration Coordination programs. (See the CALFED Handbook of Regulatory Compliance [1996] or the Regulatory Compliance Technical Appendix in the Revised Draft EIS/EIR for a more detailed description.)

♦ CHAPTER 6. INSTITUTIONAL STRUCTURE AND ADMINISTRATIVE CONSIDERATIONS

INSTITUTIONAL STRUCTURE

CALFED has not yet determined the institutional structure or entity that will be used to implement the overall CALFED Program or the constituent Ecosystem Restoration Program (ERP). The Bay Delta Advisory Council (BDAC) Assurances and Governance Work Groups have evaluated several different institutional arrangements for implementing the ERP, including:

- a continuation of informal coordination among existing CALFED agencies,
- more formal coordination of state and federal agencies through a Joint Authority, and
- a new non-regulatory agency or organization independent of existing state and federal agencies.

Regardless of the institutional structure, the ERP will not be implemented through the use of regulatory authorities. Rather, the ERP will rely on consensus-based cooperation with local watershed groups and landowners and through transactions with willing sellers only. The ERP will not preempt the existing regulatory authorities of agencies.

Many stakeholders have expressed support for a new entity to implement the ERP rather than existing CALFED agencies, reasoning that a new entity could:

- be more accountable for the success of the ERP;
- help prevent a perceived conflict of interest by separating the restoration of Bay-Delta resources from those agencies responsible for regulating Bay-Delta resources;
- be more efficient with funding and personnel resources because of more centralized funding, implementation, and decision making;
- provide greater opportunity for stakeholder participation in decision making by allowing stakeholder input, and possibly representation, on the ERP decision-making body; and
- help ensure a more scientific basis for decision making by providing independent scientific counsel and oversight more directly to a centralized decision-making body.

These are attractive characteristics of an ERP implementation entity, but it is not yet clear that a new agency or organization will be required to embody these characteristics. Reconfiguring CALFED agency administrative structures and improving interagency coordination may be able to provide greater accountability, efficiency, stakeholder participation and independent scientific oversight. There is also no guarantee that a new agency or organization will perform as planned. Determining the best institutional structure for implementing the ERP will require additional analysis and discussion among CALFED agencies and stakeholders.

Through the Bay Delta Advisory Council (BDAC) Assurances and Ecosystem Restoration Work Groups, CALFED agency personnel and stakeholders have identified some of the critical responsibilities, functions, and powers that will be required to implement the ERP successfully, regardless of the specific institutional structure or entity selected.

To conduct daily operations, the ERP implementation entity will need to perform normal administrative duties, such as the power to:

- hire and dismiss staff

- receive direct funding from both public and private sources
- enter into contracts, and
- disburse grants.

As an agent of environmental restoration and management, the ERP implementation entity will also require more specialized functions, such as the ability to:

- acquire permits,
- serve as lead agency for preparation of environmental documents, and
- acquire, hold, and sell water and property rights.

The institutional structure designed to implement the ERP will include components to help minimize conflict among stakeholders and beneficial uses of Bay-Delta resources. The features include:

- incorporating **PUBLIC INVOLVEMENT** in the planning and decision-making processes during the implementation phase;
- Informing and engaging a broad public in the ERP through a **PUBLIC OUTREACH PROGRAM;**
- Ensuring the scientific credibility of the ERP through **SCIENTIFIC REVIEW**;
- Documenting and disseminating policy and management decisions, and the scientific findings and raw data upon which they are based, through an **INFORMATION MANAGEMENT SYSTEM**; and
- Defining a **DISPUTE RESOLUTION** process to help manage conflict over intractable issues.

PUBLIC INVOLVEMENT

The CALFED process has demonstrated the value of engaging stakeholders in the planning and decision-making processes. After decades of conflict, stakeholders are now working together and with CALFED agencies to develop the long-term, comprehensive plan to restore ecological health and improve water management for beneficial uses of the Bay-Delta system. Though there are still significant points of disagreement among stakeholders and CALFED agencies, this does not detract from the remarkable success achieved thus far in defining points of agreement. The ERP institutional structure will build upon the success of public involvement in the planning phase by providing avenues for public involvement during the implementation phase. For instance, a critical strategy for implementing the ERP is to work with local watershed groups composed of local stakeholders to refine, evaluate, prioritize, implement and monitor restoration actions.

The ERP institutional structure will also explore methods for involving the public in regional planning and decision making, including the use of electronic technology. E-mail services (such as address lists and e-mail reflectors) and Internet services (such as virtual work space in which participants engage in simultaneous writing and review) can be provided for work groups and stakeholders to facilitate collaboration.

PUBLIC OUTREACH

Long-term restoration and management of the Bay-Delta ecosystem requires public support and education. Public funds will finance much of the restoration effort, so it is important that a broad public understands the benefits of ecosystem restoration. And since many human activities affect the health of the Bay-Delta ecosystem, public education will be necessary to help reduce or eliminate ecological stressors.

The public outreach program incorporated into the ERP institutional structure will use both traditional and innovative means for communicating the progress and direction of the ERP to the public. Traditional means will include the production of newsletters, brochures, press releases, and educational kits, as well as media contact.

The public outreach program will also capitalize on electronic technology to reach a broader public and to increase the type of information accessible to the public. Electronic mailing lists and a website can alert members of the public to meetings and important events. Because reproduction and mailing costs can limit or prohibit the wide distribution of important documents, electronic versions of documents posted to a website will increase the types of information that can be made available.

The public outreach program will also explore more active outreach methods, such as facilitating school visits by ERP decision-makers and scientists and arranging restoration site visits for school and community groups.

SCIENTIFIC REVIEW

An adaptive management approach to ecosystem restoration and management requires up-to-date science. Ensuring the scientific credibility of the Ecosystem Restoration Program will be an important responsibility of the entity selected to implement it, because it will help maximize the effectiveness of the restoration program and build public confidence and support. A few of the potential mechanisms for ensuring scientific credibility of the restoration program include:

STANDING COMMITTEE OF INDEPENDENT SCIENTISTS

A standing committee of independent scientists could provide scientific review and advice to the ERP implementation entity. A committee composed of recognized experts from the many scientific disciplines associated with the Bay-Delta ecosystem could help to review scientific findings, develop restoration guidelines, establish restoration priorities, design restoration actions to maximize their information value, and identify monitoring and research needs. The participation of the independent scientific committee could include informal advice or formal recommendations.

PEER REVIEW REQUIREMENTS

The ERP implementation entity can require that the science used to justify CALFED management decisions be published in national, peer-reviewed journals. This approach, used in management of the Everglades and Chesapeake Bay, provides a means of obtaining review from technical experts, free of charge, in a reasonably timely manner. It also helps to assure the quality of the science underlying the restoration program, and it provides important contact with the broader scientific community, which can be useful in establishing review teams. Because publication can take 1-2 years following the initial submission of a manuscript, management decisions will likely need to proceed following internal review by agency scientists or a standing scientific committee.

EXTERNAL SCIENTIFIC REVIEW

Annual or periodic review of the overall Ecosystem Restoration Program by a panel of scientific experts could help evaluate progress toward restoration goals and infuse the restoration program with new ideas. The panel could also assess the status of the scientific basis for CALFED actions. Experts familiar with other large-scale restoration programs could also provide valuable comparative analysis.

ANNUAL WORKSHOPS

The ERP implementation entity will conduct annual (or biennial) public meetings in which resource managers and scientists:

- describe restoration actions implemented during the previous year,
- describe restoration actions to be implemented in the following year,
- present and assess monitoring data and research findings, and
- re-evaluate restoration problems, goals, objectives and actions.

Not every restoration action will be ripe for annual review in a given year. Individual restoration actions will need to be reviewed periodically on a schedule established by the ecological time-scale appropriate to the restoration action. The interval between reviews for an individual action will be based on the time expected for the ecological process or species to respond to the restoration or management intervention.

The annual public workshops could also help to publicize the restoration program and educate and engage the public.

DISPUTE RESOLUTION

There is a long history of conflict over Bay-Delta resources. CALFED was formed to help reduce the level of conflict in the Bay-Delta system by bringing together state and federal agencies with stakeholder groups in a collaborative planning process. Working together, traditionally combative groups have helped build consensus on the broad program elements that will be necessary to simultaneously resolve the major problems affecting the Bay-Delta system. Many features of the current CALFED planning process will be incorporated into the ERP institutional structure to help prevent or reduce conflict during the implementation phase. For instance, involving the public in ERP decision-making and implementation will allow agency personnel and stakeholders to identify differences of opinion early before they fully develop and become entrenched. Similarly, working with local watershed groups to refine, evaluate, prioritize, and implement restoration actions will help build local consensus. Independent scientific review will help to resolve technical disputes, as will the adaptive management process, which can accommodate alternative hypotheses about ecosystem structure and function.

Despite a fundamental structure designed to reduce conflicts, the ERP institutional structure will need to include a dispute management strategy to address remaining conflicts or new conflicts that emerge. An effective dispute management process can help pre-empt the use of litigation to settle disputes. Litigation commonly forces each side in a dispute to take an extreme position, which can intensify conflict among stakeholders. Dispute resolution provides all parties with lower risk ways of exploring more central positions, and it can provide momentum for building consensus by enumerating points of agreement rather than focusing exclusively on points of contention.

Using a neutral facilitator to conduct the dispute resolution process will help to reduce conflict. Structuring a dispute resolution process less as a formal hearing and more as a professional workshop—with briefings, discussion, and interpretation of the information at issue—will further reduce the combative nature of the dispute.

Although specific approaches to dispute resolution will be dictated by the dispute at hand, the following general guidelines will help structure the dispute resolution process:

- A formal announcement will be made that an issue is being subjected to the dispute resolution process.
- The stakeholders to be included in the process will be identified.
- A formal description and analysis of each stakeholder's position will be provided.
- All of the main decision makers, including agencies with regulatory authority relevant to the dispute, will be identified and included in the process.
- The scope of the issue will be determined clearly.
- The means by which the final recommendation or decision is to be rendered (administrative decision, arbitration, consensus, majority vote, etc.) will be identified.
- Any limits, such as legislative mandates or limits on the delegation of authority, will be identified.

At the conclusion of the dispute resolution process, participants will compile a report identifying points of agreement, remaining points of contention, and an agenda for resolving the remaining issues.

INFORMATION MANAGEMENT SYSTEM

Underlying the public involvement, public outreach, scientific review, and dispute resolution components of the ERP institutional structure is the need for a powerful information management system. An adaptive management approach requires information. Nearly every environmental intervention offers an opportunity (and obligation) to document the ecosystem's prior condition and response to intervention and offers an opportunity to validate or revise hypotheses. Adaptive management also involves continual inventory, analysis, and interpretation of scientific data. An information management system will help collect, store, track and disseminate the decisions and raw data that drive the restoration program.

An information management system will help facilitate public involvement and scientific review by providing access to the information being used to evaluate or justify a proposed action, including not only results and conclusions, but also baseline information, monitoring data, models and their parameters, and assumptions. Participating stakeholders and CALFED agency personnel will be better informed, and individuals and organizations will be able to conduct their own independent analysis of data underlying proposed actions. An information management system could also be used in conjunction with a website to provide access to reports in common use within the CALFED community, including digital copies of printed reports.

An information management system will also be an important component of dispute management by providing common access to the data underlying decisions.

To provide rapid production and dissemination of information, the information management system will rely principally on electronic communication. However, the information management system will also accommodate the information needs of stakeholders who rely upon more traditional means of print communication.

Given the breadth and depth of CALFED issues, GIS is absolutely essential for a number of critical functions, including simple project tracking, database management, monitoring, analysis of connections between actions, and geographic visualization of complex scientific and planning information. The system should link and integrate the map libraries of all CALFED agencies and collaborators, instead of creating a new central repository. Traditional stand-alone GIS operations should be linked through web-based GIS capabilities.

♦ APPENDIX A. DEFINING THE OPPORTUNITIES AND CONSTRAINTS: A HISTORICAL PERSPECTIVE

THE IMPORTANCE OF A HISTORICAL PERSPECTIVE

The CALFED Ecosystem Restoration Program will succeed only to the extent that it is based on a solid understanding of natural physical and ecosystem processes and habitats, and how these have been changed, so that restoration actions can be effective, adequate, and realistic. To be most effective, restoration actions should restore processes that maintain conditions favorable to native species so that ecological benefits are sustainable and will not disappear in the next flood or from other impacts on artificially-created habitats. We must know the former extent of habitats and the former range of hydrologic and ecological processes to understand the habitat needs of important species, and to therefore judge the scale of restoration needed to bring about recovery and to establish healthy populations.

Many restoration actions have been very small-scale affairs when viewed in context with the losses in habitat and changes in processes since 1850. Although these projects may be very worthwhile, they should not be considered as having restored the ecosystem just because 10 acres of tidal marsh have been restored at a given site. Similarly, the irreversible changes that have occurred to hydrology and ecology of the Bay-Delta system must be recognized so that restoration goals are realistic. For example, the hydrology of the Bay-Delta system has been fundamentally transformed by massive reservoirs and diversions. Reservoir storage capacity in the Sacramento-San Joaquin River system now totals about 30 million acre-feet (MAF), with storage equivalent to over 80% of runoff in the Sacramento River Basin and nearly 140% of San Joaquin River Basin runoff (San Francisco Estuary Project 1992, Bay Institute 1998). As a result, frequent floods (important for maintaining channel form, cleaning spawning gravels, and providing periodic disturbances needed to maintain native species) have been eliminated or drastically reduced on many rivers. Most of these reservoirs are permanent, at least for the lifetimes of the structures, so restoration efforts must be designed to account for the changes wrought by the dams or must involve changes in the operation of the reservoirs. Although dam removal may be possible (with considerable ecological benefits) in a limited number of cases, as is now being considered for Englebright Dam on the Yuba River, in most cases restoration actions must be designed with the reservoirs in mind.

CONDITIONS BEFORE EUROPEAN COLONIZATION

The landscape of the Central Valley has changed on such a vast scale in the past 150 years that it is difficult to even imagine what it was originally like (see Kahrl et al. 1978, Kelley 1989, Bay Institute 1998). Arguably, the most important ecological features were the aquatic and riparian ecosystems, which covered huge areas, supported high concentrations of fish and wildlife, gave rise to many endemic species, and were the cultural focus of the Native American peoples. Before European colonization, the Sacramento and San Joaquin rivers and their tributaries carried water, sediment, nutrients, other dissolved and suspended constituents, wood, organisms, and other debris from basins (of more than 25,000 and 14,000 square miles, respectively) to their confluence in an inland delta, thence through Suisun, San Pablo, and San Francisco Bays to the Pacific Ocean. The channels of these rivers served as habitats and migration routes for fish and other organisms, notably several distinct runs of chinook salmon (*Oncorhynchus tshawytscha*), steelhead trout (*O. mykiss*), and Pacific lamprey (*Lampetra tridentata*). These species evolved to take advantage of the hydrologic and geomorphic characteristics of these river systems, some of which are discussed below. There are no firm data on pre-1850 salmon runs, but anecdotal accounts (and the large canning industry that later developed in coastal and inland cities) imply that runs were substantial, probably between 2 and 3 million per year.

The Mediterranean climate ensured that the aquatic and riparian systems were highly dynamic, driven by strong annual patterns of wet and dry seasons and longer periods of extreme drought and extreme wet. The high peaks of the Sierra Nevada intercepted much of the moisture coming off the ocean and stored it as snow and ice, which melted gradually, generating cold rivers that flowed throughout the dry summers. During periods of high snowfall and rainfall, the Central Valley would become a huge shallow lake, taking months to drain through the narrows of the Bay-Delta system. In periods of drought, the main rivers would be reduced to shallow, meandering channels, and salty water would push its way to the upstream limits of the Delta. The dry tule marshes would burn, perhaps with fires deliberately set by the native peoples, and the dry air would be filled with smoke for months at a time.

The marshes were a major feature of the lowlands of the Central Valley, especially the San Joaquin Valley, where they surrounded the huge, shallow lakes at the southern end of the valley, Lakes Buena Vista and Tulare. The Delta itself was a vast marshland, the present-day islands vaguely defined by natural levees of slightly higher ground. The river channels meandered through this marsh, making trips by boat long and arduous. Suisun, San Pablo, and San Francisco Bays were also lined with large marshes that penetrated far inland in the estuaries of in-flowing streams and in the shallows now called Suisun Marsh. The flood basins of the Sacramento River also supported extensive marshes. Upstream, the river channels were defined by thick riparian forests, with dense stands of willow, cottonwood, and sycamore close to the water, yielding to valley oak on the higher terraces. Above these woodlands were first oak savannas and then bunch grass prairies, supporting herds of pronghorn, elk, and blacktail deer.

HYDROLOGY AND LANDFORMS AND HOW THEY INTERACT TO FORM HABITAT

RUNOFF PROCESSES AND RIVERINE FORMS. The largest rivers of the Sacramento-San Joaquin River system begin in the high elevations of the Sierra Nevada (or Cascades) and receive runoff from snowmelt, which is at a maximum in late spring/early summer, as well as rainfall in their lower elevations, with maximum flows (typically with higher peaks) in winter during storms. The highest peak flows are produced when warm rains fall on a large snowpack, such as occurred in December-January 1997. There is considerable variation in precipitation (and therefore riverflows) from year to year, but snowmelt reliably produced moderately high flows in most years. The seasonal low flows typically occurred in late summer and fall, after snowmelt had been exhausted and before the onset of winter rains. Seasonal flow variability was greatest in rainfall-dominated rivers draining the Coast Ranges, somewhat less in rivers with snowmelt contributions, and substantially less in rivers draining volcanic formations, such as the regions of Mt. Shasta and Mt. Lassen (where runoff is dominated by springflow). In the Delta, inflows from the Sacramento and San Joaquin rivers mixed, with probable intrusions of salt water during dry periods, in a complex, often stratified pattern.

The upper reaches of the rivers are typically bedrock or boulder controlled, with cascade and step pool habitats, and with little opportunity for sediment storage. In their lower reaches, the rivers flow through the alluvial Central Valley in braided, wandering, or meandering channels, historically with broad, largely forested, floodplains. Braided channels were common where streams passed from bedrock-controlled channels onto the flatter Sacramento Valley floor, depositing gravel and sand. Flatter floodplain reaches were characterized by large, meandering channels, which frequently overflowed onto the adjacent floodplains, depositing sandy natural levees along the channel, with silty (and fertile) overbank sediments behind.

In the Delta, a complex of low-gradient, multiple channels was flanked by natural levees and low-elevation, frequently inundated islands (composed largely of organic-rich sediments). The tidal estuaries of Suisun, San Pablo, and San Francisco Bays were flanked by extensive tidal marshes and mudflats.

Each of these geomorphic features, interacting with a variable flow regime, created a distinct suite of aquatic or riparian habitats, as illustrated by an actively migrating meander bend (Figure A-1). As flow passes through a meander bend, the highest velocities and greatest depths are concentrated near the outside bank, which erodes, producing a steep cut bank, commonly with overhanging vegetation. These pools are important holding habitats for adult salmon and trout. In between the meander bend pools, where flow crosses over from one side of the channel to the other, a riffle typically occurs, with shallow flow over gravel or cobble substrate, providing habitat for invertebrates (which are food for fish). Gravel riffles provide spawning habitat for salmon and trout. Shallow margins of these channels, protected areas behind exposed roots and large woody debris, and the interstices between large cobbles, provide habitat for juvenile salmon.

NATIVE SPECIES AND HOW THEY USED THE LANDSCAPE

The productive marshlands and intervening waterways were extremely attractive to waterfowl. The abundant and diverse resident populations of ducks, geese, shorebirds, herons, and other birds were augmented by millions of ducks, geese, shorebirds, and cranes migrating down in fall and winter from summer breeding grounds in the north. The migratory birds would take advantage of the expanded wetlands that were the result of the winter rains and floods. Arguably, the Pacific Flyway, one of the major migratory routes for birds recognized for North America, owes its existence to the Central Valley and its wetlands. No matter how severe the drought, there would be wetlands somewhere in the valley.

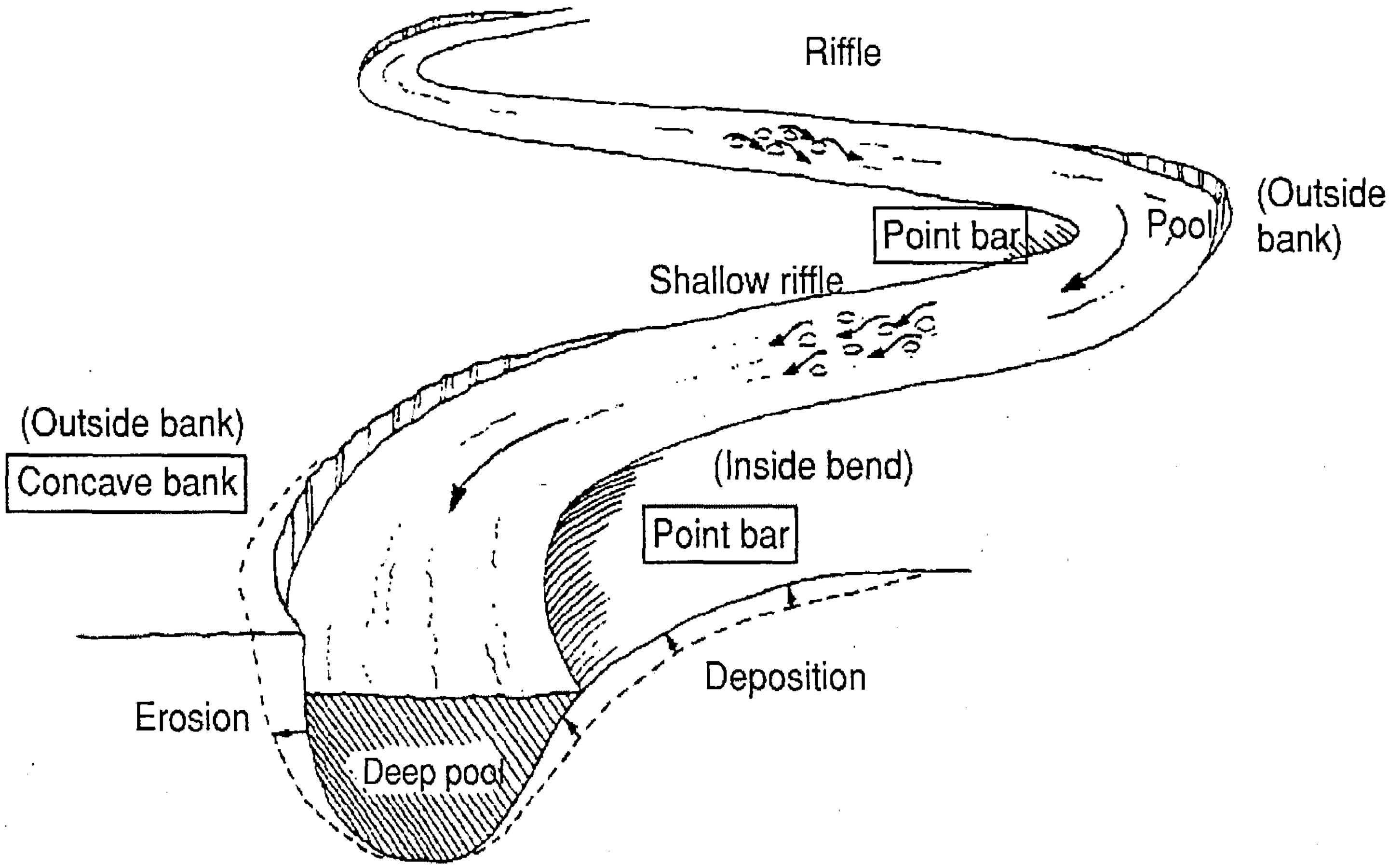
Migratory fishes also found the region to be very favorable habitat. Two to three million anadromous chinook salmon spawned in the system each year, along with large numbers of steelhead, sturgeon, and lamprey. The four distinct runs of salmon reflect a fine-tuning of this species to a fluctuating yet productive environment. Fall-run chinook were the lowland run. They came up in fall months as soon as water temperatures were cool and spawned in low-elevation rivers in time to allow their young to emerge from the gravel and leave the rivers before conditions became unfavorable in early summer. Spring-run chinook, perhaps the largest of the runs, beat the summer low flows and high temperatures by migrating far upstream in the spring and holding in deep cold pools through summer, to spawn in fall. Late-fall-run and winter-run chinook took advantage of the unusual conditions in the little Sacramento, McCloud, and Pit Rivers, where cold glacial-melt water flowed from huge springs, keeping temperatures cool even in the hottest summers, so the fish could spawn late in the season.

Steelhead migrated up in winter, when flows were high, even higher in the watersheds than spring-run chinook, and sought out smaller streams not used by salmon.

The annual influx of millions of salmon weighing 8-20 kilograms each represented a tremendous shot of oceanic nutrients injected into the stream systems, enhancing the productivity of the aquatic and riparian ecosystems and increasing their ability to support juvenile salmon and steelhead. The juveniles of all these salmon would move downstream gradually in winter and spring, taking advantage of the abundant invertebrates in flooded marshlands and the shallow waters of the Delta. In this environment, they could grow rapidly on diets of insects and shrimp, reaching sizes large enough to enhance ocean survival.

In the estuary, the abundant longfin and delta smelts could also move up and down with seasons, seeking favorable conditions for spawning and rearing of young. The short (1 to 2-year) life cycles of these fish testifies that no matter how dry or wet the year, the appropriate conditions were present somewhere in the system. The resident fishes, in contrast, were largely stream or floodplain spawners and apparently did not necessarily find appropriate conditions for spawning and rearing of young to be available every year. As a consequence, they adopted the basic life history strategy of living long enough (5 or more years) to be around when favorable conditions were present and to flood the environment with large numbers of young. Middens near Native American village sites indicate that these fishes (e.g., thicktail chub, Sacramento perch, splittail, hitch, and Sacramento blackfish) were extremely abundant and easy to harvest.

The abundance of fish in the middens also indicates that the native peoples were major predators on the



Source: California State Lands Commission 1993.

Figure A-1: Diagram of Meander Bend, Showing Variety of Forms (and thus Habitats) Associated with Actively Migrating Meander Bend.

fish, including salmon. The abundance of fish was presumably one of the reasons why these people were able to exist in relatively high densities (compared to other areas of North America). Although they may have depleted some of the resources they used (Broughton 1994), some abundant fishes were lightly used if at all. For example, the principal salmon run harvested was the fall run, both because of its accessibility and because the fish were less oily than fish of other runs, making them easier to dry for long-term storage. Other salmon runs were harvested less intensively and steelhead hardly at all.

The native species in this productive ecosystem were adapted to hydrologic extremes, with specific salmon runs adapted to take advantage of different parts of the annual hydrograph. A range of species and life stages used different habitats in different parts of the system.

CRITICAL ASPECTS OF LANDSCAPE AND ECOLOGICAL FUNCTIONS

From our knowledge of the functioning of the natural system, we can identify critical aspects that would need to be addressed in a successful restoration program.

Habitat Area and Diversity. Minimum habitat areas are needed to maintain viable populations of native species. This habitat also has to contain the complex features needed to maintain multiple species and multiple life stages of each species. For example, high-quality brackish and freshwater tideland (including shallow-water habitats, such as mudflats, tule marsh, small sinuous sloughs and distributaries, upper tidal marsh types [e.g. pickleweed], and riparian scrub) historically occurred along the Sacramento and San Joaquin River channels, in the west Delta and Yolo Basin (north Delta), and in the North Bay tidelands of Napa and Sonoma Valleys. Also historically, the salinity gradient of the estuary varied greatly seasonally and between water years, but because these habitats were well distributed along the estuarine system, there were always large expanses of shallow-water habitat associated with the saline/freshwater mixing zone (hydrologically connected). Today, these habitats occur primarily in Suisun Bay, Suisun Marsh, and lower Sherman Island. In all, the area of tidal marsh and active floodplain habitat has been reduced to probably less than 5% of its pre-1850 extent. Such massive reductions in habitat imply a substantial change in the ability of the species dependent on those habitats to sustain their population levels.

PHYSICAL AND ECOLOGICAL PROCESSES. The habitats of the pristine Bay-Delta system can be viewed as forms that developed and were maintained by processes such as flooding, sediment transport, establishment and scour of vegetation, channel migration, large woody debris transport, groundwater seepage, tidal circulation, and sedimentation. For these habitats to be sustainable in the long term, restoration of processes will be more effective than physical creation of forms no longer maintained by processes. Floodplain inundation and forest succession are two such processes along alluvial rivers.

Floodplain forests depended on periodic inundation of the floodplain to maintain appropriate moisture and disturbance regimes, which also discouraged invasion by upland species. Along many rivers, the floodplain is now leveed, and upstream dams have reduced the frequency of high flows. Thus, restoration of floodplain forests will require more than grading floodplain surfaces and planting suitable trees. Levees may need to be removed, breached, or set back, and the river will need periodic high flows capable of inundating the floodplains.

As alluvial river channels migrated across the valley bottoms (through erosion and deposition), they created new (sandy) surfaces on which pioneer riparian species (willow and cottonwood) could establish. Over time, silty overbank sediments deposited and built up the site, and later successional stage trees, such as sycamore, ash, and eventually valley oak, would establish and mature. Thus, the channel migration and its attendant erosion, deposition, and ecological succession were important processes in maintaining habitat diversity along alluvial rivers.

DELTA HYDRAULICS AND ECOLOGICAL FUNCTIONS. Bay-Delta channels were characterized by channel hydraulics that on a temporal, tidal, and seasonal basis for a given hydrologic condition supported important ecological functions such as sustaining a productive food web, providing spawning, rearing, and feeding habitat for estuarine and anadromous fish, and supporting migration of adult and juvenile fish. Reduced Delta inflow, exports from the Delta, and conversion of tidal wetlands have had a large influence on the natural hydraulic regime of the Bay-Delta. Actions such as modified water project management and flood plain and tidal wetlands restoration can contribute to restoring or a more natural hydraulic regime that sustains ecological functions and meets the life requirements of the fish and wildlife in or dependent on the Bay-Delta.

TEMPORAL VARIABILITY. The rivers of the Sacramento-San Joaquin system were dynamic environments, with temporal variations from seasonal and interannual variations in flow and sediment load, often resulting in changes to the channels themselves during floods. Such temporal variability is recognized to be important ecologically, with the periodic disturbances of floods playing an important role in maintaining riverine ecological communities (Resh et al. 1988, Wootten et al. 1996) and their habitats. Periodic droughts may also have been important, with upstream migration of salt water into Delta channels likely. This implies that seasonal and interannual variability, especially high flows, is important for restoration of the ecosystem.

In the Bay and Delta, the intrinsic value of brackish and freshwater tidelands is well documented, including high primary and secondary productivity, fish rearing and foraging habitat, and habitat for a high diversity of native animals and plants, including many at-risk species (general avian and semi-aquatic mammal [e.g., otter] habitats). Less understood are the functional relationships and interdependencies of open water (pelagic) habitats and species of the Delta to these formerly more common peripheral, shallow water habitats. Moreover, these habitats were subjected to a temporally variable salinity gradient (seasonally and year to year), with saline water intruding far upstream into the Delta during periods of low flow (especially droughts) and fresh water extending far downstream into San Francisco Bay during floods. This dynamic, temporal variability presumably favored native species, and the current reduction of such variability may have facilitated establishment of non-native species.

SPATIAL VARIABILITY. The river channels were also characterized by spatial variability (or complexity), arising from irregularities in channel form, both transverse to and longitudinal with the flow direction. For example, in meander bends the channel is typically deeper on the outside of the bend, increasingly shallow toward the inside bank onto a point bar. This variation in water depth is accompanied by variations in grain size of bed sediment and in water velocity. Longitudinally, irregularities include large-scale alternations between bedrock to alluvial reaches, steep (riffle) and low-gradient (pool) reaches, transitions between reaches of differing widths, passage over and around channel bars, and effects of boulders and large woody debris in the channel. The riverbanks were typically irregular in outline and often were made more irregular by protruding trees (living and dead). Such spatial irregularities were ecologically important because they created a diversity of habitats, which in turn supported a diversity of species and life stages of those species. The importance of complexity in physical habitat implies that in many artificially straightened or deepened channels, it may be advantageous to physically restructure the channel or to add elements likely to induce scour or deposition or both.

CONTINUITY. The longitudinal continuity of water flow, sediment transport, nutrient transport, and transport and migration of biota through the river system, as well as the longitudinal continuity of riparian and aquatic habitat along the length of a river, were important attributes of the ecosystem. The transport of gravel from mountainous source areas provided spawning habitat in alluvial channels downstream, and the continuity of channels allowed for upstream migration of spawning salmon, waterborne dispersal of seeds, and invertebrate colonization. Similarly, the longitudinal continuity of riparian vegetation flanking the stream was an important attribute of the riparian habitat for wildlife, as well as for shading the channel and providing carbon to the aquatic system. The importance of continuity implies that conservation and restoration projects should be prioritized, in part, to maximize continuity of habitat, so that sites whose restoration would connect different habitats would have priority over other, similar sites.

FLOODPLAIN INUNDATION. Alluvial channels and their floodplains behaved as functional units, with floodplains accommodating flows in excess of channel capacity. This had important ecological implications. First, as water overflowed from the channel onto the floodplain, it slowed down, because overbank flow was shallow and the floodplain was hydraulically rough, offering greater resistance to flow. Floodwaters charged with suspended sediment deposited some of the coarser part of their sediment load as they flowed overbank, typically leaving deposits of sand immediately adjacent to the channel (where the water velocity first slows) and finer grained sediment further away from the channel. Floodplain sedimentation is known to be important in alluvial rivers, responsible for measurable decreases in suspended sediment loads (Walling et al. 1998). From the point of view of water quality, the removal of suspended sediment from the water column is a potentially important effect.

Floodwater on the floodplains reduced the volume of floodwater in the channels and moved more slowly than water in the main channel. The net effect was to reduce the height of the flood wave as it moved downstream. Overflow onto the floodplain also served to limit the height of water in the channel, thus limiting the shear stress exerted on the bed. In essence, the floodplains acted as "pressure relief valves," which prevented a continuous increase in shear stress in the channel with increasing discharge. This permitted a larger range of sediment grain sizes to remain on the channel bed than would have been the case without overbank flooding because without overbank flooding, gravel may be mobilized and lost at the confined channel's higher shear stress. Similarly, overbank flows make more refuge habitat available to fish because there are zones of lower shear stress in the channel and because fish can seek refuge in the inundated floodplain.

Other important ecological interactions between the floodplain and channel include shading, food, and large woody debris provided by floodplain vegetation (Gregory et al. 1991, Murphy and Meehan 1991). During prolonged inundation of the Cosumnes River floodplain in 1997, salmon and other fish were observed feeding on the inundated floodplain, one illustration of the important migrations and interchanges of organisms, nutrients, and carbon that would have occurred frequently in the Bay-Delta system before 1850. Even along rivers where floodplain inundation was typically brief, interactions could be nonetheless important for recharging the alluvial water table, dispersing seeds of riparian plants, and increasing soil moisture on surfaces elevated above the dry season water table. Inundation of floodplains and maintenance of high alluvial water tables contributed to maintenance of floodplain aquatic habitats, such as side channels, oxbow lakes, and phreatic channels (Ward and Stanford 1995).

Floodplain soils and vegetation can also improve water quality in rivers by filtering sediments from runoff and by contributing to chemical reactions in the floodplain alluvium that can remove nitrogen and other constituents from agricultural or urban runoff.

ECOLOGICAL TRANSFORMATIONS FOLLOWING COLONIZATION

THRESHOLD EVENTS LEADING TO PRESENT CONDITIONS

GRAZING. Cattle were introduced in 1770 and rapidly expanded under Spanish rule. Along with the introduction of non-native annual grasses (which replaced most native bunch grasses), the reduction in upland plant cover, soil compaction, and reduction in riparian vegetation resulted in higher peak runoff for a given rainfall and higher erosion rates. This hydrologic transformation probably initiated a cycle of channel incision, with consequences on alluvial groundwater tables and wetlands.

GOLD MINING. Beginning about 1850, the extraction of gold transformed the channels and floodplains of many rivers, especially in the Sierra Nevada. Hydraulic mining, in which high-pressure jets of water were directed at gold-bearing gravel deposits (mostly on ridgetops), produced more than 1.67 billion cubic yards of debris, most of which was flushed from steep bedrock canyons onto the Sacramento Valley floor (Gilbert 1917). This massive influx of coarse sediment filled the river channels and spread out over floodplains, converting formerly silty farmland into gravel and sand deposits. Along the Yuba River upstream of Marysville, hydraulic mining debris created the Yuba River Debris Plain, encompassing more than 40 square miles. The bed of the Yuba River near Marysville aggraded about 90 feet, inducing the town to build levees. These could not contain the continually aggrading channel and were overtopped numerous times starting in 1875, resulting in extensive damage to the town. The increased sediment in the Sacramento River interfered with shipping and required dredging. Finer grained parts of the debris settled out in the San Francisco Estuary, adding to mudflats along the bay margins. Because of its downstream impacts, hydraulic mining was prohibited by court order in 1884, but the wave of hydraulic mining debris already in the system continued to progress downstream; the bed elevation of the Yuba River at Marysville peaked in 1905 and returned to estimated pre-mining levels by about 1950 (James 1991).

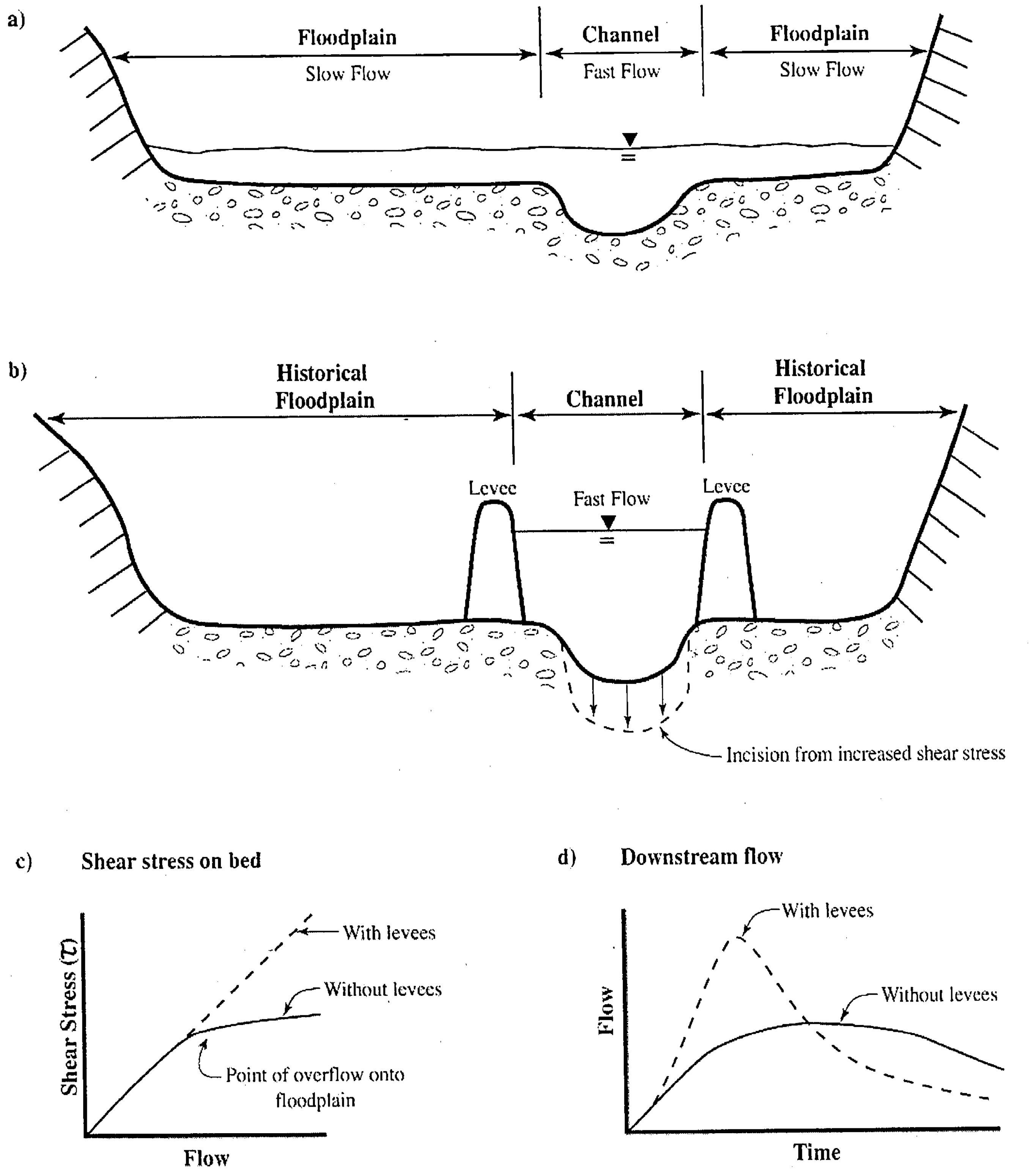
Gold-bearing floodplain and terrace gravels, including deposits of hydraulic mining debris, were extensively reworked by dredgers, which left linear mounds of tailings along many river channels in the Sacramento-San Joaquin River system. These dredger tailings have only coarse cobbles on the top, preventing establishment of vegetation except in low swales in between the tailing piles.

CHANNELIZATION FOR NAVIGATION. The Sacramento, Feather, and San Joaquin Rivers were important navigation routes, with ocean-going vessels reaching Marysville and Stockton in the 1850s. The influx of hydraulic mining sediment caused the rivers to become shallower, interfering with navigation. In response, riverbeds were dredged and levees were constructed along riverbanks (to concentrate flow and induce bed scour) to deepen channels. To facilitate navigation, large woody debris was cleared from many channels. To provide fuel for steamers, valley oaks and other trees were cleared from accessible areas near rivers.

ARTIFICIAL BANK PROTECTION. With increased agriculture and human settlement on the floodplain, it became more likely that natural channel migrations would threaten to undermine structures or productive agricultural land. To protect these resources, banks have been protected by riprap (and other artificial protection) along many reaches, including most of the Sacramento River downstream of Chico Landing. Riprapped banks effectively lock the channel in place, eliminate the contribution of gravels and woody debris from actively eroding riverbanks, and prevent the creation of new riverine habitats through meander migration. Moreover, the protected banks lack the overhanging vegetation and undercut banks (often termed "shaded riparian aquatic habitat") so important as fish habitat in natural channels (California State Lands Commission 1993). Riprap also damages the habitats of threatened and endangered bird species such as bank swallows.

LEVEE CONSTRUCTION. To protect floodplains against flooding, more than 5,000 miles of levees have been built in California, most of which are in the Bay-Delta system, and 1,100 of which are in the Delta itself (Mount 1995). Most of these are "close levees": levees built adjacent to the river channel itself (often on top of natural levees), in some cases to concentrate flow for navigation. By preventing overbank flows, levees reduce or eliminate interaction between channel and floodplain and thus reduce important ecological interactions. In addition, by eliminating overbank flows and natural floodplain storage, levees concentrate flow in the main channel, which results in greater depths, faster flow, and higher flood peaks downstream (Figure A-2) (IFMRC 1994).

FLOODPLAIN CONVERSION. Most floodplains, with their fertility enhanced by overbank silt deposits, were converted from alluvial forest or riparian marsh to agricultural land, with subsequent conversion of many areas to urban use. Valley oak woodlands were cleared extensively because they tended to occur on good soils. First cleared along the Sacramento River were the well-drained, broad, linear ridges (natural levees) developed along the current and former channels from overbank deposits. Then of lower flood basin areas were converted as they were drained and diked off from frequent floods. The floodplains of the Sacramento and San Joaquin Rivers were extensively cleared in the second half of the 19th century for dryland wheat farming, which occupied 3.75 million acres in 1880s (Kelley 1989). In the Sacramento Valley, rice growing developed since



Note: With natural floodplain functioning, much of the floodwaters are accommodated on the floodplain, where high hydraulic roughness leads to slower flows and thus slower downstream transmission of floodwaters (a). Levees concentrate floodwaters in the channel (b), resulting in deeper water and higher velocities, faster downstream transmission of floodwaters, and higher flood peaks downstream (d). Deeper and faster flows lead to higher shear stresses (force per unit area) on the channel bed (c), which may lead to bed incision (b).

Figure A-2: Effect of Levees on Floodflows and Channel Geomorphology

1910 with levee construction and availability of irrigation water, with 600,000 acres of rice in flood basins by 1981 (Bay Institute 1998).

Unfortunately, no reliable data exist on the actual extent of riparian forest before 1850, and estimates vary widely. The potential maximum area of riparian forest in the Sacramento Valley (based on soils and historically mapped riparian forest) was 364,000 acres. Only about 38,000 acres exist today, approximately 10% of the historical value. However, it is unlikely that the forest ever occupied the full 364,000 acres at one time (Bay Institute 1998). In the San Joaquin Valley, soils and historical accounts suggest a potential pre-1850 riparian zone of 329,000 acres, contrasting with a current 55,000 acres of wetlands and 16,000 acres of riparian forest (Bay Institute 1998). The area currently mapped as riparian forest includes areas of poor quality, heavily affected by human action. An illustration of a relatively recent conversion of floodplain habitats in the San Joaquin River basin is shown in Figure A-3. On the floodplain of the Merced River, a complex of side channel habitats was eliminated for agriculture between 1937 and 1967.

TIDAL MARSH CONVERSION. In the Delta and Suisun, San Pablo, and San Francisco Bays, similar transformations were underway, with most former tidal marsh and mudflats converted to agricultural lands (and some to urban uses). In the Delta, there was an estimated 380,000 acres of intertidal wetlands, 145,000 acres of nontidal wetland, and 42,000 acres of riparian vegetation on higher ground (Bay Institute 1998). Today, about 21,000 acres of wetland remain, of which about 8,200 acres are tidal (San Francisco Estuary Project 1992). The tidal wetland loss was largely finished by 1940 (Atwater et al. 1979).

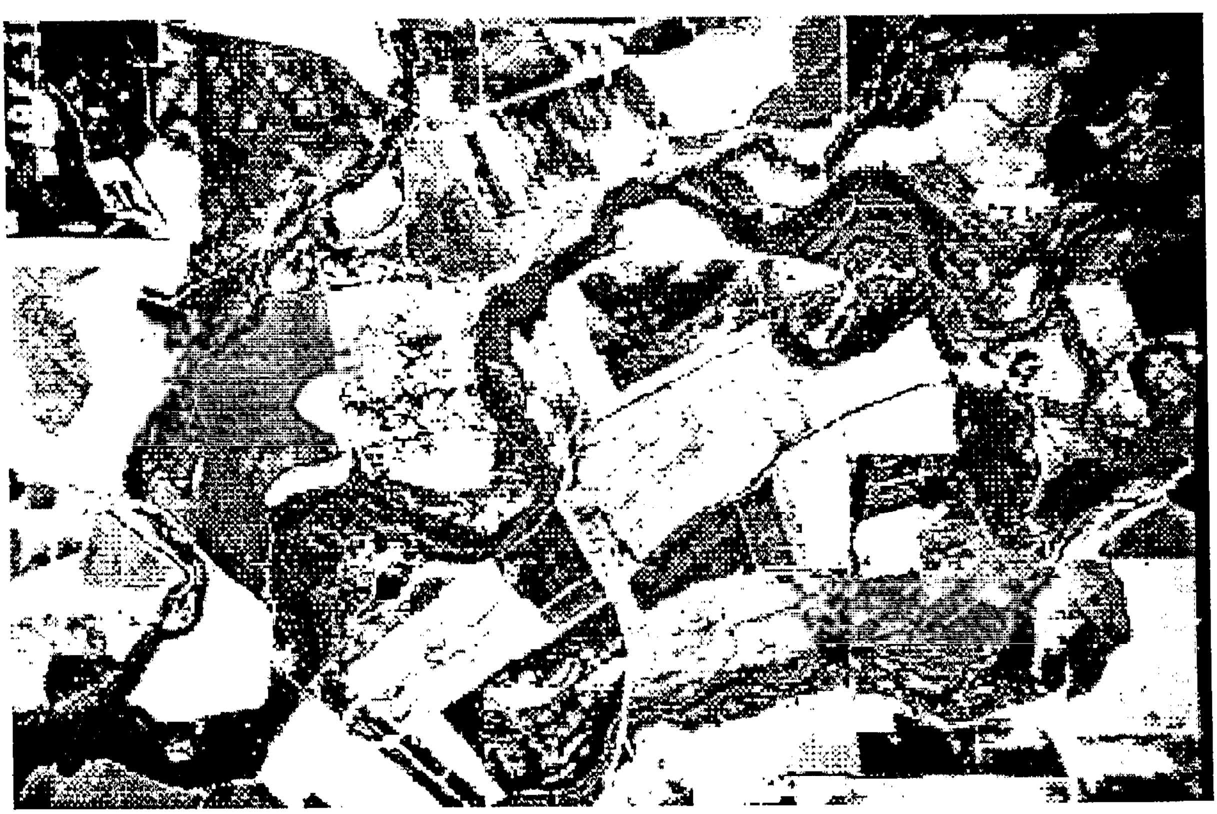
The loss of these wetlands can be considered one of the most significant human-caused functional modifications of the Bay-Delta ecosystem. The Delta tidal marshes probably formed an important link in the nutrient transfer between the riverine and open-water estuarine components of the watershed. Delta tidal marshes had the highest primary productivity and biodiversity of any comparably sized area in pre-Columbian California. Although exports from marshes to adjacent open water systems have been difficult to demonstrate (Mitch and Gosselink 1993), it is likely that the Delta tidal marshes functioned as a filter that trapped sediment and removed inorganic nutrients supplied by the rivers from the upstream watershed and produced organic inputs that were transferred to the bay. Currently, tidal marshes probably still remove inorganic and organic compounds (including toxins) from the rivers, but this function has been greatly reduced because the existing river system largely bypasses the marshes.

The loss of networks of shallow dendritic slough channels in the tidal marsh has greatly reduced the length of the linear interface between open water and vegetated marsh. Historical topographic maps show that the drainage pattern in historical tidal marshes was much more complex than in current, remnant tidal marshes. Historically, tidal marshes probably provided important feeding and reproduction habitat for many vertebrate species. Restoration of tidal marsh will be most beneficial to vertebrate species if both tidal marsh area and habitat complexity are restored. Similarly, these shallow-water habitats were formerly exposed to a variable salinity regime to which native species were adapted.

RESERVOIRS AND DIVERSIONS. Dams constitute important discontinuities in rivers, altering riverflows, eliminating the continuity of aquatic and riparian habitat, and blocking migration of fish and other organisms. Reservoirs impound water for many reasons, such as generation of hydroelectric power; flood storage; and controlling flow to allow diversions, increased consumptive use, and export. Dams have cut off upper reaches of rivers, hydrologically isolating them (Figure A-4). One implication of this fact is that most of the channels of concern to CALFED lie downstream of large reservoirs and are thus hydrologically isolated from changes in runoff or sediment load in the upper reaches of the watersheds. For example, increased erosion from timber harvest or changes in water yield from changes in vegetative cover in the upper Feather River tributaries will not affect conditions in the ERP focus area downstream of Oroville Dam as long as the reservoir continues to trap sediment and regulate flows.

As barriers to migration, dams have had an especially hard impact on spring-run chinook

1937



1967

Figure A-3: Aerial Photographs of the Merced River Floodplain, Showing Loss of Floodplain Side Channel Habitats from 1937 to 1967.

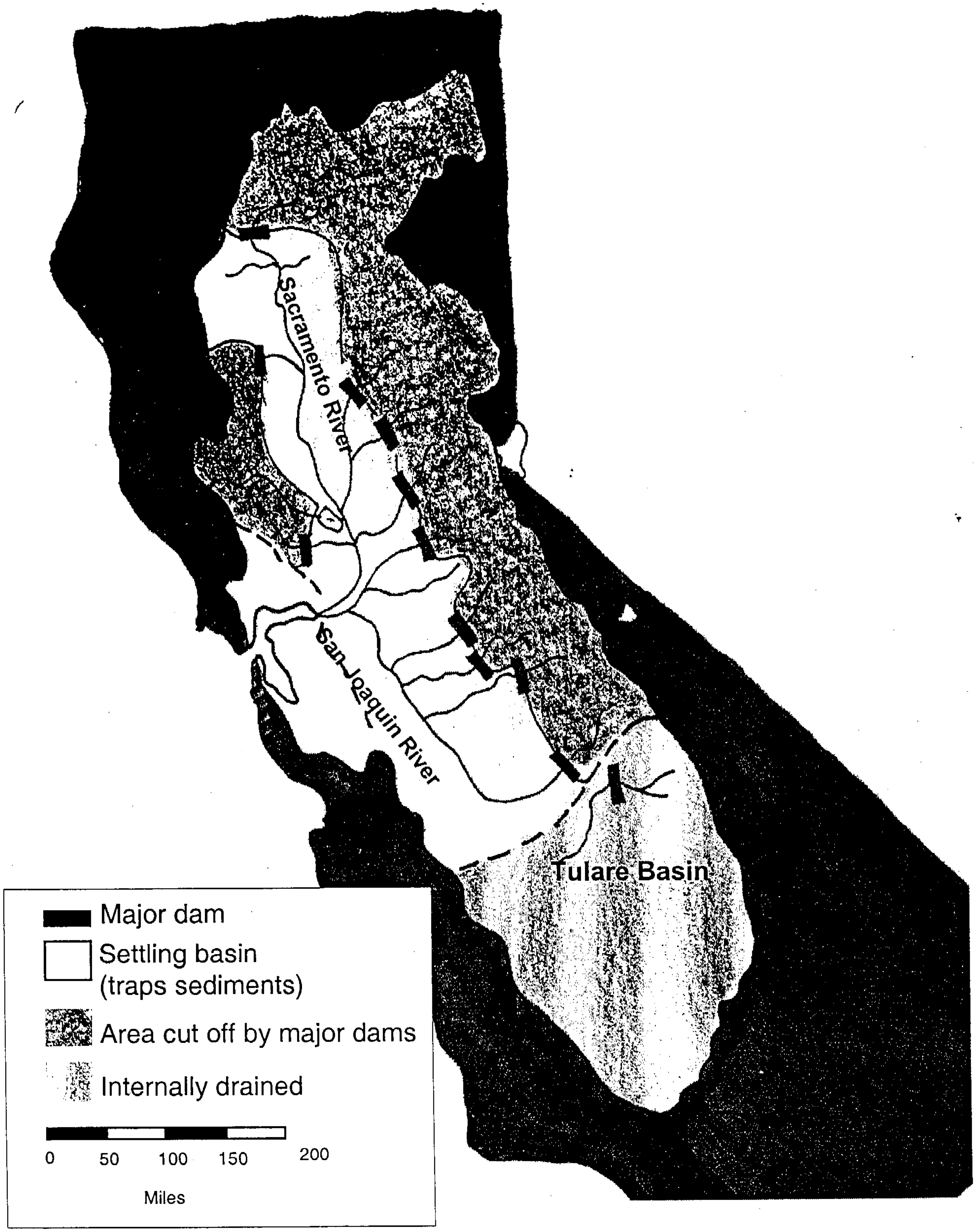


Figure A-4: Upper Watersheds in the CALFED Solution Area Cut off from the Lowland Alluvial Rivers by Dams salmon and steelhead trout, which formerly migrated to upstream reaches to spawn. In the San Joaquin Valley, Friant Dam delivered the entire flow of the upper San Joaquin River south, abruptly eliminating a major run of Chinook salmon. The extent of river channel inhabited by spring-run salmon has decreased dramatically since the early 19th century (Figure A-5). Overall, reservoirs were found to be the most important gaps in riparian habitat in rivers draining the Sierra Nevada (Kondolf et al. 1996). Diversions also entrain fish, resulting in direct mortality, especially of juveniles.

By 1940, most rivers in the Sacramento-San Joaquin River system had dams large enough to block fish passage, reduce flows during critical baseflow periods, and reduce frequent floods. However, reservoir size and cumulative reservoir storage increased dramatically with construction of the Central Valley Project, the State Water Project, and other large dams. From 1920 to 1985, total reservoir storage capacity increased from about 2 million acre-feet to 30 million acre-feet (Figure A-6) (San Francisco Estuary Project 1992, Bay Institute 1998). Reservoir storage in the Sacramento River system is now equivalent to 80% of annual average runoff; in the San Joaquin River system, reservoir storage is equivalent to 135% of runoff. As a result of dams, diversions, consumptive use, and export out of the watershed, the total runoff to the San Francisco Bay from the Delta has been reduced from pre-1940 runoff by 30-60% in all but wet years (Nichols et al. 1986, Bay Institute 1998). The seasonal distribution of flows has fundamentally changed, and flood magnitude and frequency profoundly decreased. The mean annual flood (the average of annual peak flows) has decreased by 20-65 % from pre-dam values (depending on reservoir capacity in relation to runoff) (Table A-1).

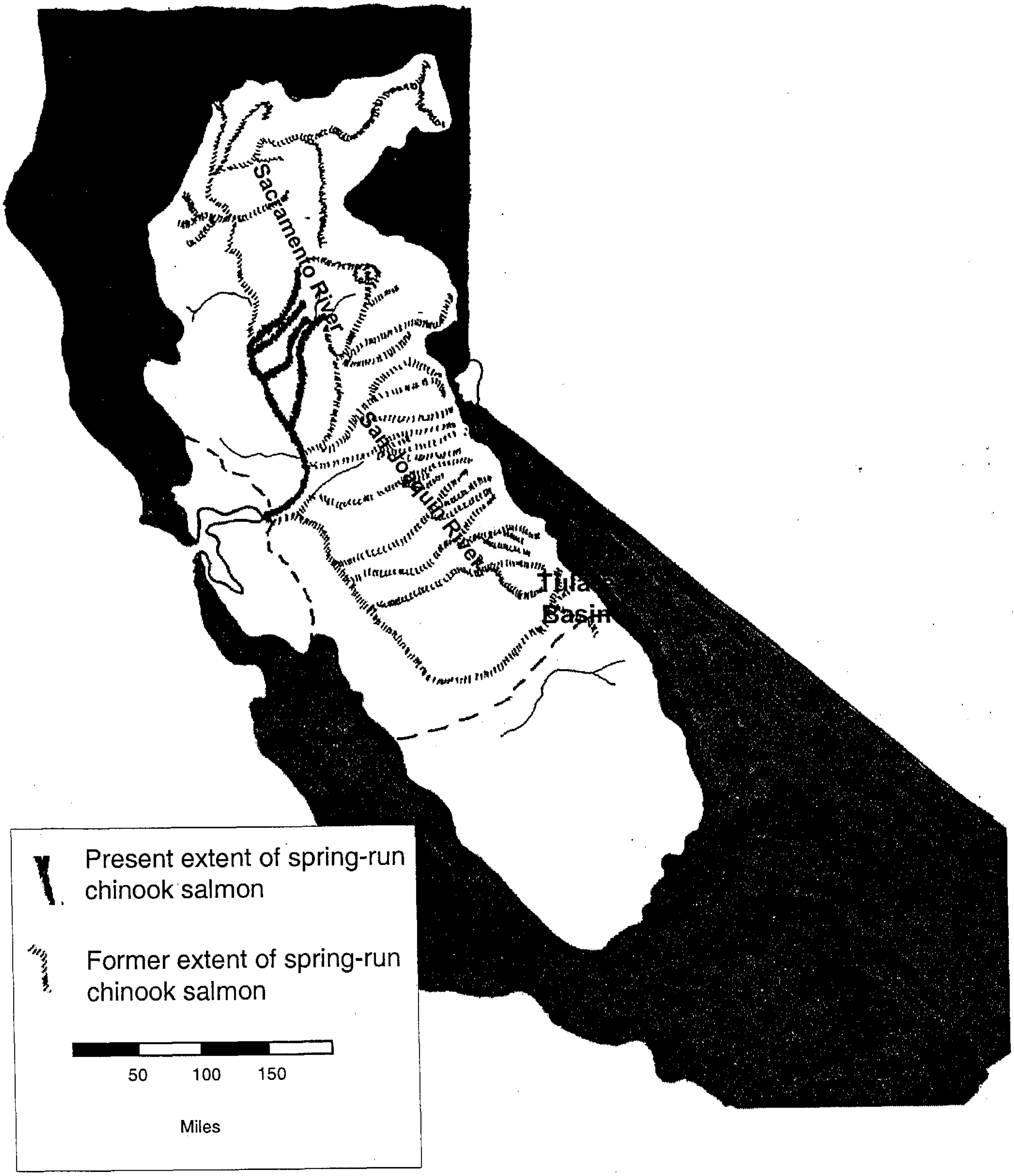
The reduction in floodflows has transformed river channels of the Sacramento-San Joaquin system. Rates of bank erosion and channel migration in the Sacramento River have declined because of dam construction and construction of downstream bank protection projects (Brice 1977, Buer 1984). The channel sinuosity (ratio of channel length to valley length) has also decreased because of numerous meander cutoffs (Brice 1977), reducing total channel length and thus total in-channel habitat. Moreover, the diversity of riparian and aquatic habitats is directly related to the processes of bank erosion, point bar building (creating fresh surfaces for riparian establishment), and overbank deposition, resulting in a mosaic of different-aged vegetation and contributing to the complexity of in-channel habitat and shaded bank cover (California State Lands Commission 1993). The reduction in active channel dynamics is compounded by the physical effects of riprap bank protection structures which typically eliminate shaded bank habitat and associated deep pools, as well as halting the natural processes of channel migration.

Reduced floodflows below dams have also rendered inactive much of the formerly active channel, "fossilizing" gravel bars and permitting establishment of woody riparian vegetation within the formerly active channel, narrowing the active channel and reducing its complexity (Peltzman 1973, Kondolf and Wilcock 1996). The reduced frequency of formerly periodic flood disturbance in channels downstream of dams has created conditions favorable to establishment of exotic species (Baltz and Moyle 1993).

Elimination of annual floodflows below dams may permit fine sediment to accumulate in gravel beds and cobble beds, reducing the quality of spawning and juvenile habitat for salmonids, and invertebrate production (Kondolf and Wilcock 1996). Reduced mobility of gravel beds may also favor invertebrate species less desirable as food for salmonids (Wootten et al. 1996).

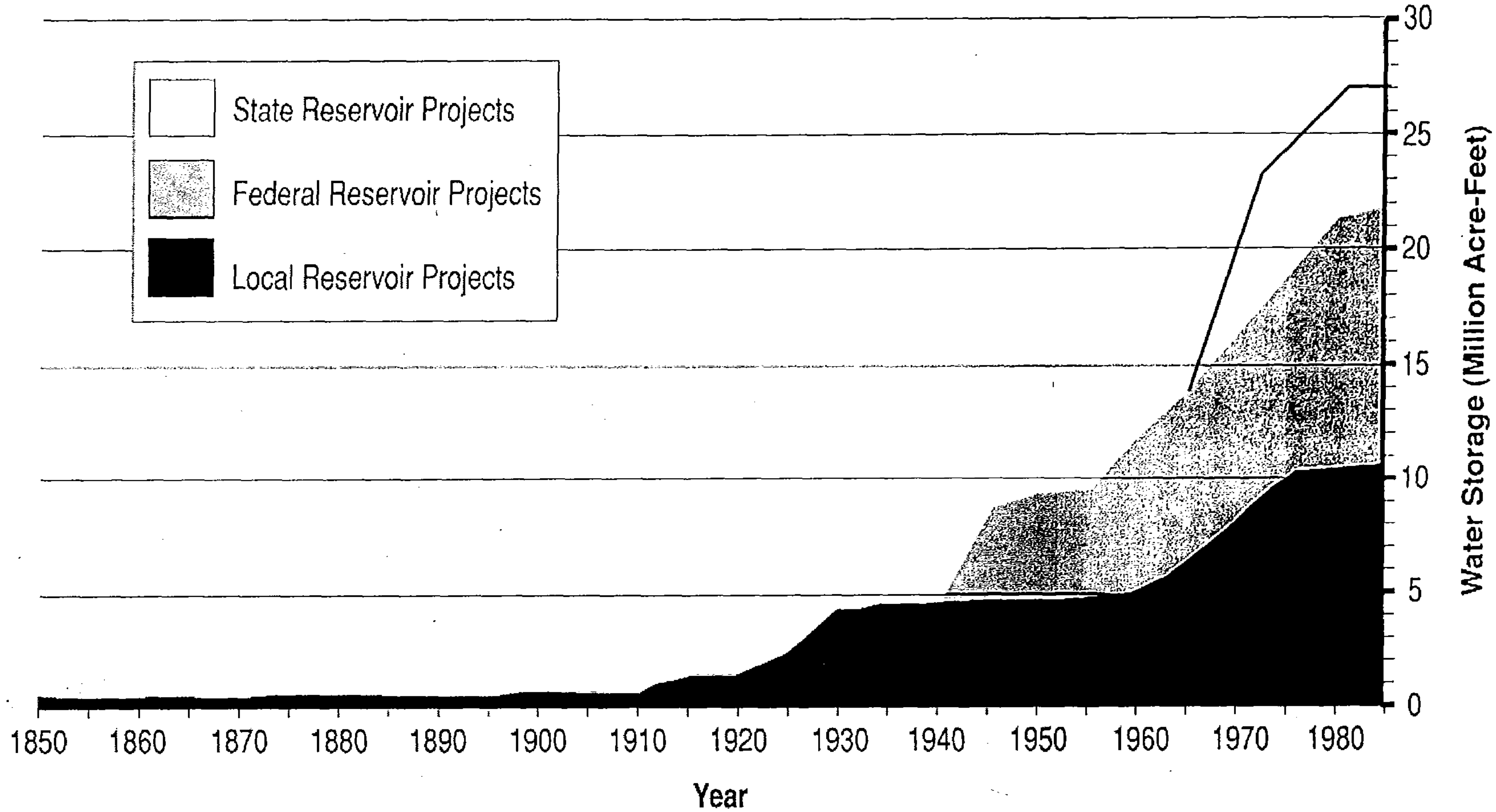
Dams also trap sediment derived from upstream, commonly releasing sediment-starved water downstream, as discussed below.

EXTRACTION OF SAND AND GRAVEL FOR CONSTRUCTION AGGREGATE. The rapid urbanization of California has required massive amounts of sand and gravel for construction aggregate (e.g., road fill, drain rock, concrete for highways, bridges, foundations), with annual production of more than 100 million tons, 30% of the national production (Tepordei 1992). Nearly all this sand and gravel is drawn from river channels and floodplains. Mining in channels disrupts channel form, causes a sediment deficit and channel incision, with resulting loss of



Source: Kondolf pers. comm.

Figure A-5: Present versus Historic Extent of Spring-Run Chinook Salmon



Source: San Francisco Estuary Project 1992.

Figure A-6: Cumulative Increase in Reservoir Storage in the Bay-Delta System

TABLE A-1. CHANGES IN MEAN ANNUAL FLOWS FOR SELECTED RIVERS IN THE SACRAMENTO-SAN JOAQUIN RIVER SYSTEM

River	Dam	Date Constructed	Gauge Number	Period of Gauge Record	Mean Annual Flood (cubic feet per second)		Percent Reduction
					Pre-dam	Post-dam	
Sacramento River	Shasta	1945	11377100	1938-1996	120,911	78,885	35
Feather River	Oroville	1968	11407000	1902-1996	69,641	22,929	66
American River	Folsom	1956	11446500	1904-1996	53,459	29,651	45
Stony Creek	Black Butte	1963	11388000	1955-1990	13,744	7,959	42
Mokelumne River	Camanche	1963	11323500	1904-1996	7,395	2,431	66
Stanislaus River	New Melones	1979	11302000	1957-1996	10,016	3,135	69
Merced River	New Exchequer	1967	11270900	1901-1996	8,287	4,560	45
San Joaquin River	Friant	1942	11251000	1908-1996	18,614	3,718	80

Source: U.S. Geological Survey.

spawning gravels and other habitats. Floodplain gravel pits commonly capture the river channel (i.e., the river changes course to flow through the pits). The pits are excellent habitat for warmwater species that prey on salmon smolts; the California Department of Fish and Game estimates that 70% of the smolts in the Tuolumne River are lost to predation annually (EA Engineering, Science, and Technology 1992). Refilling these pits to eliminate predator habitat and restore channel confinement is expensive, with $5 million recently budgeted to fix two such pits on the Tuolumne River.

SEDIMENT STARVATION FROM DAMS AND GRAVEL MINING. Dams and gravel mining can result in a sediment - deficit downstream, especially when mining occurs downstream of dams. The cumulative effect of sediment trapping by dams has been enormous. Using published reservoir sedimentation rates, and assuming sand and gravel to be 10% of total sediment load, we estimate that the mountainous reaches of the Sacramento, San Joaquin, and tributary rivers formerly delivered an annual average of about 1.3 million cubic meters to the Sacramento and San Joaquin Valleys. (This is the estimated sediment yield to the large foothill reservoirs, or to the equivalent point in an unregulated river, near the transition from mountainous upland to valley floor.) Construction of reservoirs has cut this amount to about 0.24 million cubic meters, a reduction of about 83%. This does not account for the further reduction in sediment budget from gravel mining in the channels in the valley floor.

Overall, the rate of gravel mining from rivers in California is at least 10 times greater than the natural rates at which gravel and sand are eroded from the landscape and supplied to the rivers (Kondolf 1997). On the Merced River, an estimated 150,00-300,00 tons of sediment have been trapped behind the Exchequer Dam since 1926, and 7-14 million tons of sand and gravel have been excavated from the channel and floodplain since the 1950s (Kondolf et al. 1996). This constitutes a profound alteration in the regime of rivers tributary to the Bay-Delta. Although some of the sediment deficit is made up in the short term through bank erosion and channel downcutting and the transport capacity of most rivers has been reduced by reduced floodflows, the magnitude of the overall reduction in sediment supply to the system is such that long-term adjustments in channel, floodplain, and intertidal marsh/mudflat habitats are inevitable.

Dams, gravel mining, and bank protection have so reduced the supply of gravel in the Sacramento River system that many reaches of river that formerly had suitable gravels for salmon spawning are no longer suitable for spawning (e.g., Parfit and Buer 1980). In the CALFED area alone, millions of dollars have already been spent and will be spent to add gravels (and create spawning riffles) in the Sacramento, Feather, American, Mokelumne, Stanislaus, Tuolumne, and Merced Rivers and in Clear and Mill Creeks, all in attempts to compensate for the loss of spawning habitat (Kondolf and Matthews 1993, Kondolf et al. 1996).

OVERFISHING. Fish populations have been directly affected by harvest rate, most notably the intensive harvesting of the late 19th century, with development of major commercial fisheries for salmon in the estuary and the rivers. Gill nets strung across the Sacramento River at times completely blocked access to spawning grounds. Dozens of salmon canneries sprang up along the estuary, but the last one had closed by 1916, after the runs were depleted. Sturgeon were caught in the salmon nets in large numbers and most were killed and discarded because of the damage done to the nets. Commercial fisheries also developed to catch resident fishes, such as Sacramento perch, thicktail chub, and others, which were sold as fresh fish in the markets of San Francisco.

The early 1900s marked the beginning of the era of some of the first conservation legislation at state and national levels, the sturgeon fishery was banned, salmon populations were allowed to recover, and refuges were set aside for waterfowl.

EFFECTS OF WATER DIVERSIONS FROM THE DELTA ON NATIVE FISHES. Water diversions from the Delta affect fish in two principle ways, the direct diversion of fish and adverse effects on Delta channel hydraulics.

Delta diversions result in losses of all life stages of fish, particularly eggs, larvae, and juveniles as well as the loss of nutrients and primary and secondary production needed to support a healthy aquatic foodweb.

Changes in Delta channel hydraulics began in the mid-19th century with land reclamation that restricted flows to narrow channels defined with levees. These same channels later became conduits for carrying water to the water export facilities in the central and south Delta. In 1951, the CVP began to transport water from the south Delta to the Delta-Mendota Canal. Operation of the Delta Cross Channel in the north Delta began to allow Sacramento River water to flow through interior Delta channels from the north to the southern Delta export facilities. South Delta export facilities were increased with the addition of the SWP pumping plant in the late 1960s. Delta channel hydraulics in the June through September period were adversely affected by Delta diversions as early as the mid 1950s. In the 1960s, impacts extended into the April and May period. Delta channel hydraulics, particularly in the November through April period, were dramatically affected beginning in the early 1970s and continuing into the 1980s, a period of steep declines in the abundance of native fish species. In the San Joaquin Valley, Friant Dam delivered the entire flow of the upper San Joaquin River south, abruptly eliminating a major run of chinook salmon. The fish fauna of the rivers and Delta changed abruptly as well because resident non-native fishes were favored over native fishes, resident and anadromous. Thicktail chub and Sacramento perch gradually were driven to extinction in the system.

Existing Delta hydraulic conditions inhibit the ecological functions of the Delta as a migration corridor and rearing habitat for native species such as Chinook salmon and important non-natives such as striped bass. Native residents such as Delta smelt, which depend on natural hydraulic processes that help support spawning habitat and a productive foodweb, have been impacted by changed hydraulic conditions, particularly in the last two decades.

In the 1960s, the State Water Project went into operation with the completion of Oroville Dam on the Feather River (1967) and the construction of another set of big pumps in the south Delta. By this time, nearly every major river and creek feeding the Central Valley and the estuary was dammed. Not only was the water available for natural ecosystem processes increasingly diminished in amount, but it was increasingly polluted, the result of the ever-increasing urbanization of the region and more intensive agriculture.

Native resident and anadromous fishes continued to decline, as did the native flora and fauna of riparian areas and wetlands as water diversions increased and as wetland and riparian habitats continued to be diminished. (In dry years, migratory waterfowl were largely confined to artificial wetlands and showed marked downward trends as well.)

POLLUTION. Industrial, municipal, and agricultural wastes have been discharged into waters of the Bay-Delta system, with major historical point sources including wastes from fish and fruit/vegetable canneries and municipal sewage. The large-scale pollution of the estuary and rivers was partially relieved by the passage of the Clean Water Act, resulting in the construction of sewage treatment plants in all cities. Mines such as the Penn Mine on the Mokelumne River and the Iron Mountain Mine on the Sacramento River continue as serious sources of contaminants, with some releases from Shasta Dam made explicitly to dilute Iron Mountain leachate below lethal levels in the river to avoid fish kills. Nonpoint sources of pollution, such as urban runoff and agricultural runoff, continue to impair water quality. Agricultural drainage (often highest in summer from irrigation return flow) typically has elevated temperatures and contains excessive loads of constituents such as organic carbon, nitrates, phosphates, as well as herbicides and pesticides toxic to phytoplankton, invertebrates, and larval fish (Bailey et al. 1995).

INTRODUCTION OF NON-NATIVE SPECIES. As the native fishes became depleted in the late 19th century, non-native species were brought in (especially following the completion of the transcontinental railroad in 1872): American shad, striped bass, common carp, and white catfish. As their populations boomed, those of native fishes declined further. Introduction of non-native species accelerated in the 20th century through deliberate introductions of fish and unintended introductions of harmful invertebrates and fish, mainly through ballast water of ships. Establishment of non-native species was probably facilitated by altered hydrologic regimes and reduction in habitats suitable for native species.

Non-native birds have also adversely affected native bird species populations through competition, predation, and other means.

Changes in Populations of Native Species Resulting from Human Alteration to the Ecosystem

Populations of a number of species have declined sufficiently since the 19th century to warrant their listing under the federal Endangered Species Act of 1973. Twenty-one species of plants, seven species of invertebrates, four fish species, one amphibian species, one reptile species, six bird species, and one mammal species present in the Bay and Delta region alone that are listed as threatened or endangered, with a number of others proposed for listing or listed under the equivalent state law. Perhaps the most significant of these listings have been those for winter-run chinook salmon, delta smelt, and steelhead trout because their recovery is likely only if there is a significant reallocation of water for environmental purposes, as well as significant improvements in their remaining habitats.

Present Conditions and Trends

Present Conditions

The status of the ecosystem is described in detail in the affected environment chapters of the Fisheries and Aquatic Ecosystems Technical Appendix and Vegetation and Wildlife Technical Appendix to the CALFED Programmatic EIS/EIR.

Environmental Trends. Specific currently discernable environmental trends are likely to continue during the next few decades. These trends would largely result in continued environmental degradation, although some positive trends are also apparent. Population growth will lead to an increase in the demands on water and other resources in California (e.g., gravel, petroleum, and wood products). Other possible sources of increased environmental degradation include conversion of agricultural lands to urban land uses, a likely shift in agricultural practices to more intensive crops, flood control activities, new introductions and expansion of non-native species, sea-level rise, and global climate change. On the positive side, several legislative and policy initiatives could result in improvements in habitat and water quality.

These trends in the demand for natural resources present constraints and opportunities on the extent to which CALFED can successfully rehabilitate elements of ecosystems that are critical to achieving the goals and objectives of the ERP (e.g., recovery of endangered species and maintenance of populations of other native species at levels sufficient to prevent potential future listings of species). The effect of these trends (along with the current commitment of land and natural resources to other uses) is to necessarily preclude wholesale rehabilitation of the ecosystem to a semblance of its historical condition. Instead, these trends will most likely limit CALFED to successful rehabilitation of representative "islands" within the Bay-Delta system in which most or all of the ecological processes associated with the historical ecosystem have been restored and to partial rehabilitation of some attributes historically associated with the ecosystem throughout the Bay-Delta system.

Trends in Population and Water Usage. The California Department of Finance projects California's population to grow from its 1995 level of 32.1 million to 47.5 million in 2020, an increase of approximately 48%. Irrigated crop acreage is expected to decrease slightly from 9.5 million acres to 9.2 million acres. These factors (as well as changes in use rates) are expected to lead to a slight decrease in agricultural water use (from 33.8 MAF to 31.5 MAF), but significant increases in urban water uses over the same period (from 8.8 MAF to 12.0 MAF). These numbers are estimates from DWR's State Water Plan Update (California Department of Water Resources 1997) and are subject to different assumptions regarding the size and effectiveness of water conservation programs.

Increasing demand on water for urban uses will lead to increasing competition for water between agricultural, urban, and environmental uses, particularly during drought periods. Additionally, because the greatest population increases are projected to occur in southern California, an area dependent on water exported from the Delta, there is the potential to intensify the environmental impacts created by the existing water supply system. Population increases may also intensify environmental degradation through increased urbanization (conversion of natural and agricultural lands to urban uses) and increased demand for resources (such as sand and gravels, petroleum, wood products and other construction materials).

In view of this, attempts to restore the ecosystem in the future or increase the extent of natural habitats in the Bay-Delta system that are dependent on fresh water, including the physical processes associated with its flow, is likely to be more difficult than under current circumstances. Recognition that the availability of water for all uses is ultimately limited underscores the necessity of the ERP to focus the use of environmental water on rehabilitation of sufficient portions of the Bay-Delta system that are critical to meeting the goals and objectives of the ERP. Recognition of this trend also underscores the necessity for the ERP to secure sufficient environmental water in balance with other uses sooner, rather than later, to ensure success of the ERP.

CHANGES IN AGRICULTURAL CROPPING PATTERNS. Agricultural cropping patterns are expected to shift away from field and forage crops to higher intensity crops, such as vegetables, vineyards, and orchards, which typically provide less wildlife habitat for listed species such as the Swainson's hawk and greater sandhill crane. Because these more intensively managed crops are more profitable, agricultural land is expected to become more expensive and difficult to purchase for habitat restoration. These trends will place greater demands on remaining and restored native habitats to support displaced wildlife populations and constrain the quantity and location of habitat that can be restored.

INCREASES IN FLOOD PROTECTION. Periodic flooding is an important river function that sustains ecological functions by creating a matrix of diverse habitats, by replenishing nutrients in the system, and by transporting sediments and biota through the system. Plans for increased flood protection could lead to greater constraints on ecological structure and functions.

Increased flood protection can directly affect ecological functions by decreasing habitat diversity; creating barriers to the movement of sediment, nutrients, and species; removing riparian habitat; and reducing or eliminating floodplain inundation. Indirect impacts can also result. As the perceived threat of flooding is reduced, more floodplain lands are subject to urban and agricultural development. The increasing demand for flood control increases the urgency to provide innovative flood management solutions that increase the flood conveyance capacity of the rivers by restoring meander belts and enlarging the floodplain area.

NON-NATIVE SPECIES. As discussed elsewhere in this strategic plan, the introduction and spread of non-native species into the Bay-Delta system has affected native species by competing with them for food and habitat, preying on native species, and interfering with restoration efforts. For example, the non-native mitten crab can clog fish screens, reducing their effectiveness or completely blocking flows. In spite of efforts to address this problem, it is likely that new species will continue to be introduced into the ecosystem and that non-native species introduced in the past will continue to expand their range.

GLOBAL CLIMATE CHANGE AND SEA-LEVEL RISE. In spite of expectations of more extreme weather patterns, sea-level rise, and the potential for these changes to affect the structure and functioning of the ecosystem, the rate and nature of global climate change are still too poorly understood to be explicitly considered in this document, but as such information improves, it should accounted for in decision making under the adaptive management framework.

IMPORTANT LEGISLATIVE ACTIONS AFFECTING ENVIRONMENTAL TRENDS

Although the pressures created by increasing population and urbanization, by changes in agricultural cropping patterns, and the introduction and spread of non-native species will most likely continue to exert negative forces on the environment and on ecological processes in the

Bay-Delta system, several recent and important legislative actions have been initiated that will serve to moderate potential effects of these adverse trends.

CENTRAL VALLEY PROJECT IMPROVEMENT ACT. The Central Valley Project Improvement Act (CVPIA) is a federal law passed in 1992 that adds the maintenance of fish and wildlife to the list of objectives of the Central Valley Project (CVP). CVPIA provides resource managers with a large number of tools to aid in the recovery of fish and wildlife species, including the dedication of water to instream flows and Delta outflow, the creation of a fund to pay for further water purchases for habitat restoration, the allocation of CVP water supply to improve the reliability of deliveries to wildlife refuges, the retirement of agricultural lands to improve water quality, and the creation of a program to provide incentives for farmers to maintain habitat values on their lands. Among the goals of CVPIA is to double the population of naturally reproducing target fish species. Although it is not yet clear whether the tools provided by CVPIA will lead to the achievement of this goal or how the various provisions of it will ultimately be implemented, it is very likely that implementation will lead to improvement in habitat conditions for many fish and wildlife species.

1995 WATER QUALITY CONTROL PLAN. In 1995, the SWRCB adopted a water quality control plan for the Bay-Delta that includes rules governing Delta exports and Delta outflows. This plan intended to maintain salinity in the Delta at levels needed to maintain the health of the ecosystem. Since 1995, it has been the responsibility of CVP and the State Water Project (SWP) to comply with these rules, but SWRCB is now holding hearings to decide how the responsibility for compliance should be allocated among all water users in the Bay-Delta system. The results of these hearings will most likely lead to increases in instream flows in most, if not all, of the tributaries to the Delta. This change would improve conditions for fish and other aquatic species in those tributaries.

SACRAMENTO AND SAN JOAQUIN RIVER BASINS COMPREHENSIVE STUDY. The Comprehensive Study is being conducted by the U.S. Army Corps of Engineers and the California Reclamation Board with support from Department of Water Resources' staff and in cooperation with numerous other agencies and organizations. The study will cover a four-year period with Phase I being completed by April 1999. The study will initially identify problems, opportunities, planning objectives, constraints and measures to address flooding and ecosystem problems in the study area. It will ultimately develop a strategy for flood damage reduction and integrated ecosystem restoration along with identification of projects for early implementation. Solutions will include consideration of both structural and non-structural measures. The study objectives are expected to lead to innovative solutions to flooding and environmental problems in the Central Valley.

The Comprehensive Study reflects evolving policy at both state and federal agencies regarding the environment. Agencies that historically focused exclusively on improving flood protection are now incorporating the maintenance or enhancement of environmental values into their missions. This change in approach will most likely lead to more environmentally friendly solutions to water supply and flood control problems.

CLEANUP OF THE SOURCES OF TOXIC POLLUTANTS. The role of toxic pollutants in the decline of ecosystem functions in the Bay-Delta system is not yet well understood, but it is clear that these pollutants do contribute to morbidity and mortality in some aquatic species. Several efforts are currently underway under the EPA's Superfund program to clean up major sources of these pollutants. Although the solution to problems such as the Iron Mountain Mine will not easily be achieved, if successful, they could contribute considerably to restoring the health of the Bay-Delta system.

LAND USE PATTERNS AND TRENDS

The Bay-Delta system is undergoing major changes in land use and intensification (San Francisco Estuary Project 1992b). The San Francisco Bay itself and the central Delta are under the jurisdiction of the San Francisco Bay Conservation and Development Commission (BCDC) and the Delta Protection Commission, respectively. Land use in the periphery of the Delta and in the lower watersheds are the prerogative of local governments, with the federal government (U.S. Forest Service, U.S. Bureau of Land Management, National Park Service) managing a larger proportion of the upper watersheds.

Urbanization of the periphery and immediate watersheds of San Francisco Bay are relatively stable, but other areas are undergoing rapid change, especially the watershed of Suisun Marsh, eastern Contra Costa County and the western Delta (residential subdivisions, "New Towns"); the south-Delta/lower San Joaquin River historical floodplain ("New Town" proposals); the east-Delta periphery (low-density residential, "New Towns," and very-low-density residential). Fairfield, Oakley, Brentwood, Tracy, Lathrop, Stockton, Lodi, Elk Grove, Sacramento, Winters, and other cities within the periphery of the Delta are experiencing strong growth pressures. Rural areas above the Delta and below dams are expanding, with both residential subdivisions (e.g., three to five dwelling units/acre), and very low-density residential development (e.g., five to 20 acres/dwelling unit). Land use is also changing in the lower-watershed/intertidal zone where sea-level rise and flooding are an issue.

Urbanization and concomitant increased motor vehicle use are a major contributor of contaminants (especially heavy metals). Residential development, even at very low densities, raises important land use considerations, including habitat fragmentation, loss of the use of fire as a vegetation management tool, and increased demand for flood protection.

Although CALFED's focus is on state and federal activities in ecosystem restoration, the program must be cognizant of land use issues that may help or hinder these activities and work with those responsible to encourage and support land use patterns that are compatible with ecosystem protection and restoration. Collaborative work in flood management, waterfront development, stream-corridor management, park and recreation design, and watershed management and planning will be especially important.

♦ Appendix B. Further Examples of Conceptual Models

Landscape Level Model

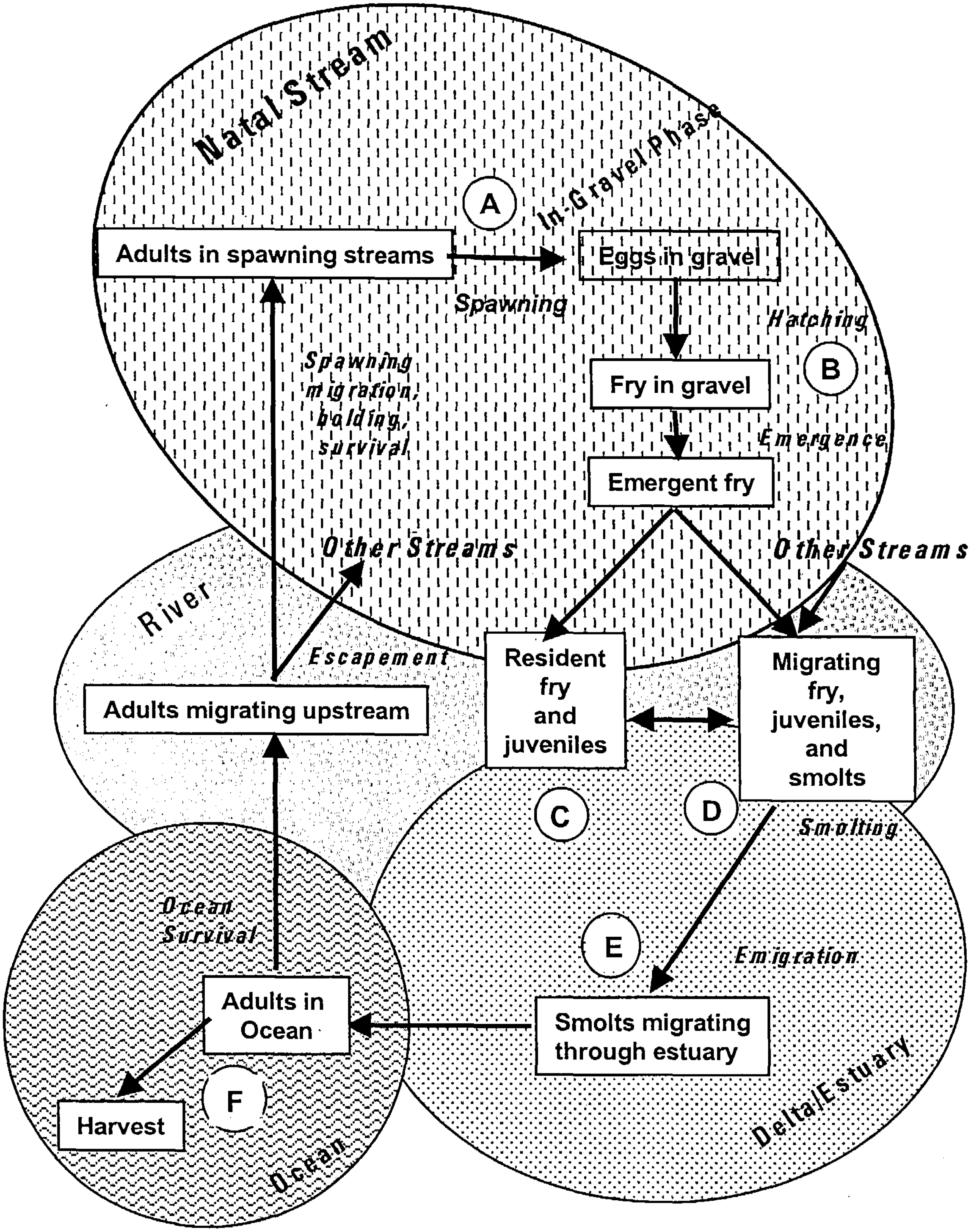
Figure B-1 illustrates a landscape level conceptual model. This model applies to chinook salmon, but its principles also could be applied to striped bass, other anadromous fish, and several species that spawn in the coastal ocean and rear in the estuary. These species link the system across boundaries by migrating between the rivers and the estuary or between the estuary and the ocean. Through their migrations, they expose themselves to variable human and environmental forces well outside the boundaries of the Bay-Delta ecosystem. The principal landscape level issue for managing these populations is the relative importance of events in each region in affecting their abundance. For example, chinook salmon experience rigorous conditions in their spawning and freshwater nursery regions, during migration through the Delta, and in the ocean. If the Delta causes a substantial fraction of their mortality, the opportunity exists for restoration that will be effective in reducing mortality and increasing salmon production. On the other hand, if mortality in the Delta is small, restoration of conditions there may have little effect on salmon production. Similar issues exist for the other species although the lack of direct human influence on oceanic conditions (except harvest) limit the opportunities for restoration in that region. A detailed example of ecosystem restoration for chinook that makes use of this model is discussed in Appendix C.

Conceptual Model of Entrainment

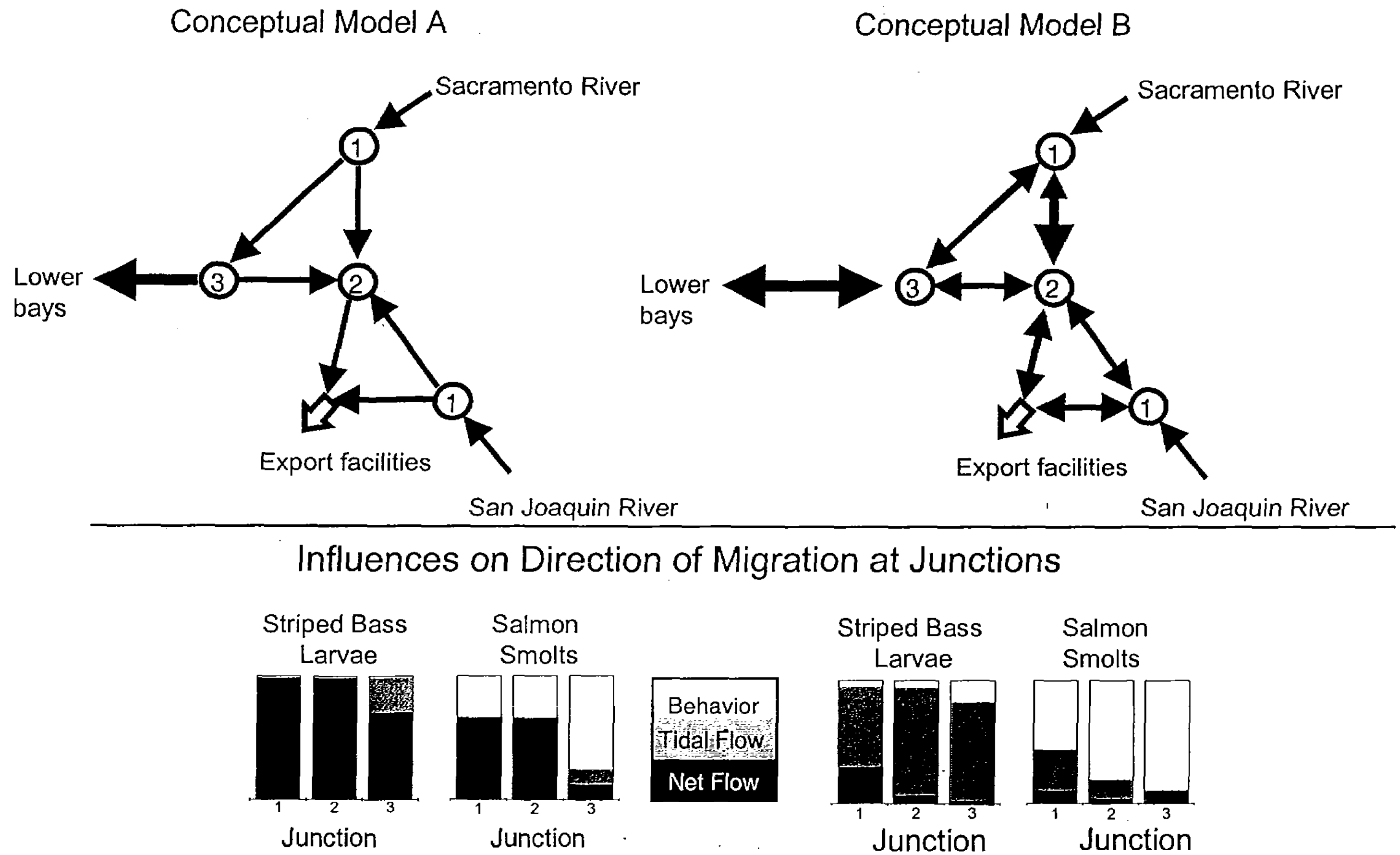
We present two alternative conceptual models of how anadromous fish can be entrained in the state and federal water projects under low-flow conditions (Figure B-2). The upper part of the figure shows schematic maps of the Delta with the key nodes identified at which water and anadromous species diverge into separate pathways. Conceptual model A is the "old" model, in which the emphasis is on net flow. Water moves downstream in the rivers and either toward the ocean or toward the pumps in the Delta, including a landward net flow in the lower San Joaquin River ("QWEST").

Conceptual model B is based on more recent developments in understanding of hydrodynamics of the Delta and on the realization that fish are not passive particles but are capable of quite complex behavior. Flow in the rivers is downstream, but as we move into the Delta, the flow becomes increasingly dominated by tides. The further west in the Delta we go, the more important the tides are and the less important is riverflow in terms of instantaneous velocity. For example, at Chipps Island under low-flow conditions, net flow is only 1-2% of tidal flow. The bottom panel in Figure B-2 illustrates how the selection of models determines the factors influencing the proportions of fish that take one course or another at each of the numbered nodes in the upper panel. Starting from the left-most bar chart, according to conceptual model A, striped bass larvae are largely subject to net flow, with tides affecting them to some degree at the confluence of the rivers (node 3). Salmon smolts, by contrast, are affected more by their own behavior. Still, the major influence is net (river) flow. Under conceptual model B, by contrast, striped bass larvae are affected mainly by tidal flows and to a lesser extent by net flows. Furthermore, the influence of net flows is nearly gone by the time the larvae reach node 3 (i.e., the low-salinity zone, which under low-flow conditions in late spring is at about the confluence). Behavior of the larvae plays an important role in this model, particularly when they reach brackish water and begin to migrate vertically.

In model B, the fate of salmon smolts is governed primarily by whether they migrate along the shore or distributed across the river. If they migrate



Note: The four oval areas represent the four major geographic regions. Arrows indicate a change of state of surviving salmon, with only ocean harvest mortality displayed explicitly. Terms in italics indicate the major transformations occurring in each phase.



Note: Arrows and circles comprise a schematic of the Delta, with the circles representing key nodes where flow and fish diverge. Single arrows indicate river inputs, and double arrows indicate flows that are partly or mostly tidal, with the sizes of the arrowheads reflecting relative flow velocities for each location. Conceptual model A depicts net flows, with arrows indicating how fish would move under the influence of these flows. Conceptual model B illustrates how water moves in response to both tides and net flow. Fish move under the influence of these flows and their own behavior. Bar charts in the bottom panel illustrate how these conceptual models differ in their prediction of the relative influence of fish behavior, tidal flow, and net flow on the proportion of fish taking alternative pathways at each of the nodes.

Figure B-2: Alternative Conceptual Models of Flow and Fish Movement in the Delta under Low-Flow, High-Export Conditions along the shore, they are more vulnerable to diversions such as at the Delta Cross-Channel than if they are distributed across the channel. In addition, we assume that, like other organisms living in tidal environments, salmon smolts are exquisitely sensitive to the tidal movements and phasing and are capable of moving downstream rapidly using the tidal currents. At the more landward modes, therefore, tidal flow rather than net flow has the most influence on smolt movement patterns.

These alternative models make radically different predictions about the effects of entrainment on salmon and the most effective measures to minimize these effects (Figure B-2). According to model A, losses can be minimized by reducing exports and maximizing flow. Moving the intake up into the Sacramento River would have a clear benefit. According to model B, on the other hand, export flows are not very important in killing salmon, and the most important issue is the strength of the environmental cues available to guide the salmon to sea. Note that this model is more consistent with recent statistical modeling results, which do not find that variation in salmon smolt survival is statistically related to export flows (Newman and Rice in prep.).

For young striped bass, model A again predicts that increasing flow and reducing exports would increase early survival. Model B, on the other hand, predicts a probability of entrainment that depends on the initial position of the fish and the strength of tidal and net flows, including export flows. The further seaward the larvae, the less likely it is to be entrained. Moving the salt field seaward (i.e., moving X2 seaward) reduces the exposure of the fish to entrainment and is therefore more effective than curtailing exports. Note the sharp contrast in the two models' predictions of the effects of moving the intake site.

For delta smelt, the picture is less clear. Under model A, minimizing exports is very important, and moving the intake facility would be very helpful for the species. Minimizing the ration of exports to inflows is believed to reduce the proportion of the smelt population that is entrained. Under model B, X2 determines the position of the bulk of the population and, therefore, the exposure to entrainment, while variation in export flow has little effect unless X2 is far upstream. Thus, moving the intake facility would have little effect except under very low-flow conditions.

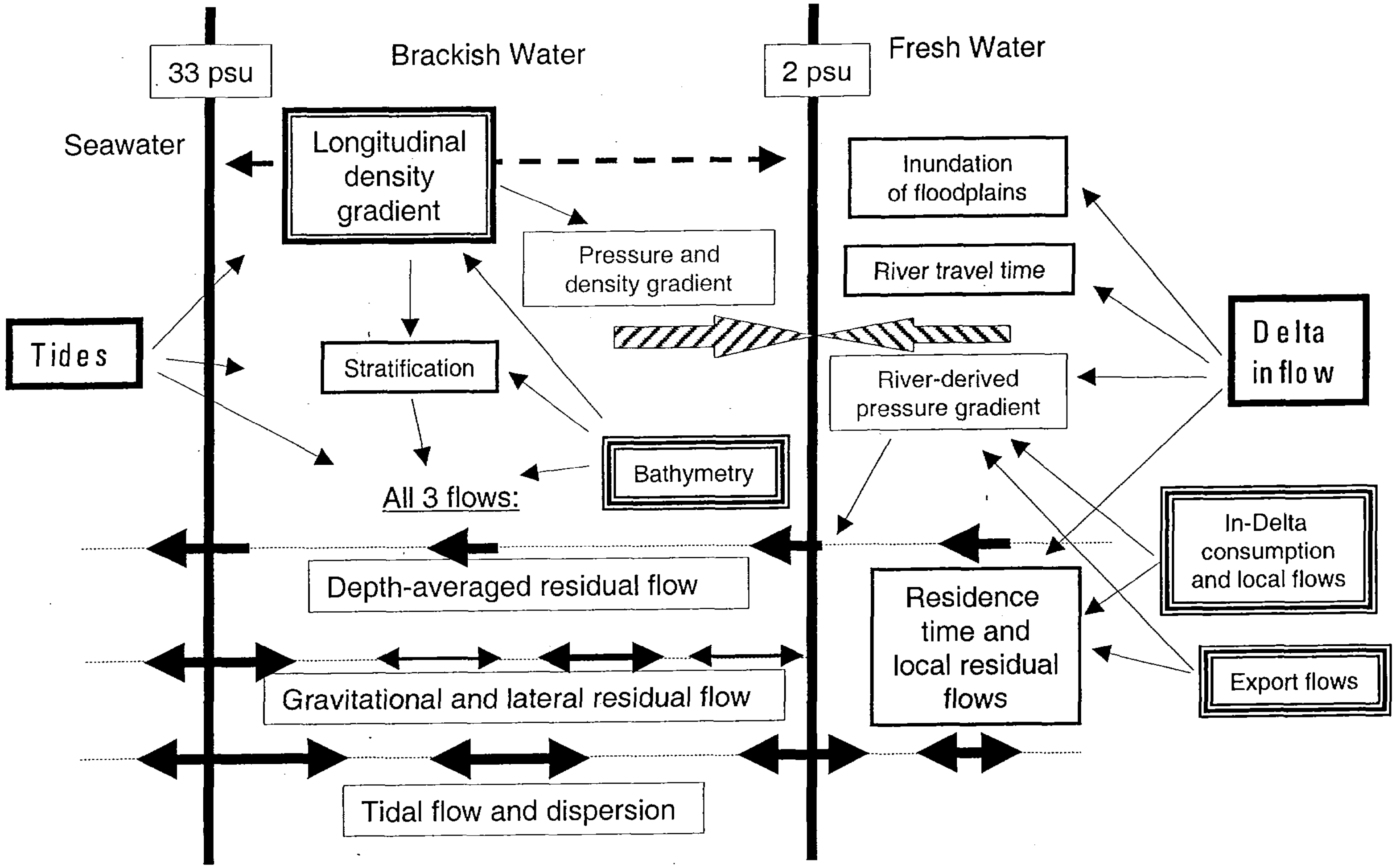
These models, along with the findings of the Diversion Effects on Fish Team (1998), suggest that we have a great deal to learn about entrainment effects before a decision can be made on the construction of large-scale water transfer facilities.

Model of Contrasting Mechanisms Underlying X2 Relationships

In this section, we contrast two mechanisms believed to be important for species that enter the estuary from the ocean as young or spawn in the lower bays and rear in the estuary. These models look in more detail at aspects of the Fish-X2 relationship described in the main body of the text. The two mechanisms are gravitational circulation and extent of physical habitat for rearing.

Recent developments in understanding of the physical characteristics of the estuary have altered our perception of how biota use their environment (e.g., Burau 1998 in Kimmerer 1998). Figure B-3 provides a conceptual model of estuarine circulation patterns designed to illustrate these concepts. For the purposes of this exercise, the main points are as follows. Flow in the brackish parts of the estuary can be considered to have three components as illustrated. First, there must be a cross-sectionally averaged residual (i.e., averaged over the tides) flow to seaward that is equal to the river flow. Second, vertical and lateral asymmetries in residual flow occur through the interaction between stratification, tides, and bathymetry. Third, the strongest flows in most of the estuary are reversing tidal flows, which induce strong longitudinal and lateral dispersion.

Freshwater flow introduces a pressure or level gradient that directs water seaward through the estuary. At the same time, tides drive the denser ocean water into the estuary through a combined pressure and density gradient. These opposing forces determine the length of the salinity gradient and therefore the density gradient. High



Notes: Freshwater inflow and tides are the major forcing functions. The principal role of freshwater input is in setting up a pressure (level) gradient along the axis of the estuary, which forces the depth-averaged residual flow throughout the estuary. Tides introduce a pressure gradient that varies in time, and the salinity gradient attributable to tidal mixing between fresh water and saltwater sets up a density gradient. This interacts with tidal mixing and bathymetry to produce various degrees of stratification and gravitational circulation.

psu = practical salinity units.

Figure B-3: Conceptual Model of Flow Effects with Emphasis on the Brackish Parts of the Estuary freshwater flow over a period of time compresses the longitudinal density gradient, enhancing stratification and possibly gravitational circulation. The opposing density gradient acts like a compressed spring, moving salt landward when freshwater flow (and the accompanying pressure gradient) declines.

Gravitational circulation (Figure B-4) can occur throughout the estuary if stratification occurs. This happens primarily in deep regions, such as beneath the Golden Gate Bridge, in the main channel through northern San Francisco and San Pablo Bays, and in Carquinez Strait. It is rare in the main channel of Suisun Bay (Burau 1998 in Kimmerer 1998). We assume (this theory has not been tested) that stratification is stronger when freshwater input is high because of the compression of the longitudinal density gradient (Figure B-3). Under low-flow conditions (Figure B-4, top), stratification is slight. Near-bottom currents are weaker than near-surface currents. Surface currents are stronger on the ebb than on the flood, whereas bottom currents are stronger on the flood than on the ebb. When freshwater flow is high, the density gradient is compressed and stratification is stronger, causing gravitational circulation to intensify. Under these conditions, the asymmetry in ebb-flood currents is greater, particularly near the bottom.

Certain species of bay organisms may use gravitational circulation to enter the estuary and to move landward. This is a common mode of transport for flatfish, crab, and shrimp larvae (e.g., Cronin and Forward 1979). Essentially, all they need to do is move down in the water column, and gravitational circulation will take them landward. Presumably, the stronger the gravitational flow the more rapid the movement and the larger the abundance of animals that will arrive at the rearing habitat. If correct, this model could explain the X2 relationships for bay shrimp, starry flounder, and possibly Pacific herring.

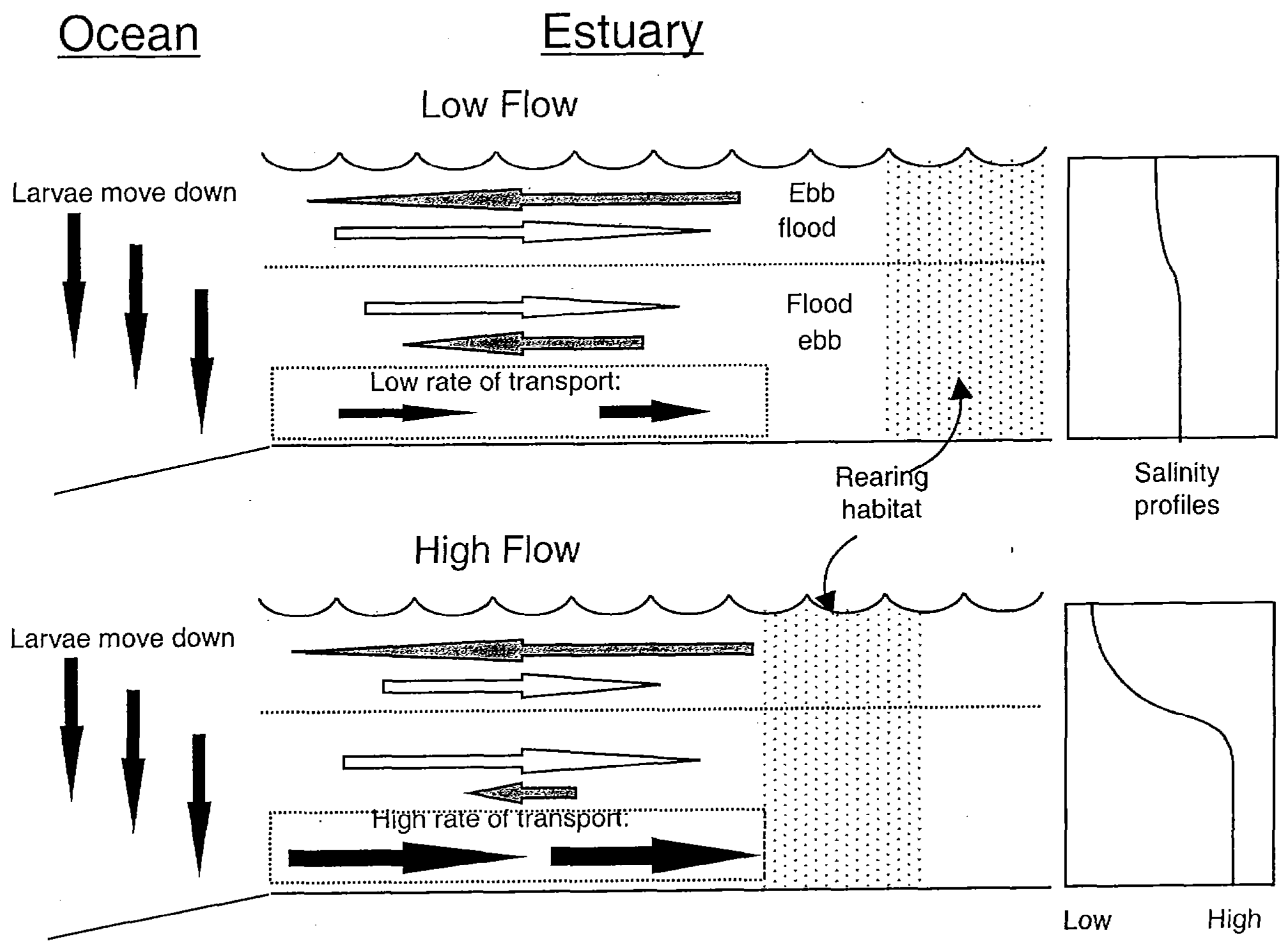
The alternative model holds that the physical extent of nursery habitat increases with increasing flow. This model is supported by a preliminary analysis of the area in the estuary encompassed by selected salinity values (Unger 1994). If habitat is limiting the development of some populations, and if it does indeed increase with flow, then this too could explain the observed relationships.

Actions to protect and enhance the abundance of these species that correlate with X2 (and the predatory species that depend on them) differ depending on which mechanism is most important. If the most important mechanism is gravitational circulation, little can be done to enhance these populations other than to increase freshwater flow (note that dredging channels also may accomplish this, but an additional result may be greater salt penetration). However, if limiting habitat is the key issue, then it may be possible to provide more, better, or more accessible habitat and achieve a suitable level of protection or enhancement with the same or less flow.

Conceptual Model of Meander Migration in a Regulated River

This conceptual model (Figure B-5) illustrates factors influencing meander migration, habitats created as a consequence of migration, and influence of management actions. River meanders migrate through a combination of eroding the outside (concave) bank and simultaneously depositing a point bar on the opposite (convex) bank. The highest velocity flows are concentrated on the outside of the bend, and a pool forms at the outside of the meander bend. Right and left bends alternate, with the highest current shifting from one side of the channel to the other at the "crossover" point between bends, where a gravel riffle forms (Figure B-6). As the meander bend migrates across the valley bottom, the channel dimensions remain essentially constant because erosion of the outside bend is compensated for by deposition on the point bar.

The process of meander migration is ecologically important because it creates and maintains channel and floodplain forms with a diversity of habitats (e.g., undercut banks, overhanging vegetation, scour pools, gravel riffles), delivers large woody debris to the channel, and maintains a diverse assemblage of riparian vegetation at different succession stages. As the outside bend erodes, late-stage successional riparian trees are typically eroded and fall into the channel, providing large



Note: Several species recruit from outside the estuary and must enter the bay to reach nursery areas; some other species reproduce in the bay but then move up the estuary for rearing. Tidal flows in the low-salinity and high-salinity layers are shown as arrows, with gray representing ebb and white representing flood. Black arrows indicate larval movement. Under low-flow conditions, stratification and gravitational circulation are weak; landward transport of larvae is slow. High flow compresses the longitudinal density gradient (Figure 5-3), increasing stratification and gravitational circulation and increasing the rate of larval transport. Note that this model has not been tested.

Figure B-4: Conceptual Model of the Mechanism for the X2 Effect Based on Gravitational Circulation

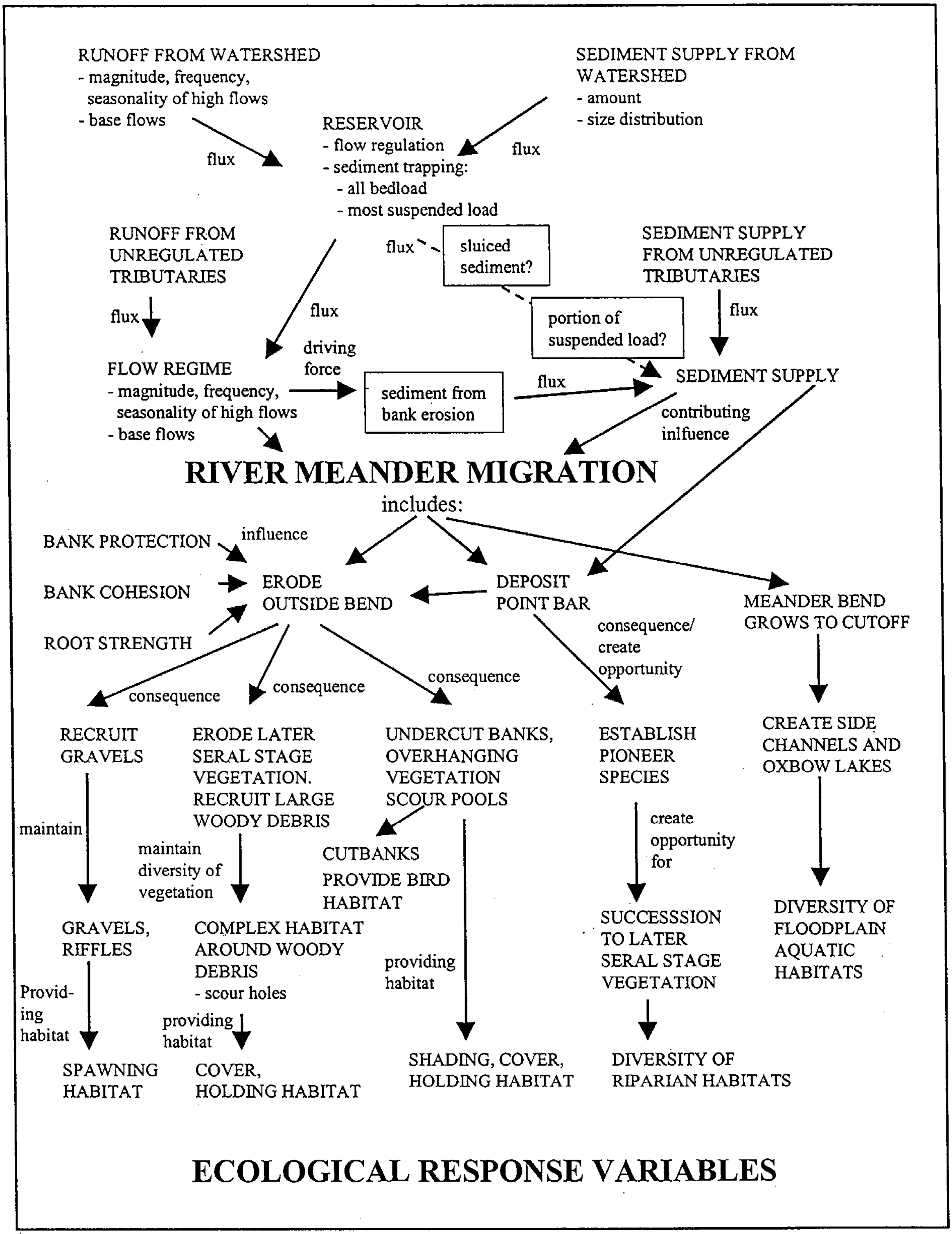
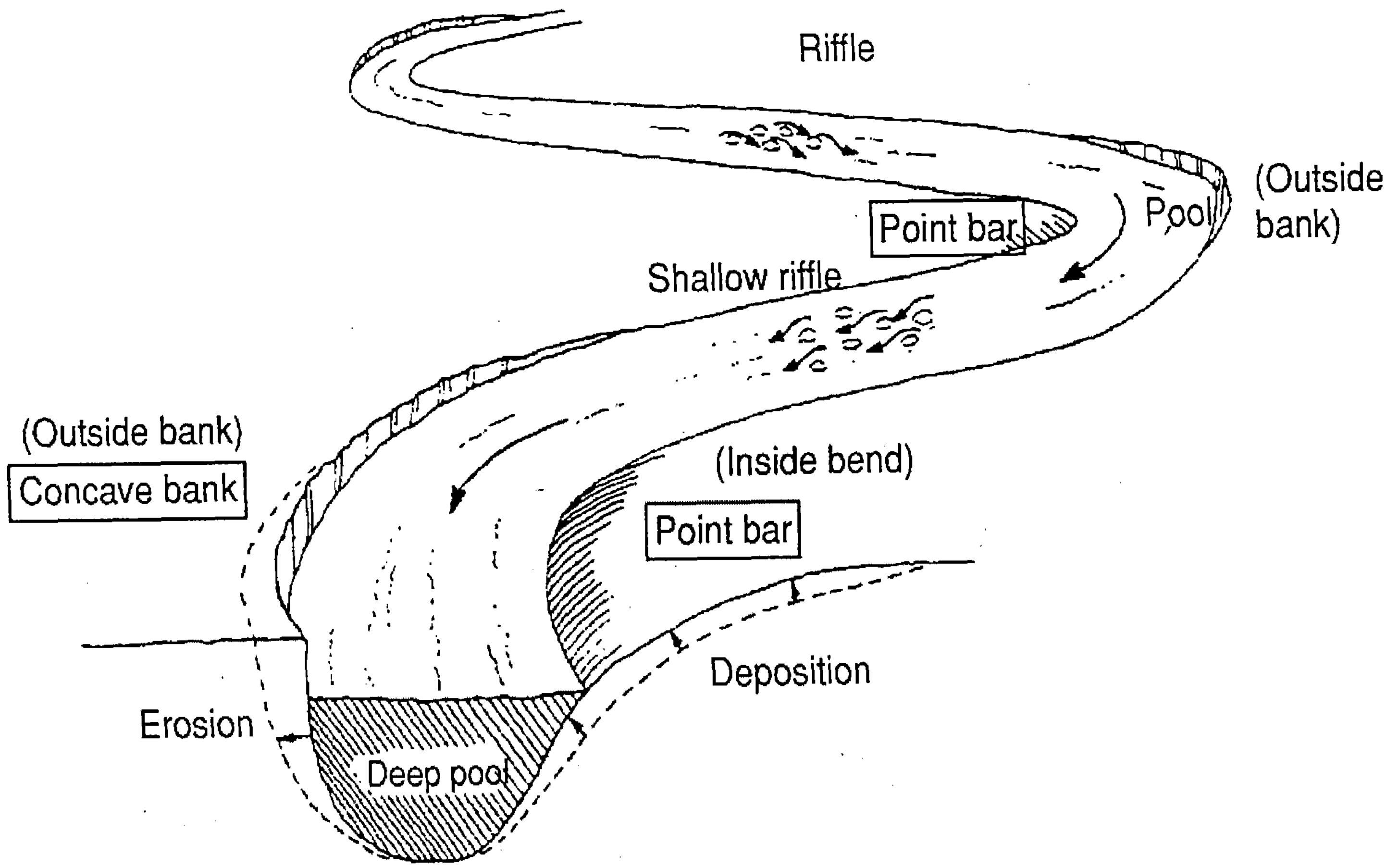


Figure B-5: River Meander Migration Model



Source: California State Lands Commission 1993.

Figure B-6: Diagram of Meander Bend, Showing Variety of Forms (and thus Habitats) Associated with Actively Migrating Meander Bend.

woody debris to the stream, which in turn increases channel complexity through providing cover and inducing scour. On the newly deposited point bar surface, pioneer riparian species establish and undergo gradual succession to species adapted to finer grained soils and less frequent inundation as the surface builds up through overbank sedimentation, which occurs as the channel migrates away from the site. The evolution from point bar to floodplain is accompanied by frequent inundation and a high connectivity with the channel.

Meander migration rate is driven largely by flow and is influenced by sediment supply. In an unregulated river, runoff and sediment load are derived from the watershed and upstream reaches. Below a reservoir, high flows are typically reduced, reducing the stream energy and slowing the rate of the erosion and deposition through which meander migration occurs. The system becomes less active overall although with distance downstream of the dam and increasing input from tributaries, the river typically becomes more dynamic because the effects of the dam are moderated by runoff from the drainage area downstream. Because the reservoir traps all gravel and sand from upstream, sediment supply is reduced, which can lead to channel enlargement as sediment-starved water erodes the bed and banks. Both of these effects are illustrated on the upper Missouri River below Harrison Dam. Rates of erosion and deposition were formerly high and roughly balanced, but after dam construction, the rates of erosion and deposition dropped sharply, and the erosion rates now greatly exceed deposition rates (Johnson 1992).

Management actions can influence meander processes and habitats in a variety of ways. In some cases, high flows can be released from dams to reactivate dynamic channel processes. However, if the high flows are not accompanied by an augmented supply of sand and gravel, the result may be further degrading of the channel and a paucity of gravel deposits. A recognition of the ecological importance of riparian zones (Gregory et al. 1991) and the role of dynamic channel-floodplain interactions (notably meander migration) suggests that restoration of salmon habitat should be undertaken, wherever possible, by restoring the dynamic river processes that create and maintain the desirable habitats.

♦ Appendix C. An Example of Adaptive Management Using Conceptual Models: Chinook Salmon and Deer Creek

Overview

This appendix provides an example of how Ecosystem Restoration Program (ERP) actions should be formulated and selected. The example given is for spring- and fall-run chinook salmon in the Deer Creek ecosystem (Figure C-1). Chinook salmon are a useful focus for this example because they are a valuable fish species, are sensitive to environmental conditions throughout the system, and integrate across the entire landscape of the Bay-Delta system. Spring-run salmon are of particular interest because their populations are a tiny fraction of their historical numbers and they have been proposed for listing as a threatened species. Fall-run chinook also have been proposed for listing, but their overall abundance is much higher than that of spring-run. The Deer Creek ecosystem is of interest because it is a relatively undisturbed stream, one of the last drainages in the Bay-Delta system to support spring-run chinook salmon, and because several specific restoration measures have been proposed for Deer Creek in recent years. In this appendix, we show how simple conceptual models can be used to evaluate various possibilities for rehabilitating salmon populations and habitat and how these might fit into the larger context of spring-run chinook life history and factors limiting its population.

Background

Species-Based vs. Ecosystem-Based Restoration

This example also illustrates the different assumptions underlying species-based and ecosystem-based restoration. Species-based restoration attempts to identify and remove limiting factors and bottlenecks to production. It requires specific knowledge about the species' life history and ecology that may be difficult to obtain and provides little progress toward ancillary objectives. On the other hand, it is easier to understand and justify and can capitalize on specific opportunities (e.g., harvest limits). Species-based approaches may be especially important for fishes such as chinook salmon that move between major ecosystems because removing limiting factors in one area may be offset by increased mortality in another area. Finally, state and federal endangered species legislation is essentially species based, although efforts are growing to apply them using ecosystem-based approaches.

Ecosystem-based restoration uses knowledge of the ecological context in which individual species thrive and attempts to restore that ecological context (structure and function) under the assumption that a species' well-being will emerge from a well-functioning ecosystem. It requires less knowledge about the species but incorporates the often-untested assumption that restoring the ecosystem will benefit the species. It can be used to achieve multiple objectives but also can be difficult to justify as a method for restoring individual species. As illustrated in this appendix, a comprehensive approach to ecosystem restoration, emphasizing an understanding and then restoration of physical and ecological processes affecting habitat, is likely to be more sustainable in the long term than attempts to create habitat features.

Deer Creek Chinook Salmon Life Histories

The life histories of spring- and fall-run chinook salmon are the same except for the seasonal timing of migration and spawning, the typical locations with the river system, and the length of time spent rearing in fresh water.

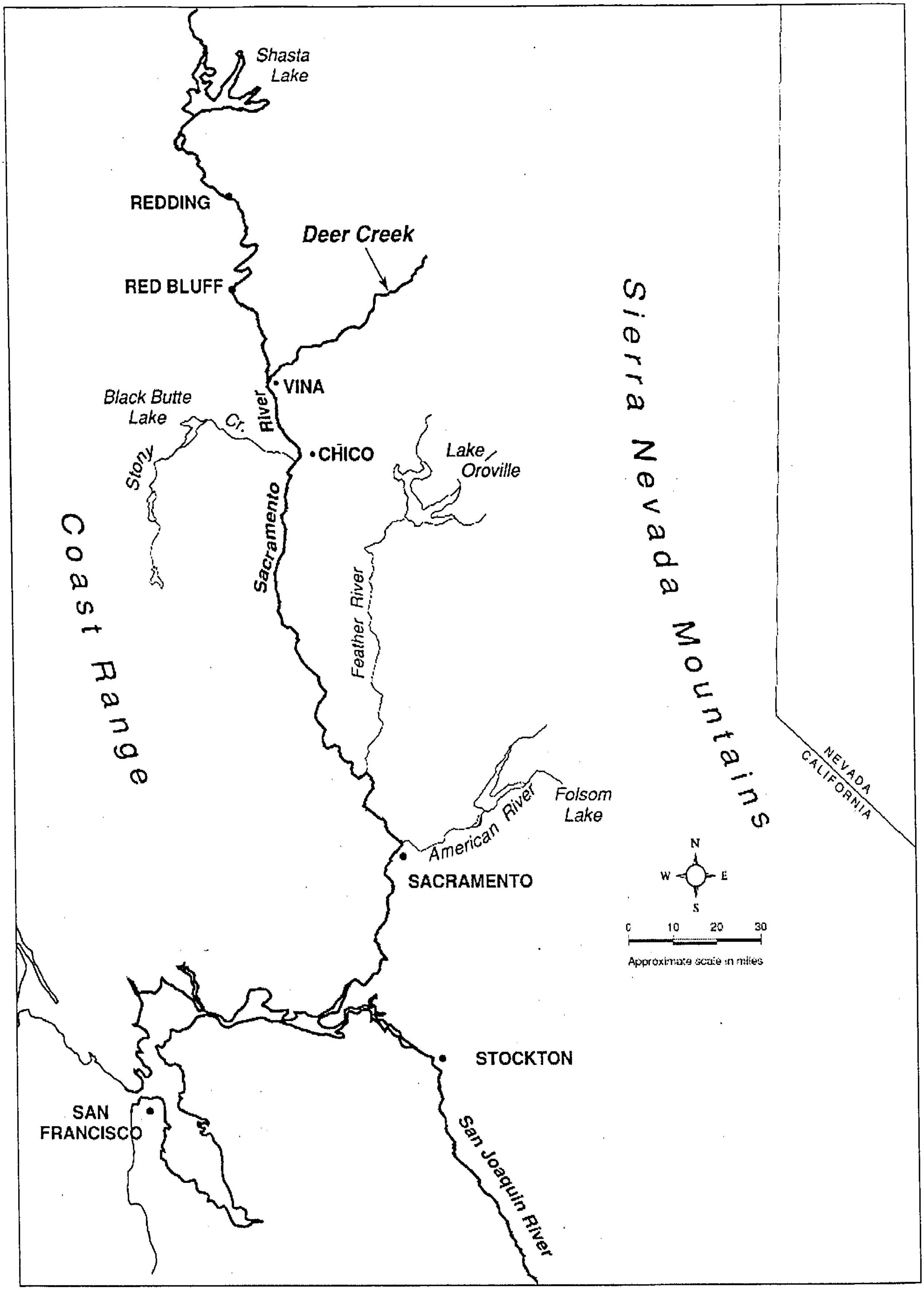


Figure C-1: Deer Creek Location Map

Spring-run chinook enter the rivers from the ocean from March through May. While migrating and holding in the river, spring-run chinook do not feed, relying instead on stored body fat reserves. They are fairly faithful to the home streams in which they were spawned, using chemical cues to locate these streams; however, some ascend other streams, especially during high-water years; in dry years, they may be blocked from their streams and forced to remain in main rivers.

Adult spring-run chinook migrate up Deer Creek from April through June (Vogel 1987a, 1987b), aggregate in the middle reaches (Airola and Marcotte 1985), and spawn from late August to mid-October. In Deer Creek, most hold and spawn between the Ponderosa Way bridge and upper Deer Creek falls, which is a natural barrier to migrating fish (Marcotte 1984). When they enter fresh water, spring-run chinook are immature; their gonads mature during the summer holding period (Marcotte 1984). Eggs are laid in large depressions (redds) hollowed out in gravel beds. The embryos hatch following a 5- to 6-month incubation period and the alevins (yolk-sac fry) remain in the gravel for another 2-3 weeks. After their yolk sac is absorbed, the juveniles emerge and begin feeding.

Historically, spring-run adults were a mixture of age classes ranging from 2 to 5 years old. Possibly because of fishing in the ocean, most of the fish now are probably 3 years old. During the summer holding period in freshwater pools, many large adult salmon may be caught by anglers (who snag them accidentally with spinning lures), and some by poachers. The importance of this source of mortality is indicated by the distribution of the fish; they are most abundant in the more remote canyon areas and scarce in pools close to roads.

Fall-run chinook salmon ascend Deer Creek from October through November (when they are sexually mature) and spawn immediately (October to early December), using gravels in lower elevation reaches, primarily in lower Deer Creek. Fall-run chinook spend less time in fresh water as adults and as juveniles, leaving their natal stream soon after emergence.

During most years, juvenile spring-run salmon in Deer Creek spend 9-10 months in the streams, where they feed on drift insects. The timing of emigration from Deer Creek has not yet been clearly determined, but it seems to be much more variable than for fall-run chinook. Some juveniles may move downstream soon after hatching in March and April, others may hold in the streams until fall, and still others may wait for more than a year and move downstream the following fall as yearlings (Harvey pers. comm.). The outmigrants may spend time in the Sacramento River or estuary to gain additional size before going out to sea, but most have presumably left the system by mid-May. Once in the ocean, salmon are largely piscivorous and grow rapidly. During downstream migrations in the Sacramento River and Delta, the smolts presumably stay close to the banks during the day (near cover) and then move out into open water at night, to migrate. Historically, they may have moved into flooded marshy areas in the Delta to feed, but there is little evidence of such activity today.

STATUS OF CHINOOK SALMON POPULATIONS

Spring-run chinook salmon are in a state of decline and are listed by the State as threatened species and are federally proposed for listing as endangered (see ERPP Volume I, Species and Species Groups Visions); therefore, actions likely to protect and enhance this stock should receive high priority. At the same time, actions to protect and improve habitat should help not only spring-run chinook, but also other fish, such as fall-run chinook, steelhead, Pacific lamprey eel, and a complete assemblage of native foothill fishes and native amphibians. Similarly, actions to benefit spring-run chinook habitat probably would achieve other objectives at the ecosystem level. The principal assumption is that restoration of habitat will be effective in improving conditions for this stock.

Spring-run chinook salmon of the Sacramento-San Joaquin River system historically comprised one of the largest set of runs on the Pacific coast. Campbell and Moyle (1991) reported that more than 20 "historically large populations" of spring-run chinook have been extirpated or reduced nearly to zero since 1940. The three largest remaining runs (Butte, Deer, and Mill Creeks) have exhibited statistically significant declines during the same period. The only substantial, essentially wild populations of spring-run chinook remaining in California are in Deer and Butte Creeks in the Sacramento River drainage and in the Salmon River in the Klamath-Trinity River drainage (Campbell and Moyle 1991).

In Deer Creek, spring-run chinook abundance has been low since the early 1980s (Figure C-2). The Mill and Big Chico Creek populations have suffered similar declines, but the Butte Creek population has not, for reasons that are uncertain.

Fall-run chinook populations have also declined, but not so precipitously. In large part, this decline has been less severe because, unlike for the spring-run chinook, access to the fall-run chinook's (lower elevation) spawning grounds has not been cut off.

Habitat Restoration Proposed for Deer Creek

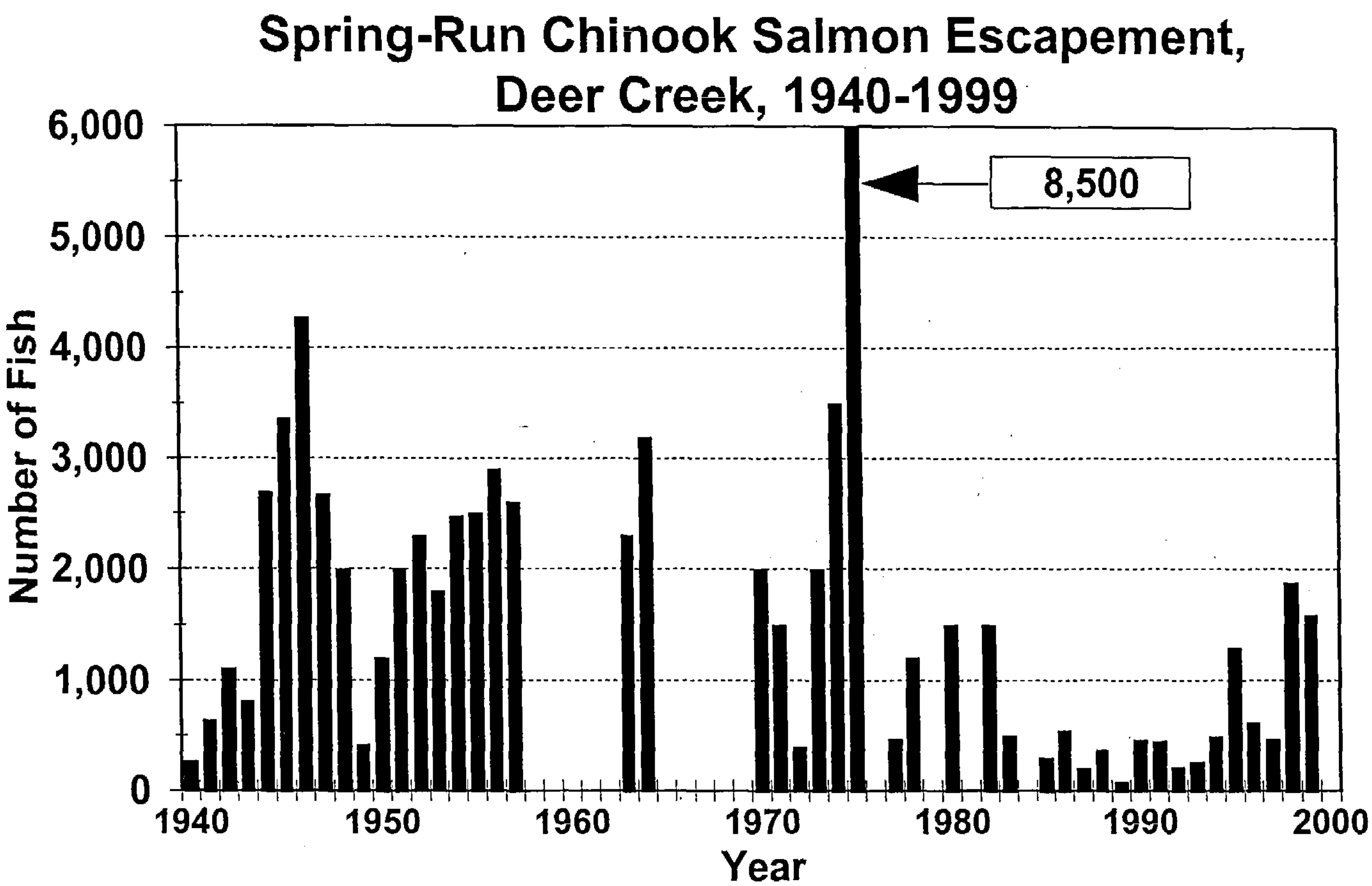
With declining salmon returns throughout the Bay-Delta system and the extinction of spring-run chinook in most of the rivers they formerly inhabited, Deer Creek and the other remaining spring-run chinook streams have attracted attention, and various proposals have been put forth to enhance salmon habitat and passage. These proposals have included measures such as minimum flow requirements in reaches formerly de-watered below irrigation diversions. Although there may be argument about the amounts of water needed, minimum flows in the reach are clearly required.

Other proposed measures have addressed the apparent armoring of the bed of Deer Creek, through mechanical ripping of the gravelbed, artificial addition of smaller gravel, and installation of log structures to hold the imported gravel in place (California Department of Fish and Game 1993, U.S. Fish and Wildlife Service 1995, CALFED Bay-Delta Program 1997). The relative lack of riparian vegetation on the banks along most of lower Deer Creek was addressed by the proposed planting of riparian trees. Although measures such as adding smaller gravel to the channel may provide short-term benefit, the shear stresses in the channel are so high that the gravels would be likely to wash downstream during the next flood. Similarly, in-channel structures and even riparian bank plantings may be washed out during high flows under present channel conditions.

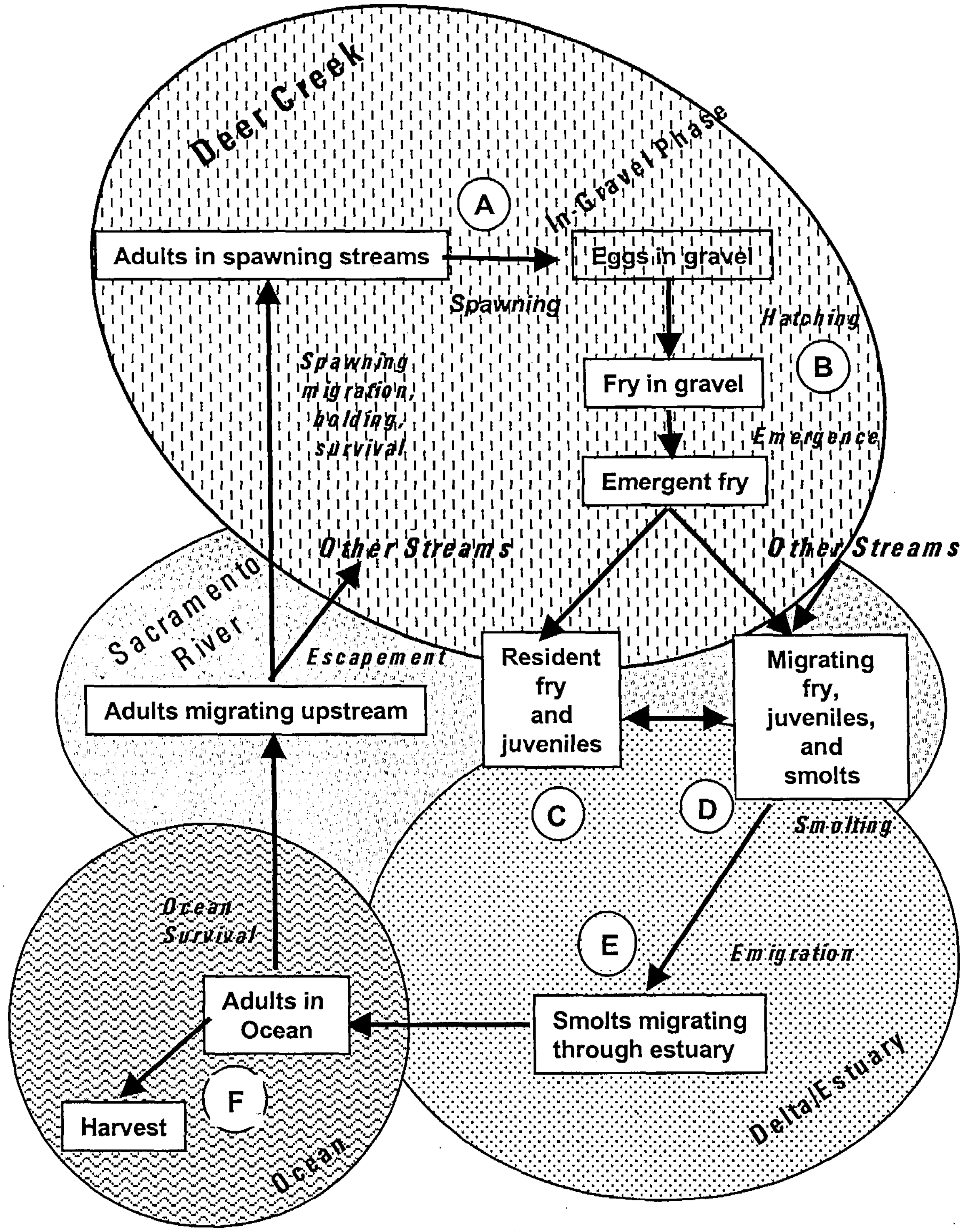
Overall Conceptual Model for Spring-Run Chinook Salmon

Figure C-3 shows a schematic diagram of the life cycle of spring-run chinook salmon in Deer Creek. Beginning with the ocean phase, surviving adults migrate upstream to hold through the summer and then spawn. Spawning, hatching, and initial rearing take place within Deer Creek. Rearing juveniles may remain in Deer Creek or begin moving downstream, some moving as far as the Delta. The distribution of spring-run juveniles that survive is not known. Spring-run salmon may smolt and migrate to sea in their first winter-spring, or the following winter as yearlings.

Efforts to restore habitat for spring-run chinook salmon within Deer Creek must be considered in the context of the species' life cycle. Restoration of habitat for one life stage may have little effect if other life stages are limiting. Furthermore, different stages in the life cycle could be limiting at different times, and releasing a limit at one part of the life cycle could result in another part of the life cycle becoming the limiting point. Circled letters on Figure C-3 show points in the life cycle at which interventions might be possible to restore habitat and conditions: (A) survival during migration to and holding near spawning areas, which may be affected by flow conditions or mortality including fishing; (B) spawning habitat, which may be affected by area of gravel of suitable quality in suitable hydraulic conditions, flow and variability in flow, and temperature; (C) rearing habitat including Deer Creek, the Sacramento River, and the Delta, which may be affected by flow, connection to floodplains, riparian vegetation, diversions, and temperature; (D) survival during migration down the river, which may be affected by flow, temperature, hatchery releases, predators, and diversions; (E) passage through the Delta, which may be affected by flow in the river, net flow across the Delta, temperature, contaminants, agricultural diversions, and possibly export flow; and (F) ocean survival, which is affected by ocean conditions and the percentage of salmon harvested.



Note: Data from Candidate Species Status Report 98-01 to the Fish and Game Commission.



Note: The four oval areas represent the four major geographic regions. Arrows indicate a change of state of surviving salmon, with only ocean harvest mortality displayed explicitly. Terms in italics indicate the major transformations occurring in each phase.

Density-dependent and density-independent factors affect salmon populations differently. Of the factors limiting the abundance of salmon, saturation of spawning habitat by high densities of redds, or possibly saturation of favorable rearing habitat by large numbers of juveniles, may result in density-dependent effects. In the case of spawners, this happens because females spawn in fairly restricted areas of high-quality habitat, and the resulting crowding, which can occur even at fairly low numbers of spawners, results in lower survival of the early-spawned eggs (superimposition). If this happens, providing more habitat or improving habitat quality should increase population size by increasing carrying capacity, thereby lifting the limit; however, if the population is too low for significant density-dependent mortality to occur, density-independent factors, mainly downstream, will predominate. In that case, habitat restoration upstream will have little if any effect on population size.

The current low abundance of spring-run salmon suggests that the population may not be greatly influenced by density-dependent effects, but until specific studies are made of this issue it cannot be resolved. In the meantime, ecosystem restoration can also be justified, along with actions designed to reduce density-independent mortality in other parts of the life cycle, because of other objectives (e.g., goal 2, ecological process objectives for high flows and floodplain inundation; goal 4, habitat objectives for tidal marsh and riparian wetlands).

A conceptual model of fall-run chinook salmon would be similar to that of spring-run except that the length of residence of juveniles and adults in the stream and use of the Delta for rearing by juveniles would be much less and the seasonal timing of migration would differ.

GEOMORPHIC AND HYDROLOGIC SETTING

Deer Creek drains 208 square miles of volcanic rocks on the west slope of Mount Lassen. It flows through canyons cut into volcanic strata before debouching onto the Sacramento Valley floor, flowing across its alluvial fan, and joining the Sacramento River near Vina (Figure C-1). For its first 2 miles, lower Deer Creek (the alluvial reach on the Sacramento Valley floor) migrates across an active channel 1,000-2,000 feet wide, bounded by bluffs (typically 5 meters [m] high) of older, cemented river gravels (Helley and Harwood 1985). Downstream of the bluffs, the multiple channels characteristic of alluvial fans can be clearly seen in the contour lines (Figure C-4). These contour lines reflect the process by which alluvial fans build up: A channel (or more than one channel) is active at a given time, carrying sediment from the watershed, and (because of the flattening of the gradient on the valley floor) aggrades (builds up with sediment) until the creek abandons that channel in favor of another channel, which now offers a higher gradient, until it too aggrades and the channel shifts again. Thus, over centuries or millennia, the locus of deposition shifts around the entire alluvial fan such that a low-gradient cone of sediment is created.

Strong, cold base flows are maintained in Deer Creek by springs in the volcanic rocks. The average flow at the U.S. Geological Survey gauge (located at the transition from the bedrock canyon to the valley floor) is 317 cfs (Mullen et al. 1991). Despite the base flows from the watershed, parts of Lower Deer Creek have been dry during the summer and fall of many years because of irrigation diversions. Dewatering of the stream no longer occurs thanks to voluntary releases by the irrigation districts, but the dewatered reach has been a barrier to migration until recently, and adequate flow to maintain cool temperatures remains an issue.

There is a high snowmelt flow virtually every year (forty percent of the Deer Creek watershed lies above 4,000 feet), but most big floods result from warm winter rains, and the biggest floods derive from warm rain on snow events. Deer Creek experienced such a rain-on-snow flood of 20,800 cfs in January 1997, which damaged farmland, and nearly washed out the under-sized Leininger Road bridge. The 1997 flood was only the third largest flood in the period of continuous record for the stream gauge, 1921-present, and is thus considered a 25-year flood (following standard formulae for flood frequency analysis) (Dunne and Leopold 1978). Other important floods occurred in December 1937 (23,800 cfs), 1940 (21,600 cfs), December 1964 (20,100 cfs), and 1970 (18,800 cfs) (published records and preliminary estimates of the U.S. Geological Survey). It is during such large floods that Deer Creek would historically shift

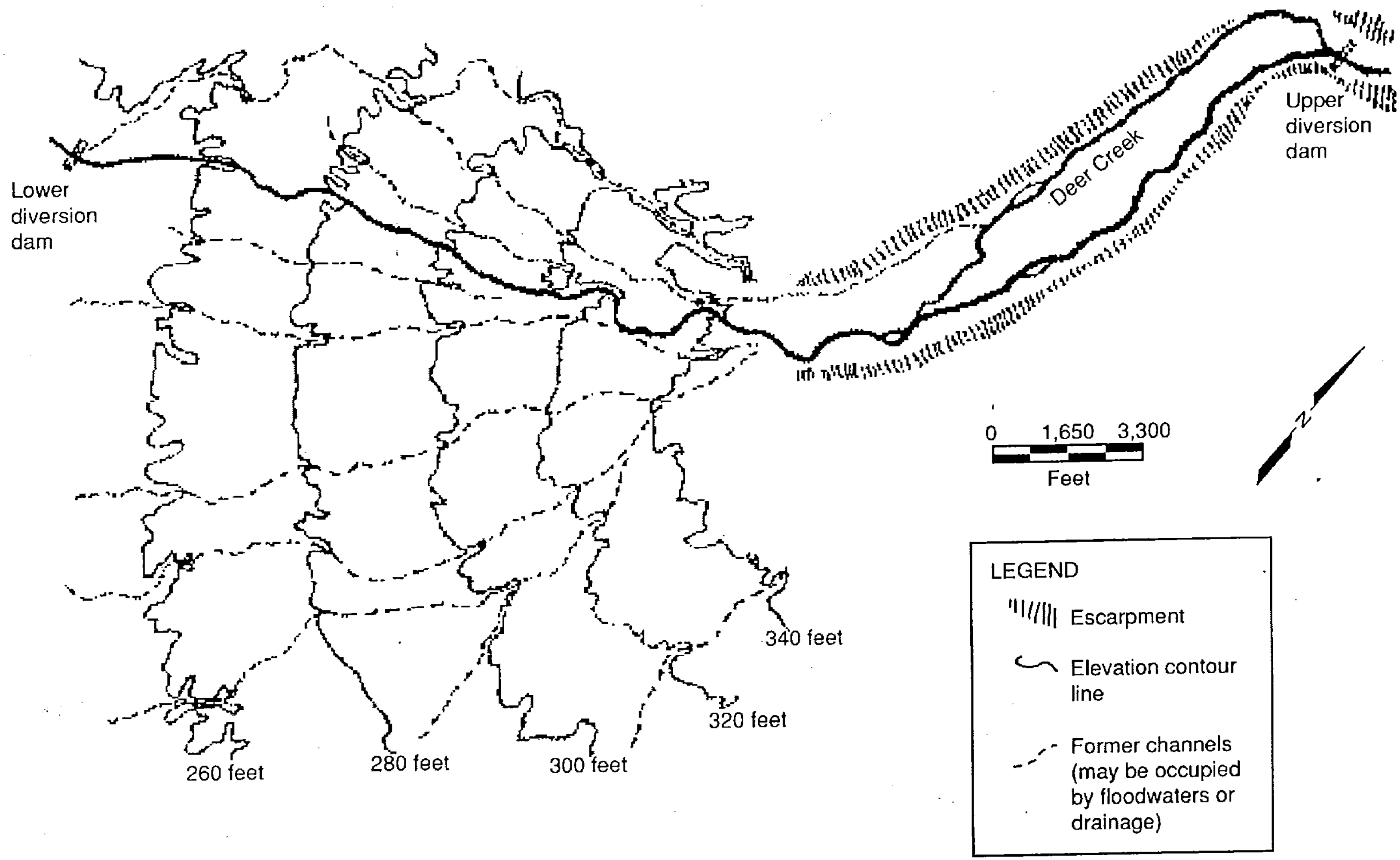


Figure C-4: Characteristic Multiple Channels Radiating from the Apex of the Alluvial Fan on Deer Creek channels. About ten miles of levees were built by the U.S. Army Corps of Engineers along Lower Deer Creek in 1949 to control flooding. During the 1997 flood and others, Deer Creek overflowed its banks, washing out levees on the south bank, and flowed across the floodplain for about 2 miles down to U.S. Highway 99, following another of the many distributary channels of the alluvial fan.

HABITAT CHANGE FROM HISTORICAL GEOMORPHIC ANALYSIS

Historical aerial photographs taken in 1939 clearly show Lower Deer Creek was highly sinuous, with small-scale bends, point bars, and alternating pools and riffles. For much of its course, the low-flow channel was against cut banks with overhanging trees, which provided the channel with habitat under cut banks and roots, shading of the stream, input of nutrients and carbon, and large woody debris. The bends in the channel created secondary circulations and complex flow patterns, which produced zones of higher and lower shear stress distributed through the channel, which in turn led to deposition of gravels and other sediments (Deer Creek Watershed Conservancy 1998). The complexity of channel form resulted in a diversity of microhabitats for invertebrates and fish. During floods, Deer Creek would regularly overflow its banks and inundate adjacent floodplains, a process which prevented continued build-up of water depth in the channel and thus limited the increase in shear stress on the channel bed. Inundation of the floodplain had numerous other ecological benefits, such as providing fish with refuge from high velocities, and abundant food sources on the floodplain, and watering the floodplain to maintain vegetation and floodplain water bodies (Stanford and Ward 1993, Sparks 1995).

Habitat conditions in Deer Creek were profoundly changed in 1949 by a U.S. Army Corps of Engineers flood control project, which built over 10 miles of levees along Deer Creek and straightened and cleared the low-flow channel. In effect, the flood control project sought to confine flood flows to the main channel, which required levees to prevent overflow, and increasing the capacity of the main channel by reducing its hydraulic roughness through straightening and clearing vegetation and large woody debris. Since 1949 there have been repeated efforts to maintain the flood control channel and levees by the U.S. Army Corps of Engineers, the California Department of Water Resources, and Tehama County Flood Control. After each major flood, heavy equipment was usually used to repair levees and clear the channel of gravel bars and large woody debris, with a particularly large gravel removal project after the 1983 flood by the Department of Water Resources (Deer Creek Watershed Conservancy 1998). Gravel removal and levee repair in the early 1980s cost about $1 million, and similar work in 1997 cost about half that amount.

Beginning with the aerial photographs of 1951 (the first available after the flood control project) and continuing to the present, the low-flow channel of Deer Creek is visibly less sinuous and less vegetated than it was in 1939. The alternating pool-riffle sequences visible on the 1939 aerial photographs have been largely replaced with long riffles and runs. There is less riparian vegetation bordering the low-flow channel, partly because there is less riparian vegetation on the banks and partly because there are fewer points where the (now straightened) low-flow channel is undercut at the base of a wooded bank.

Although there are no data on the bed material sizes before 1949, a number of reports have speculated that the gravels of Deer Creek are "armored" (California Department of Fish and Game 1993, U.S. Fish and Wildlife Service 1995, CALFED 1997). While Deer Creek probably does not fit the geomorphic definition of 'armored' (Dietrich et al. 1989), it is very likely true that the bed material is substantially coarser now than before 1949. The reason is that smaller gravels (which would be preferred by most spawning salmon) are now transported out of Deer Creek to the Sacramento River due to the increased shear stresses in the straightened and leveed channel.

The 1949 flood control project and subsequent maintenance efforts were undertaken with good intentions and reflected the best thinking at the time, but there is increasing recognition worldwide that channelization and other river control efforts are frequently detrimental to aquatic and riparian habitat, and often expensive to maintain because they are, in effect, "fighting" river processes. The literature is replete with evidence that natural, complex channels (i.e., channels with irregular banks, undulating bed morphology, and large roughness elements such as large woody debris) provide better aquatic habitat than simplified, channelized reaches (see Brookes 1988 for a review). It should come as no surprise that aquatic habitat is usually maximized with an unfettered, naturally migrating river channel (Ward and Stanford 1995), as these are the freshwater stream conditions with which the fish evolved.

Impacts of channelization include loss of aquatic habitat area and diversity, reduction in shading of the channel with attendant increase in water temperature, loss of riparian habitat for wildlife, specifically loss of undercut banks and overhanging vegetation, loss of pool-riffle structure, and loss of spawning habitat. These relations are visible from field observation on Deer Creek, and would probably be evident from detailed habitat mapping within channelized/leveed vs. more natural reaches of Deer Creek. One way in which channelization and levees reduce the quality of habitat in Deer Creek is by eliminating refuge from high flows: all the flow is concentrated between the levees, leading to increased shear stress in this narrow band. Not only do fish have no place to hide in such channelized/leveed reaches, but the resulting channel typically becomes simpler as well. Thus, the initial 1949 channelization project and subsequent channel clearing, gravel removal, and levee repairs (including post-1997-flood emergency work) were detrimental to aquatic habitat in Deer Creek.

Channel modifications are commonly accompanied by installation of rip-rap on banks. Rip-rapped banks lack bank overhangs, trees and roots, and other irregularities. Although the interstices of rip-rap can provide some habitat for juveniles, overall there is a loss of habitat when a natural bank is converted to rip-rap. Numerous studies have shown that rip-rapped banks support lower densities of fish (e.g., Cederholm and Koski 1977, Chapman and Knudsen 1980, Hortle and Lake 1983, Knudsen and Dilley 1987). Moreover, hardening river banks in one location typically produces a reaction elsewhere along the channel, because flows speed up, slow down, or change in direction. As a result, erosion is initiated elsewhere, and bank protection may be proposed for the new site of erosion, initiating a cycle of erosion and costly rip-rap projects, ultimately with substantial, negative, cumulative effects on aquatic habitat.

Channel maintenance for flood control has included removing accumulated gravel deposits and large woody debris. The gravel removed from the channel is important for building complexity of channel forms (e.g., point bars, riffles) and as part of the gravel delivered to the Sacramento River by Deer Creek. Large woody debris is increasingly recognized as providing important habitat in streams (Angermeier and Karr 1984, Dolloff 1986, Fausch and Northcote 1992, Fausch et al. 1995), so the loss of this wood from the system reduces habitat complexity and contributes to the rapid transmission of flow downstream.

Upstream reaches of Deer Creek most used for spawning and rearing by spring-run chinook salmon (the canyon reaches between the Lower Falls and the Ponderosa Way bridge) have remained largely unchanged since the 1930s. Farther upstream, the Deer Creek Meadows have experienced substantial erosion and channel widening and incision, which has caused the alluvial water table to drop, drying the meadow, and changing the distribution of pools, riffles, and other habitat features. The amount of sediment from the channel erosion, and from road construction, timber harvest, and landslides in the upper basin has no doubt increased in recent decades, and most of this sediment has passed downstream. However, important spring-run salmon habitats do not appear negatively affecting by excessive fine sediments at this time, implying that most of this sediment has been transported through the system during flows sufficiently high to maintain suspension.

A Systemic, Process-Based Strategy for Ecosystem Restoration of Lower Deer Creek

With an understanding of the effects of the flood control project (and its maintenance) on Deer Creek, we can see that many of the problems in Deer Creek are, in effect, symptoms of the underlying geomorphic effects of the flood control strategy. Many of the restoration actions proposed for Deer Creek can be viewed as treatments of these symptoms, rather than addressing the underlying problem. If the style of flood management were changed to set levees back, permit overbank flooding, and eliminate channel clearing, Deer Creek would, in the course of one or more floods, reestablish a more natural channel form with better habitat.

The Deer Creek Watershed conservancy is now exploring alternative flood management strategies. One concept is to let Deer Creek overflow its south bank at the same point it overflowed in 1997 (and in previous floods) and flow across a swath of the south bank floodplain (bounded along the south by set-back levees), through enlarged culverts under Highway 99, and past the town of Vina and into the Sacramento River through an enlarged China Slough. Vina, the Abbey of New Clairvaux, and other buildings on this floodplain would be protected by ring levees. This strategy would aim to manage floods rather than control them, to let Deer Creek release pressure during floods by overflowing as it has historically done, but to set back or protect vulnerable infrastructure.

Along many rivers and streams, it is too late to reestablish natural floodplain processes because intensive urbanization of the floodplain precludes its inundation, or upstream dam construction has reduced flood frequency. Fortunately, along Deer Creek, this is not the case, and a number of landowners have expressed willingness to consider periodic flooding of their agricultural lands. The Nature Conservancy and other organizations and programs could purchase easements or title to flood-vulnerable lands, compensating the landowners. Similarly, bank protection could be removed, destabilized, or not maintained, so that Deer Creek would become free to migrate across the floodplain. In the long run, this approach (of stepping back from the river and giving it a corridor in which to flood and erode) would reduce maintenance costs, in addition to improving habitat.

Because Deer Creek is a high energy channel with essentially unaltered flow and sediment yield from its watershed, it is capable of reforming its bed and banks from channelized to natural quickly, once the disturbing factors of levees and channel clearing were removed. We could expect to see substantial return to natural conditions in one large flood, as was illustrated by some of the channel changes effected by the 1997 flood.

Taking a systemic approach such as this need not preclude short-term measures such as planting riparian trees along de-vegetated channels, or even additions of spawning sized gravel to the channel, but these measures should be undertaken with the understanding that they are unlikely to be sustainable until the channel of Deer Creek can evolve to a more complex, natural form.

LIMITING FACTORS IN THE LIFE CYCLE OF SPRING-RUN AND FALL-RUN CHINOOK SALMON

SPAWNING. Gravels in Lower Deer Creek are used for spawning by fall-run chinook, despite grain sizes considered somewhat coarser than ideal. Spring -run spawning is concentrated upstream, where the gravels occur in smaller deposits. Restoration efforts in Lower Deer Creek would benefit spawning for fall-run chinook and rearing habitat for both runs. However, there may be other, less-visible, limitations on salmon at other stages of their life cycles. For example, if abundance is very low, spawning habitat may not be limiting, because even the limited spawning habitat is adequate for the depressed populations. In this case, restoration efforts directed at other parts of the life cycle may be more effective. This has probably been the case in some years of low abundance (Figure C-2). For some of these life cycle stages, ecosystem restoration seems like a logical and supportable way to proceed; for others, species- or even stock-specific actions are more likely to yield tangible results. Limitations at different stages of the life cycle are discussed below, with letters referring to Figure C-3.

FRY REARING IN RIVERS (C). In general, chinook fry tend to disperse downstream after emergence, taking up residence along edges of streams and rivers, and selecting habitat of increasing velocity as they develop (Chapman and Bjornn 1969, Lister and Genoe 1970, Reimers 1973, Healey 1991). Habitat characteristics seem to be important, particularly the availability of cover at the banks, and riprapped banks seem to provide especially poor habitat for rearing (Michny and Hampton 1984, Schaffter et al. 1983, Brusven et al. 1986). Under the assumption that these characteristics apply equally well to Deer Creek spring-run salmon, then restoration activities in both the creek and the Sacramento River should increase growth and survival of Deer Creek spring-run by an unknown amount. These improvements may include increasing the extent of meander belts, increasing riparian vegetation and woody debris, and reducing the effect of structures that impede migration and concentrate predators. Continuing to maintain Red Bluff Diversion Dam gates open will eliminate what had been believed to be an important concentration of predators.

HABITAT CONDITIONS IN THE DELTA (D). Data on conditions for juvenile salmon in the Delta is largely confined to fall-run smolts and, to a lesser extent, fry. Although many brackish estuaries provide important rearing habitat for chinook salmon (Healey 1982), spring-run races tend to rear more in rivers. Rearing of fall-run salmon in the Sacramento-San Joaquin estuary is believed to occur in freshwater regions of the Delta (Kjelson et al. 1982). Survival of migrating hatchery-reared smolts is lower if they are released in the interior Delta than if they are released on the Sacramento River, suggesting poor conditions for survival within the Delta (USFWS data). To the extent that these poor conditions are due to inadequate habitat, ecosystem-based restoration efforts may help smolt survival as well as that of fry. Too many unknown factors exist, however, to suggest large-scale restoration efforts on behalf of salmon (e.g., the extent and importance of rearing in the Delta, the characteristics of favorable habitat, and the degree to which habitat may be occupied by either salmon or their predators). This suggests that a stepwise, adaptive-management approach to this restoration be used to begin to test assumptions about how habitat in the Delta may be improved and what affect that has on key species such as salmon.

FISH PASSAGE THROUGH THE DELTA (E) Although this is included as an illustration of potential effects on salmon, improvement of fish passage through the Delta is an ecosystem-level action which should benefit other species and stocks. Most of the emphasis in the Delta has been on survival of fall-run salmon smolts passing through on their seaward migration (Newman and Rice in prep.). The principal factors affecting survival appear to be flow in the Sacramento River, salinity distribution, and Delta cross-channel gate position (Newman and Rice in prep.). If spring-run salmon respond similarly to conditions in the Delta (except that temperature should not be a factor), there may be opportunities for improving their survival. Proposals in the Central Valley Improvement Act Anadromous Fish Restoration Plan included closing the Delta Cross-Channel gates in winter, and conducting adaptive management experiments (as in the Vernalis Adaptive Management Program), manipulating flow and exports during experimental releases of tagged late-fall-run fish to represent spring-run. Additional actions that improve the effectiveness of directional cues should benefit all salmon stocks as well.

ADULT PASSAGE AND SURVIVAL (A) Adult passage into Deer Creek is probably not a limiting factor under most flow conditions. However, high temperature in the Sacramento River could result in physiological damage or exhaustion with resulting poor survival or egg viability. Because adults hold in the stream through summer, spring-run chinook may be particularly vulnerable to poaching, which may have contributed to their decline (Sato and Moyle 1989).

OCEAN CONDITIONS (E) Survival of salmon in the ocean is reduced by natural mortality (an ecosystem condition) and fishery mortality (largely a species-based condition). Natural mortality is a function of ocean conditions, out of the control of CALFED. The fraction of fall-run salmon caught (harvest fraction) has been increasing by 0.5% per year for the last 40 years to values over 70% (based on data in Mills and Fisher 1994). This value seems excessive if it applies also to spring-run salmon, given their population size. Thus an obvious management option is to reduce harvest, particularly if it can be done in a way that uses the different migratory patterns to reduce impacts on spring-run fish.

ALTERNATIVE CONCEPTUAL MODELS FOR SALMON RESTORATION IN DECISION MAKING

With these limiting factors in mind, we now illustrate the application of conceptual models to formulating ERP actions, by identifying key events in the life cycle that affect production. We first present alternative models for spring-run chinook salmon system-wide, which lead to alternative restoration approaches, depending on the relative importance of each life stage. Second, we present a conceptual model of fall-run spawning in Lower Deer Creek, which provides a basis for choosing restoration actions in Deer Creek.

EXAMPLE 1: CONCEPTUAL MODELS FOR SPRING-RUN SALMON

ALTERNATIVE POINTS IN THE LIFE CYCLE. For illustration, we have selected just two qualitatively different models of the life cycle of spring-run chinook salmon (Figure C-5). These models are briefly summarized in Table C-1. According to Model A, spring-run salmon could be restored through control of poaching in the streams and improvement of rearing habitat in the streams and river. Model B suggests restoration by improving spawning habitat and Delta rearing habitat, and reducing ocean harvest. Both models indicate a moderate improvement through reduction of mortality on passage through the Delta. Delta conditions are discussed further below.

Clearly the expected benefits due to improvements in different locations differ greatly among these and other possible alternatives. The only way to resolve these issues is through modeling of the life cycle. With a model containing the various mortality factors, their expected response to restoration actions, and the degree of uncertainty about each, one could estimate the effectiveness of various actions and how well that effectiveness is known. The principal output of such a modeling effort would be a set of constraints on the improvement to be expected from each action. The model would not need to be very complicated, and in this case a simple model would most clearly distinguish among scenarios.

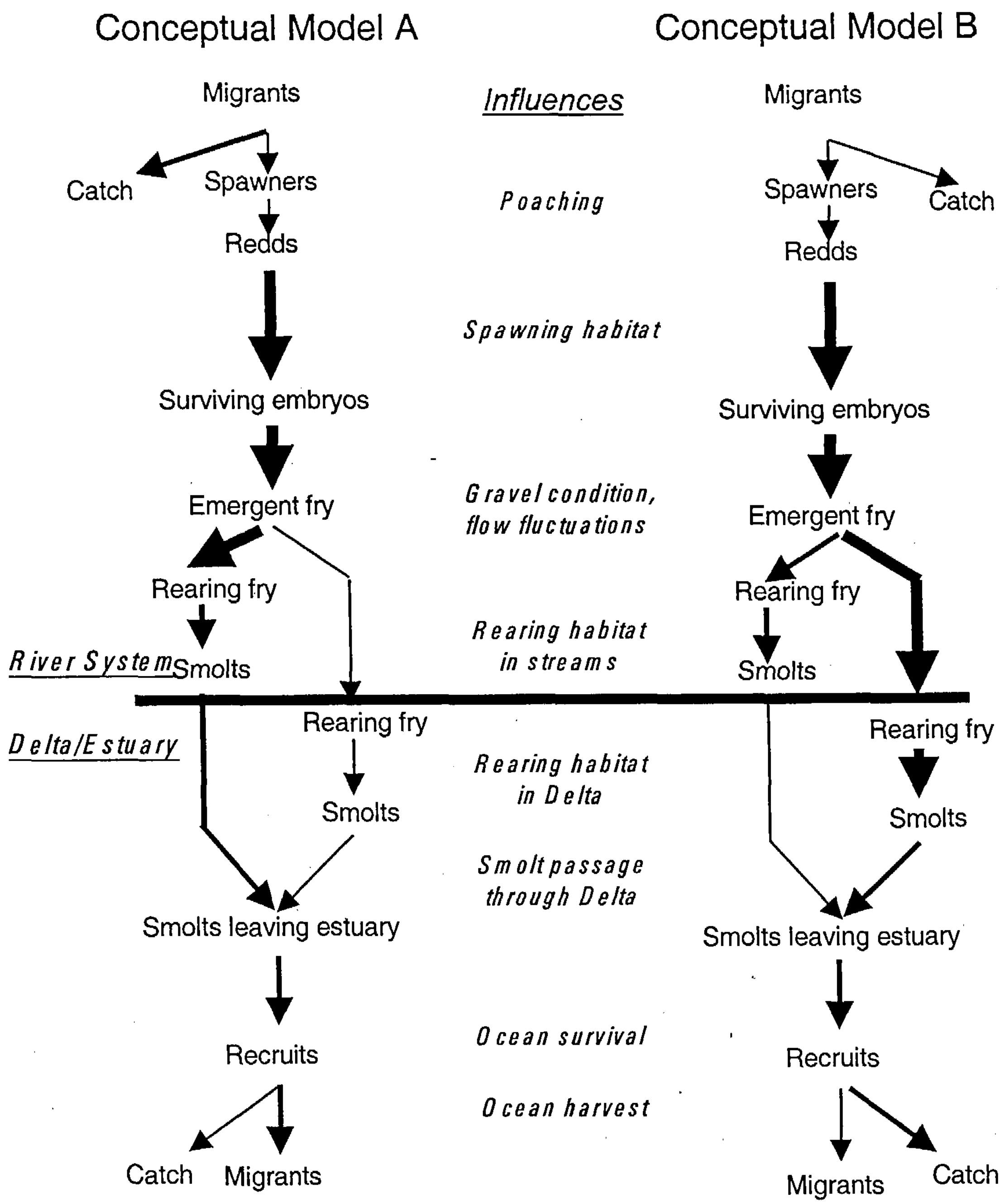
SURVIVAL IN THE DELTA. Because conditions in the Delta have received a lot of attention, and because this is the centerpiece of CALFED, we illustrate several important issues regarding survival and passage through the Delta.

Again, we use alternative conceptual models, but in this case the models differ in only one important respect: the degree of importance of tidal vs. net flows within the Delta channels (Figure C-6). Conceptual model N (for Net) holds that net flows are more important than tidal flows. According to this model, young salmon are diverted off the Sacramento River mainstem in approximate proportion to estimated net flow splits. Reverse flows such as QWEST (net flow in the lower San Joaquin River) are important either in drawing young fish toward the export pumps, or in altering salinity or other cues, confusing migrating fish as to the correct direction in which to migrate. The influence of Delta agricultural diversions (not shown in the figure) is to remove salmon in approximate proportion to the diversion flow. This model has predominated over the last few decades, despite a lack of data suggesting a strong influence of reverse flows, results of a recent study showing low abundance of salmon in agricultural diversion flows, and relatively low rates of capture of tagged salmon at the export pumps.

TABLE C-1. SUMMARY OF DIFFERENCES BETWEEN ALTERNATIVE CONCEPTUAL MODELS A AND B IN FIGURE C-5 IN RELATIVE IMPORTANCE OF VARIOUS LIFE STAGES TO POTENTIAL IMPROVEMENT IN PRODUCTION OF DEER CREEK SPRING-RUN CHINOOK SALMON.

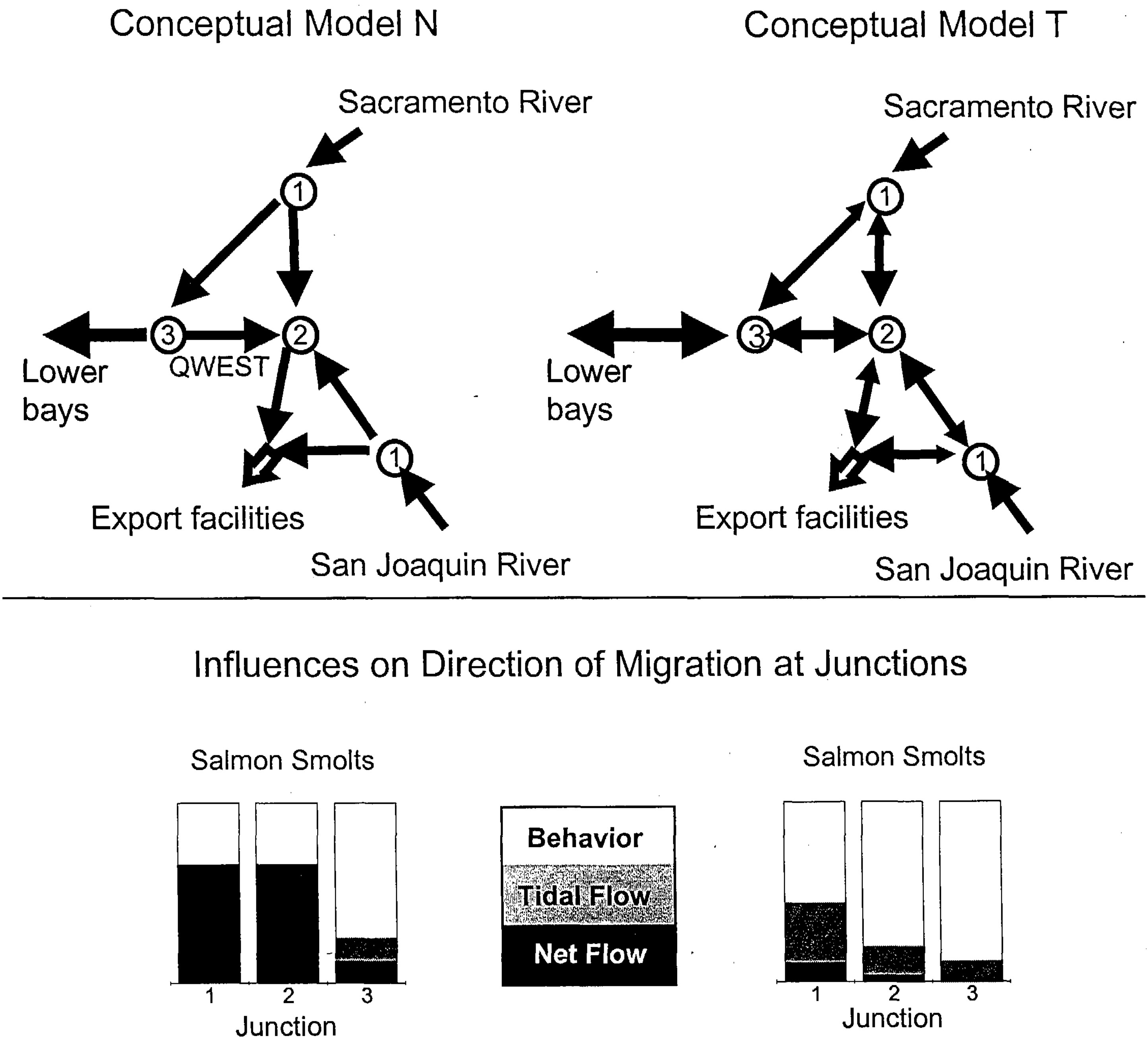
Life Stage or Event	Density-Dependent	Relative Importance	
		Model A	Model B
Poaching	Yes?	High	Low
Availability of spawning habitat	Yes	Low	High
Rearing in stream/river	No?	High	Low
Rearing in the Delta	No	Low	High
Passage through the Delta	No	Moderate	Moderate
Ocean harvest	No?	Low	High

The alternative model T (for Tides) holds that water movement is asymmetric, with dominance by ebb or flood due to net flow and tidally-driven residual flow; the further west in the Delta, and the lower the freshwater flow, the more predominant



Note: Arrows represent transformations of fish from one life stage to the next, and thickness of arrows indicates relative magnitude of population undergoing transformation. Conceptual models A and B differ in the importance of effects at several stages of the life cycle (Table C-1).

Figure C-5: Alternative Conceptual Models of Salmon Smolt Production for Deer Creek Spring-Run Chinook



Note: Arrows and circles comprise a schematic of the Delta, with the circles representing key nodes where flow and fish diverge. Single arrows indicate river inputs, and double arrows indicate flows that are partly or mostly tidal, with the sizes of the arrowheads reflecting relative flow velocities for each location. Conceptual model A depicts net flows, with arrows indicating how fish would move under the influence of these flows. Conceptual model B illustrates how water moves in response to both tides and net flow. Fish move under the influence of these flows and their own behavior. Bar charts in the bottom panel illustrate how these conceptual models differ in their prediction of the relative influence of fish behavior, tidal flow, and net flow on the proportion of fish taking alternative pathways at each of the nodes.

Figure C-6: Alternative Conceptual Models of Flow and Salmon Movement in the Delta Under Low-Flow, High-Export Conditions the tidal effects. A passive particle released in the Sacramento River has a high probability of eventually moving into Suisun Bay, a moderate probability of entering the central Delta or being entrained in Delta agricultural diversions, and a low but non-zero probability of being entrained in the pumping plants. Salmon behavior complicates this in unknown ways: e.g., splits at Delta channel junctions are a complex, at present unpredictable, function of tidal flow splits and fish behavior. Furthermore, adult salmon (and probably juveniles) use tides to assist in migration. Net flows probably have little effect except where they set up or obliterate gradients (e.g., in salinity) that may provide cues for seaward migration. QWEST and other small (relative to tidal) net flows have little or no effect, although they may be related to the environmental gradients referred to above. Finally, losses to agricultural diversions depend on the size and location, as well as the flow rate, of each diversion, and because of avoidance by fish these losses may be generally low.

In the conceptual models presented thus far, we have referred to habitat restoration in a general way, implicitly assuming that restoration projects will actually benefit salmon. However, the effectiveness of restoration projects is highly variable, depending upon the degree to which their design accounts for physical and ecological processes. In the following conceptual model, we consider in more detail the factors affecting spawning success of fall-run chinook salmon, and potential strategies for restoration.

Example 2: A Conceptual Model for Fall-Run Chinook Salmon Spawning Habitat Restoration in Lower Deer Creek

Although Deer Creek is probably most important as habitat for spring-run chinook salmon, Lower Deer Creek also provides spawning habitat for fall-run chinook (and, potentially, rearing habitat for spring-run). A number of the proposed restoration measures in Deer Creek (e.g., gravel ripping, addition of spawning gravels, installation of retaining structures) relate to spawning habitat for fall-run. Thus, an understanding of the processes and factors controlling the distribution of this habitat, and how management decisions can affect them, is important.

The conceptual model shown in Figure C-7 lays out the life stage functions involved in migration, spawning, incubation, fry emergence from gravels, and juvenile rearing. The model also discusses management and restoration actions in light of their effects on the requirements of each life stage. Under Upstream Migration, the fish must be able to swim from the ocean to their natal spawning grounds, which requires a path free of migration barriers. Barriers include dams, diversions, dewatered reaches, or reaches with high temperatures, contaminant concentrations, or low dissolved oxygen. For management, this implies that all dams and diversions below potential spawning grounds be evaluated for passage or removal, and adequate flows be provided to insure sufficient water quantity and quality to permit migration.

Under Digging Redds, the fish must be able to move the gravel, which is mostly a question of gravel size. Larger fish can move larger gravels, with the maximum size (median grain diameter) moveable being about 10 percent of the fish's body length. The sizes of gravel available is largely a function of the balance between the amount and size of gravel supplied by the watershed and local channel transport capacity. Below dams, the supply of gravel is usually reduced, so gravel may need to be added to make up for the lack of supply from upstream. In channelized and leveed reaches, the transporting power is locally increased, so gravels that might formerly have been stable are likely to be washed downstream.

Under "Incubation" in Figure C-7, the eggs must have their metabolic wastes removed and adequate dissolved oxygen, both of which depend on adequate intragravel flow past the eggs, which in turn depend on sufficient hydraulic gradient to drive the flow and sufficient permeability in the gravels to permit the flow. The hydraulic gradient depends upon the location within the longitudinal profile and local channel geometry, with the pool-riffle transition typically creating an excellent gradient for intragravel flow (water wells down into the bed at the tail of the pool, upwells from the riffle). For ecological management, this implies that undulations in the streambed are important

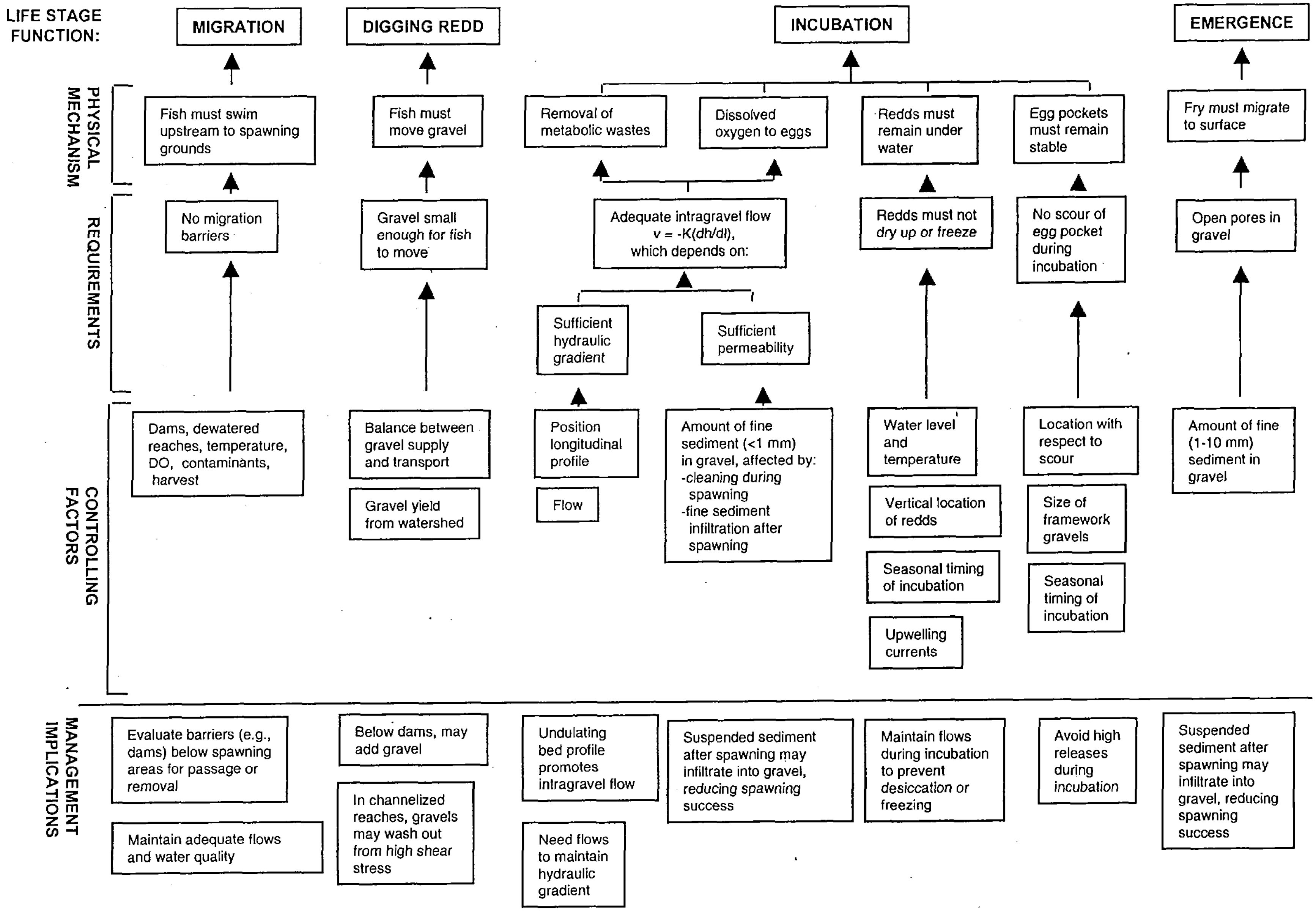


Figure C-7: Conceptual Model of Salmon Spawning, Showing Factors Affecting Success at Various Life Stages ecologically, and should be maintained. The permeability depends upon the amount of fine sediment (finer than 1 mm) in the gravel, which in turn is affected by the amount of fine sediment present before the fish spawned, the cleaning effect of the fish, and fine sediment infiltration after spawning. This implies that gravels with initially high levels of fine sediment can be improved during spawning, but subsequent high suspended sediment concentrations can be detrimental. Thus, the timing of fine sediment delivery to the channel may be as important as the amount.

Also under Incubation, redds must remain underwater, so they must be located where they do not dry up (or, in other climates, freeze). This is controlled by the streamflow (especially any drops during incubation), the location of individual redds with respect to seasonal low water levels, and the timing of incubation with respect to seasonal flows. For management this implies that adequate flows are needed during the spawning and incubation season. For successful incubation, the egg pockets of the redds must remain stable, i.e., the gravel must not be scoured (at least down to the depth of the egg pocket), because salmon eggs are vulnerable to crushing if the gravel moves. This is controlled by the location of redds in the channel with respect to bed mobility, the size of the gravel, and the timing of incubation with respect to high flows. For management, this implies that on channelized reaches with increased shear stress for a give discharge, redds are more likely to be scoured than in unchannelized, natural reaches.

Under Emergence, the fry must be able to migrate through interstices in the gravel upward to the surface, so the interstices must not be filled with fine sediment (1-10 mm). This depends on the amount of fine sediment (1-10 mm) in the gravel, which is controlled by the factors discussed above.

Under rearing, the juveniles require habitats with suitable temperatures, adequate cover, refugia from high velocity flows, and food. The habitats provided by a sinuous channel, with an undulating bed and dense riparian trees along the banks and floodplain are ideal for rearing, as they meet these requirements. For management, this implies that either the characteristics of natural, sinuous channels be artificially recreated and maintained, or that the processes which maintained those conditions be reestablished.

IMPLEMENTING ADAPTIVE MANAGEMENT

In adaptive management, we select actions, implement, and monitor ecosystem response. However, because our primarily target species in Deer Creek, chinook salmon, is affected by many factors besides the physical habitat we modify, we should not only monitor salmon population levels in Deer Creek and nearby drainages (which is already done). We need to monitor a suite of ecosystem responses, such as growth and survival of juvenile salmon, abundance of amphibians, abundance of native fishes, sprouting and establishment of cottonwoods.

The two spring-run chinook salmon conceptual models lead to very different choices of restoration actions. For example, Model N would suggest that moving the point of diversion might be effective in reducing losses in the Delta, and that screening agricultural diversions is an obviously effective means of improvement. By contrast, Model T implies that survival may be more a function of flow in the Sacramento River and tidal and possibly habitat conditions in the interior Delta, so that moving the point of diversion would have no measurable effect. Furthermore, agricultural diversions may have a small effect on salmon, and altering the intakes or diversion schedules to account for salmon behavior may be as effective as the far more expensive alternative of screening diversions.

The fall-run chinook spawning conceptual model illustrates the needs of different freshwater life stages of fall-run chinook salmon, and can be used to evaluate various restoration actions. For example, adding gravel to the specific sites in the channel may provide localized, short-term benefits to spawning habitat, but a more sustainable approach to increase habitat lies in re-establishing natural processes of channel migration, erosion, and deposition, overbank flooding, natural establishment of riparian vegetation, and transport of large woody debris.

The conceptual models also help to identify gaps in our understanding, and thus focused research and adaptive probing that would help resolve uncertainties to improve future management. For example, proportional entrainment of salmon in agricultural diversions and its dependence on location of intakes and timing of water withdrawal is not well understood and should be the subject of focused research before a large commitment of funds is made to expensive screening projects. Similarly, more needs to be known about spring-run adult mortality during summer, which can be approached by mark-recapture or other techniques. If mortality is significant, we should evaluate the potential magnitude of poaching, and design strategies to limit poaching if it is appreciable. In addition, the extent to which salmon, particularly spring-run, use the Delta for rearing should be investigated, and salmon passage through the Delta under winter conditions should be modeled using various alternative assumptions about behavior in response to environmental cues.

If ecosystem restoration is undertaken by setting back levees and permitting a dynamic, irregular channel to develop on Lower Deer Creek, the evolution of channel form should be carefully monitored. After each flood capable of moving bed material, the channel should be resurveyed, and the distribution of habitats inventoried from detailed aerial photographs and compared with similar information from 1939 aerial photographs as a way to measure recovery back to the favorable conditions that existed before the flood control project.

Improvements to freshwater habitat should be accompanied by reductions in ocean harvest to a level consistent with restoration, and we should monitor both harvest and total escapement of salmon to gauge success.

CONCLUSIONS

Implementing an effective restoration program will require more than developing site-specific restoration projects. It is essential that we step back and look at the big picture, and the big picture can be defined in more than one way. Conceptual models can provide a useful approach to look at the big picture. We have illustrated species-based and river-ecosystem-based conceptual models and demonstrated their use in decision making. Each kind of approach is useful, and each provides different information.

In any restoration program, the complex nature of river systems and multiple causes for declines in populations of important must be acknowledged and planned for. Because of this complexity, restoration actions may not yield the anticipated results. For example, habitat restoration measures for fall-run chinook salmon may not result in increased populations due to downstream factors such as over-harvesting, but the habitat restoration may increase populations of yellow-legged frogs. If the downstream problems are addressed, eventually salmon populations may increase as a delayed result of habitat improvements. Meanwhile, there are other benefits from habitat restoration, including, for example, hydrologic benefits from restoration of meadows in the upper watershed.

On Deer Creek, spawning and rearing habitat for spring run (in the canyon reaches) is in generally good condition. This implies that we should not undertake habitat enhancements in this reach to increase populations, but also that protection of this habitat becomes a top priority. One potential threat to spring-run habitat would be spills of hazardous materials into the creek from trucks on Highway 32 (upstream of the best spring-run habitat). In the past, diesel fuel has spilled into the creek, demonstrating the potential for more serious accidents. Restrictions on or elimination of truck traffic in hazardous materials on this highway should be considered.

APPENDIX D. DRAFT STAGE 1 ACTIONS

This chapter describes at a programmatic level of detail the draft list of priority ERP actions that will be implemented in the first 7 years of the CALFED program. The draft Stage 1 actions describe:

- the critical processes, habitats and species that will be addressed for key tributary watersheds,
- the rationale for the selection of actions to be implemented during Stage 1,
- actions already being implemented as part of CALFED's Restoration Coordination Program, CVPIA, or other restoration programs, and
- uncertainties about ecosystem structure and function that can be answered by designing restoration actions to maximize their information value.

DRAFT SACRAMENTO-SAN JOAQUIN DELTA STAGE 1 ACTIONS

DESCRIPTION OF THE SACRAMENTO-SAN JOAQUIN DELTA REGION

The Sacramento-San Joaquin River Delta (Delta) is the tidal confluence of the Sacramento and San Joaquin rivers. Once a vast maze of interconnected wetlands, ponds, sloughs, channels, marshes, and extensive riparian strips it is now islands of reclaimed farmland protected from flooding by hundreds of miles of levees. Remnants of the tule marshes are found on small "channel" islands or shorelines of remaining sloughs and channels.

Despite many changes, the Delta remains a productive region for many species of native and non-native fish, waterfowl, shorebirds, and wildlife. All anadromous fish of the Central Valley migrate through the Delta or spawn in, rear in, or are dependent on the Delta for some critical part of their life cycle. Native resident fish including delta smelt and splittail spend most of their lives within the Delta. Many of the Pacific Flyway's waterfowl and shorebirds pass through or winter in the Delta. Many migratory songbirds and raptors migrate through the Delta or depend on it for nesting or wintering habitat. Considerable areas of waterfowl and wildlife habitat occur along the channels and sloughs and within the leveed agricultural lands. The Delta also supports many plants with restricted distribution and some important plant communities.

Factors having the greatest influence on Delta ecological health include:

1. Hydrologic regime altered by reduced inflow, reduced seasonal and inter-annual hydrologic variability and large in-Delta diversions;
2. Hydraulics and hydrodynamics altered by leveed islands, channel dredging, and south Delta pumping;
3. Food web altered by introduced species, reduced inputs of organic carbon and decreased residence time of water and organisms;
4. Conversion of agricultural land (which provides surrogate habitat for many avian species) to low habitat value crops or to urban development.
5. Tidal marsh and riparian habitats lost to island reclamation to agriculture, levee construction and maintenance (rip-rapping), wave and boat wake erosion;
6. Water quality degraded from industrial, agricultural and residential pollutants;
7. Elevated water temperatures; and
8. Entrainment of fishes in power plants and south Delta State and Federal diversions.

STAGE 1 APPROACH

Stage 1 actions in the Delta have been selected to address the following key issues (described earlier in Chapter 5):

- The impact of introduced species and the degree to which they may pose a significant threat to reaching restoration objectives.
- Development of an alternative approach to manage floods by allowing river access to more of their natural floodplains and integrating ecosystem restoration activities with the Comprehensive Study.
- Increasing the ecological benefits from existing flood bypasses, such as the Yolo Bypass, so that they provide improved habitat for waterfowl, fish spawning and rearing, and possibly as a source of food and nutrients for the estuarine foodwebs.
- Thoroughly testing the assumptions that shallow water tidal and freshwater marsh habitats are limiting the fish and wildlife populations of interest in the Delta.
- The need to better understand the underlying mechanisms of the X2 salinity standard in the Delta and the resultant effects on aquatic organisms.
- The need to better understand the linkage between the decline at the base of the estuarine foodweb and the accompanying decline of some higher level species and trophic groups.
- Clarify the extent to which entrainment at the CVP and SWP pumping plants affects population sizes of fish and invertebrate species; and
- Clarifying the suitability and use of the Delta for rearing by juvenile salmon and steelhead.

The proposed Stage 1 approach for the Sacramento-San Joaquin Delta is to broadly design and implement actions that will make a substantial contribution to developing aquatic and terrestrial habitat through the Delta which connect with upstream areas. In addition to the focus on the corridor concept, a variety of general actions will be implemented, ranging from large-scale tidal marsh restoration and research projects (Frank's Tract, Little Holland Tract and Liberty and Prospect islands), floodplain restoration, and control and eradication of introduced species. Implementation of these actions and linking them through adaptive management to the Comprehensive Monitoring, Assessment and Research Program will be major steps toward resolving the important Stage 1 issues and will set the direction for subsequent implementation stages.

The three major habitat corridors envisioned include the following:

- **THE NORTH DELTA HABITAT CORRIDOR** will provide a contiguous habitat corridor connecting the mosaic of tidal marsh, seasonal floodplain, riparian and perennial grassland habitats in the Yolo Bypass, Cache Slough Complex, Prospect Island, Little Holland Tract, Liberty Island and Steamboat Slough.
- **THE EAST DELTA HABITAT CORRIDOR** will restore a large, contiguous corridor containing a mosaic of habitat types including tidal perennial aquatic, riparian and riverine aquatic habitat, essential fish habitat, and improved floodplain-stream channel interactions. The focus area includes the South Fork of the Mokelumne River, East Delta dead-end sloughs, Georgiana Slough, Snodgrass Slough, and the Cosumnes River.
- **THE SAN JOAQUIN RIVER HABITAT CORRIDOR** will provide a contiguous habitat corridor of tidal perennial aquatic habitat, freshwater fish habitat, essential fish habitat and improved river-floodplain interactions.

NORTH DELTA HABITAT CORRIDOR STAGE 1 ACTIONS

Major features of the North Delta are the Yolo Bypass, the Sacramento Deep Water Ship Channel, the Sacramento River downstream of Sacramento to Rio Vista, and sloughs connecting the Sacramento River to the Cache Slough complex at the base of the Yolo bypass.

The Stage 1 proposal for the North Delta is to restore a large, contiguous habitat corridor connecting a mosaic of tidal marsh, seasonal floodplain, riparian, and upland grassland habitats. This involves:

- Increasing the quantity and quality of seasonal and perennial wetlands,
- Improving flows, riparian and seasonal wetlands and fish passage in the Yolo Bypass,
- Restoring Prospect Island to tidal and seasonal wetlands to connect with the Cache Slough complex,
- Restoring Little Holland Tract to tidal wetlands to connect with the Cache Slough complex,
- Restoring Liberty Island to tidal and seasonal wetlands to connect with the Cache Slough complex, and
- Protection and enhancement of riparian habitat in Steamboat Slough.

These actions are a high priority because there is the potential to effectively restore and connect multiple habitat types into a functional habitat corridor. The habitat corridor will improve an important rearing, migration, and spawning area for anadromous and resident fishes as well as important habitat for waterfowl, special-status plants, reptiles, and other species. This suite of actions provides a unique opportunity to restore the only functional floodplain ecosystem in the Delta at a large scale, low cost, and with high information and learning potential. Restoration at this location offers the ability to address major restoration issues and uncertainties including:

- Evaluation of species utilization of flood bypasses,
- Ability to control introduced aquatic and riparian plants,
- Evaluation of mercury methylization potential,
- Experimentation of tidal marsh restoration techniques, and
- Experimentation of the relationship between variable salinity regimes, physical habitat and species.

The Restoration Coordination Program has funded many projects that are critical to restoring this habitat corridor and may fund additional projects during 1999. Before major actions are taken in Stage 1, the results of the previously funded projects will be assessed and the proposed Stage 1 actions may be refined accordingly. Many of the projects listed below will require planning studies and outreach to local landowners, recreation interests, and coordination with other agency and CALFED Program activities.

The proposal for the Yolo Bypass is to coordinate planning with the Yolo Bypass foundation to restore permanent flows, fish passage, and seasonal wetland habitat consistent with flood management requirements. The Yolo Bypass is a managed floodway that provides extremely important habitat when flooded for splittail spawning and salmon rearing. When not flooded, the Yolo Basin wetlands provide critical habitat along the Pacific Flyway for tens of thousands of migratory waterfowl and wading birds. This habitat could be enhanced at a low-cost and large scale because restoration will not have significant impacts to existing agricultural practices, bypass land is either publicly owned or privately owned land with flood easements, and restoration actions can be bundled with flood control improvements. There is an unknown, potential benefit by improving salmon passage through the major Bypass slough, the Tule Canal/Toe Drain, to connect with the Sacramento River and Cache Creek.

Potential restoration actions in the Yolo Bypass must be modeled for potential flood control impacts and will only go forward if compatible with flood control requirements or if the impacts are mitigated. For example, the increased channel roughness caused by new riparian habitat in Tule Canal/Toe will have to be offset by increased flood capacity.

ACTION 1: Increase the duration of Yolo Bypass flooding in winter and spring by modifying the Fremont Weir to allow lower-stage flows of the Sacramento River to pass through the Yolo Bypass.

- Install an inflatable barrier to induce overbank flooding out of the Tule Canal/Toe Drain or modify the Tule Canal/Toe Drain as described in Action 3 to create an excavated, shallow flooded region.

RATIONALE: Before the Yolo Basin was developed as a flood bypass system, flow from the Sacramento River entered the basin at much lower flows than the Fremont Weir currently allows to reduce flood risk associated with the Sacramento and American rivers; consequently, the Bypass only receives flow from the Sacramento River during very high flow events.

Floodplains, and in particular the Yolo Bypass, are seasonally important habitats for native fishes including splittail and chinook salmon and may provide a large source of food and nutrients for the estuarine food web. The beneficial impacts of bypass flooding can be increased without sacrificing flood control capabilities and not interfering with agricultural practices. Lowering the height of a portion of the Fremont Weir (and possibly the Sacramento Weir) would allow lower-stage Sacramento River flows in winter and spring to flood a portion of the Bypass. Because the basin slopes toward the East, additional flows may simply concentrate in the Tule Canal/Toe Drain rather than inundate the floodplain. To increase the extent of floodplain inundation, an inflatable barrier can be installed at the base of the Toe Drain channel to induce overbank flooding. Increased flood duration would also improve fish passage to Cache and Putah creeks.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Evaluate use of inflatable barrier to induce overbank flooding of the Tule Canal/Toe Drain.
- Study invasion of exotic plants such as Arundo and tamarisk. Develop control measures.
- Evaluate potential for mercury methylization potential (from Cache Creek).
- Evaluate potential flood control impacts and mitigation alternatives.
- Value for splittail spawning.
- Value of improved chinook salmon survival.
- Contribution to total organic carbon and phytoplankton growth.
- Potential adverse effects of total organic carbon on drinking water supplies.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

The Yolo Basin Foundation recently completed wetland restoration in the Yolo Bypass that is now being managed by the Department of Fish and Game. CALFED FY 98 Restoration Coordination Program funds were provided for Lower Putah Creek watershed planning and Yolo Bypass restoration planning.

CALFED FY 97 Restoration Coordination Program funds were provided for an assessment of the capacity of different Delta habitats to support the nutritional requirements of the invertebrate biota that sustain upper trophic level organisms. FY 97 funds were also provided to evaluate the potential of mercury methylization produced through wetland restoration.

ACTION 2: Construct a fish ladder at Fremont Weir to provide for fish passage through the Tule Canal/Toe Drain to the Sacramento River.

RATIONALE: Improved flows through the Bypass will attract adult anadromous fish that must navigate past the weir to reach their natal spawning habitat on the upper Sacramento River. Providing passage around the Fremont Weir will help prevent migratory fish from being stranded.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- The ladder must be evaluated for effectiveness of adult and juvenile fish passage including white sturgeon, green sturgeon, American shad, striped bass and lamprey.

ACTION 3: Evaluate the feasibility and benefits of widening the Tule Canal/Toe Drain channel, restoring riparian vegetation and improving year-round flows. Potential actions include:

- Excavate a wider channel to convey winter and spring flows from the Fremont Weir;
- Allocate water to sustain higher summer and fall flows (non-flood) through the Tule Canal/Toe Drain;
- Better connect the channel by enlarging existing culverts, etc. to allow fish passage at low flows;
- Construct new channels connecting the Tule Canal/Toe Drain with Putah Creek, Cache Creek and the Fremont Weir fish ladder; and
- Restore riparian habitat along the Tule Canal/Toe Drain, including on the Sacramento Ship Channel levee.

RATIONALE: The Tule Canal/Toe Drain is a slough along the east side of the Bypass (the slough is referred to as "Tule Canal" from the Fremont Weir to the Yolo Causeway and as the "Toe Drain" from the causeway to Cache Slough). During most of the year when the bypass is not flooded, the Tule Canal/Toe Drain does not provide migratory fishes access to Putah Creek, Cache Creek and the Sacramento River. However, when the bypass is flooded, fish can migrate through the Bypass to Cache and Putah creeks and the Sacramento River. In 1997 and 1998, adult chinook salmon spawned in Putah Creek. Outmigration of juveniles from Putah Creek may be impeded or impossible in the absence of better-connected channels to the Toe Drain.

Tule Canal/Toe Drain channel improvements and restored riparian, in conjunction with increased winter and spring flows from Action 1 and a fish ladder at Fremont Weir from Action 2, will enable year-round fish passage and longer-duration seasonal floodplain habitat.

It may also be beneficial to improve summer and fall flows through the Bypass to allow for fish passage to Cache and Putah Creeks and the Sacramento River. It may also serve as a better migration corridor than the Sacramento River for migratory fishes. If it is determined that additional flow would primarily benefit non-native fishes, this action will not be implemented.

ADAPTIVE MANAGEMENT CONSIDERATIONS: Evaluate native and non-native species utilization of the bypass.

ACTION 4: Evaluate potential flood conveyance impacts from actions 1 to 3. Conduct a feasibility analysis to increase flood flow capacity in the Yolo Bypass to compensate for lost flood capacity from Bypass restoration.

- Enlarging the openings of the railroad causeway may be an alternative to increase capacity.

RATIONALE: Restored riparian habitat in Tule Canal/Toe Drain will increase the roughness of the Bypass, reducing its flood conveyance capacity. The railroad causeway restricts the flow of floodwaters through the Bypass and also creates conditions that tend to strand larval, juvenile, and occasionally adult fish when the water recedes. The small openings through the railroad causeway can be enlarged to increase net flood capacity of the Bypass and reduce stranding effects.

ACTION 5: Conduct a feasibility analysis of opportunities to reduce fish stranding in the Bypass. Refine Actions 1, 3 and 4 accordingly.

RATIONALE: The Bypass tends to drain quickly after flooding, potentially stranding a significant number of salmon, Delta smelt and other fishes. Fish stranding can be reduced by creating new channels through ponded areas to improve drainage to the Tule Canal/Toe Drain and by re-grading land to provide better connectivity with distributary sloughs.

TARGETED RESEARCH: Evaluate conditions favorable to splittail spawning (wetted perimeter, depth, timing, and duration).

RATIONALE: Splittail are known to use the Bypass and other flooded seasonal habitats to spawn, but the optimal spawning conditions are unknown. By studying spawning behavior and habitat preferences in different water year floods, the knowledge gained may be used to better manage Bypass flows to benefit splittail.

The Department of Water Resources has been conducting these types in the Yolo Bypass. These studies need to continue and include the development of conceptual models.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Through Action 1, vary flow rates from Fremont Weir to study splittail spawning.

ACTION 6: Plan and implement restoration of shallow water habitat on Little Holland Tract.

ACTION 7: Plan and implement restoration of shallow water habitat and seasonal wetlands on Prospect Island.

ACTION 8: Plan and implement restoration of shallow water habitat and seasonal wetlands on Liberty Island.

ACTION 9: Plan and implement restoration of shallow water habitat in the lower Yolo Bypass.

RATIONALE: Prospect, Liberty, and Little Holland are ideal locations to restore tidal marshes. Most of the land is or will soon be publicly owned, therefore it will reduce the need to convert additional agricultural land to habitat. Since they are located at the outlet of the Yolo Bypass, they are more susceptible to flooding. The islands are not as subsided as other Delta islands, so they will require less effort to construct suitable land elevations for habitat. Restoration can build upon existing tidal marsh habitat on the margins of these islands. Tidal marsh restored on these islands will connect with the important riparian and seasonal floodplain habitats in the Yolo Bypass, tidal marsh and riparian habitats in the Cache Slough complex, Steamboat Slough, and the Sacramento River.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Evaluate multiple tidal marsh restoration techniques.
- Evaluate species colonization and succession.
- Study native vs. non-native species use of shallow-water habitats.
- Develop control measures for non-native aquatic plants.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

CALFED FY 97 and 98 Restoration Coordination Program funds were provided for acquisition and restoration of Prospect Island, acquisition of Liberty Island, restoration of SRA, tidal slough habitat, and perennial grasslands along/adjacent to Barker Slough and Calhoun Cut, restoration of SRA habitat along a Cache Slough levee, and relocation and screening of diversions on Hastings Tract to reduce the entrainment of delta smelt.

Category III funds were provided for a North Delta salmon rearing study.

PILOT PROJECT/TARGETED RESEARCH: Develop a plan to design and evaluate tidal marsh restoration of Prospect, Liberty and Little Holland in the North Delta. Study the relationship between salinity gradients, salinity variability, and physical habitat and the effect on species in the tidal North Delta.

- Modify physical habitat configurations to vary salinity gradients and evaluate effects on species.

RATIONALE: Restoration in the North Delta provides an opportunity to learn about species utilization of shallow-water, tidal marsh habitats and salinity gradients. The seasonal and inter-annual variations in Delta inflow created a variable salinity regime. Construction of reservoirs, water diversions, and modification of Delta islands have reduced the variability of flow and salinity conditions. Native plant, wildlife and fish species evolved with the variable flow and salinity regimes. Reducing the variability may have provided competitive advantage to non-native species. Developing a plan to experiment with flows and salinity gradients may identify conditions that benefit native species.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Extent to which physical habitat may be limiting native and introduced species.
- How salinity gradients and variability affect conditions and species in shallow-water habitats.

- Calibration of models to evaluate changes in Delta hydraulics resulting from wetland restoration.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

CALFED FY 97 funds were provided for a Delta sediment transport and availability study.

Category III funds were provided for a North Delta salmon rearing study.

ACTION 10: Develop and implement measures to rehabilitate and restore a riparian and shaded riverine aquatic habitat corridor along Steamboat Slough.

RATIONALE: Steamboat Slough is an important migratory corridor for Sacramento River salmon. Habitat conditions are more favorable in Steamboat than the Sacramento River, and there is little opportunity to restore riparian habitat on the large, federal levees of the Sacramento River. Attempts should be made to protect existing habitat from boat wakes and other activities associated with heavy recreational use on Steamboat Slough. Existing boat speed restrictions have not been effective in stopping degradation of existing habitat.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Evaluate Sacramento salmon smolt survival through Coded Wire Tag (CWT) (paired) experiments to assess baseline survival and survival after restoration.

EAST DELTA HABITAT CORRIDOR STAGE 1 ACTIONS

Major features of the East Delta are the North and South Forks of the Mokelumne River, the Cosumnes River and floodplain, dead-end sloughs adjoining the South Fork, and Georgina Slough. For purposes of Stage 1 action grouping, Snodgrass Slough of the North Delta region is considered a functional unit of this habitat corridor. The East Delta is an important region for its diversity of plant, fish and avian species, and a functioning floodplain on the Cosumnes River.

The objective for the East Delta is to restore a large, contiguous corridor containing a mosaic of habitat types. Restoration in the East Delta offers the best opportunity to evaluate and restore natural ecological functions in the Delta. Stage 1 actions will focus on tidal marsh and riparian habitat restoration on the South Fork of the Mokelumne River, East Delta dead-end sloughs, Georgiana Slough, Snodgrass Slough and the Cosumnes River floodplain.

ACTION 1: Restore and rehabilitate a contiguous corridor of riparian, shaded riverine aquatic, tidal freshwater, and seasonal and perennial habitats along the South Fork of the Mokelumne River.

RATIONALE: Restoration of this corridor may improve rearing and migration of salmon from the Mokelumne and Cosumnes rivers. It is an opportunity to restore critical ecological processes including flood processes. Land elevations are suitable for tidal marsh and riparian restoration.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Evaluate the benefits of large-scale restoration of ecological processes on the Mokelumne.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

CALFED FY 97 and 98 Restoration Coordination Program funds were provided for acquisition of property along the lower Cosumnes River floodplain, community-based planning for the lower Mokelumne River watershed, construction of a 3.4 mile long, 400 foot levee setback on the Mokelumne River, and fish passage and fish screen improvements at Woodbridge Dam. FY 98 funds are being used to acquire McCormack-Williamson Tract

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ACTION 2: Restore tidal marsh and riparian habitats on McCormack-Williamson Tract in conjunction with other flood control measures.

RATIONALE: McCormack-Williamson, a highly flood-prone tract, is planned to be acquired in FY 99. Breaching McCormack-Williamson levees and restoring the tract to tidal marsh and riparian habitat in conjunction with other flood control efforts can relieve flooding pressure in the North Delta and improve habitat connectivity with the Cosumnes River floodplain. The tract is ideal for restoration to tidal and riparian habitats due to favorable land elevations.

Adaptive Management Considerations:

- Evaluate species colonization and succession.
- Evaluate the effects of natural process restoration on the evolution of riparian and tidal marsh habitats.

Current or Recent Restoration Activities or Investigations:

CALFED FY 97 Restoration Coordination Program funds were provided for acquisition and planning for restoration of 4,600 acres of property adjacent to the Cosumnes River and FY 98 funds are being used to acquire McCormack-Williamson Tract.

Sacramento County Flood Control Agency (SAFCA) and North Delta Flood Management will be consulted with on restoration efforts.

Action 3: Restore tidal marsh and riparian habitats on Georgiana Slough.

Rationale: Georgiana Slough is a major migration corridor for salmon. Substantial losses to salmon may occur due to predation and entrainment in the slough.

Adaptive Management Considerations:

- Evaluate benefits of restoring additional habitats in areas of high predation and entrainment

Current or Recent Restoration Activities or Investigations:

CALFED FY 97 Restoration Coordination Program funds were provided for restoration of SRA and riparian habitat along 2,000 ft of Georgiana Slough and 3,000 ft along the North Fork of the Mokelumne River on Tyler Island.

Action 4: Restore tidal marsh and riparian habitats on East Delta sloughs in conjunction with control of non-native aquatic plants.

Rationale: Backwater habitats are critical habitat for Delta native fishes. The dead-end sloughs tend to be clogged with non-native plants like water hyacinth. Restoration of riparian and wetland habitats will provide food and cover for native fishes. Restoration of these sloughs to benefit native fishes and plants must include eradication of non-native plants.

Adaptive Management Considerations:

- Evaluate native vs. non-native species use prior to and after restoration.

Action 5: Restore mid-channel islands and experiment with multiple techniques to allow natural sediment accretion to create new mid-channel islands and to protect mid-channel shallow-water habitat from boat wakes.

Rationale: Boat wakes and other stressors have significantly reduced the quantity and quality of mid-channel habitat. Multiple approaches should be used to protect existing mid-channel islands including limiting boat speeds in sensitive areas, installing wave attenuation structures, and also to encourage natural creation of islands.

Adaptive Management Considerations:

- Experiment with techniques to reduce erosion.
- Relationship to Delta sediment transport and depositional processes.

Current or Recent Restoration Activities or Investigations:

CALFED FY 97 funds were provided for a Delta sediment transport and availability study and for an in-channel islands restoration demonstration project (Little Tinsley, Webb Tract 3, 10 and 21).

Action 6: Develop and implement incentives for wildlife-friendly agriculture on Staten Island.

Rationale: Agricultural fields provide surrogate habitat for resident and migratory wildlife. Incentives could include not harvesting crop to improve forage value for wildlife or changing cropping patterns.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Monitor the use of lands in the incentive program by waterfowl and other species.
- Prepare an economic analysis of the most cost-effective means to fully support the agricultural industry while increasing the value for wildlife.
- Evaluate the relationship of bioenergetics and nutrients to migratory species

SAN JOAQUIN RIVER HABITAT CORRIDOR STAGE 1 ACTIONS

The San Joaquin is an important region for many native fishes including delta smelt, splittail and salmonids. Little shallow-water and riparian habitat remains on the San Joaquin River. The habitat that does remain in-channel and along levees is being degraded by wind and boat waves and levee maintenance. Water quality is poor for much of the year; there is low dissolved oxygen, high salinity, agricultural, residential and industrial contaminants, and water temperature is often elevated. Restoration opportunities are limited by the requirements of flood control, levee maintenance and dredging for ship navigation.

The Stage 1 proposal for the San Joaquin River is to restore a contiguous habitat corridor of tidal marsh, shaded riverine aquatic, riparian, and floodplain habitats. Reconnaissance studies should be initiated to evaluate opportunities for wetland and floodplain habitat in the river channel, on levees, on shallow levee berms, and for incorporation into the design of levee upgrades. CALFED Water Quality Program actions will also enhance the San Joaquin River restoration efforts in Stage 1.

ACTION 1: Conduct a feasibility study and, as appropriate, construct setback levees or shallow water berms along the San Joaquin River between Stockton and Mossdale where practicable to restore floodplain and riparian habitats and to increase channel capacity.

RATIONALE: Restoration of the San Joaquin River corridor can improve an important rearing and migration corridor for fishes and would provide information on our ability to reestablish floodplain processes in the Delta. There is the potential to utilize clean dredge material available from other areas in the Delta for in-channel restoration. As floodplains are restored splittail spawning and delta smelt and salmon usage will be evaluated.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Determine the feasibility of larger-scale restoration of riparian floodplain habitat and flood processes in the Delta.
- Evaluate species utilization of riparian and floodplain habitats, including benefits to splittail spawning and outmigrant San Joaquin salmon mortality.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

FY '97 Category III funds have been used to purchase fee title or easements on over 6,000 acres of land adjacent to the San Joaquin National Wildlife Refuge and have been used to help screen Banta-Carbona Irrigation District's diversion.

- Vernalis Adaptive Management Plan (VAMP)
- San Joaquin River Management Plan
- CALFED Levee Program
- Comprehensive Study

TARGETED RESEARCH: Evaluate species utilization of shallow-water wetlands on Venice Tip and McDonald Tip.

RATIONALE: Knowledge of the habitat preferences and utilization of shallow-water and floodplain habitats along the San Joaquin River by fish such as splittail (for spawning) and juvenile salmon (for rearing) is limited.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Determine San Joaquin River salmon smolt survival through Coded Wire Tag (CWT) (paired) experiments to assess baseline survival and the change in survival following restoration.

- Determine the residence time and rearing of San Joaquin River salmon, delta smelt, and other native species.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

CALFED FY 98 funds were provided for a study to identify the movement of adult chinook salmon in the lower Delta and lower San Joaquin River and evaluate the impacts of barrier operations and dissolved oxygen (DO) levels.

The DFG has conducted studies of chinook salmon smolt migration.

- VAMP

ACTION 2: Restore mid-channel islands and experiment with multiple techniques to allow natural sediment accretion to create new mid-channel islands and to protect mid-channel shallow-water habitat from boat wakes.

RATIONALE: Restoration of mid-channel islands may be the most effective means to improve habitat continuity along the San Joaquin. There is some existing mid-channel habitat (although diminished from boat wakes and channel modifications) that can be enhanced and a considerable amount of new habitat can be accommodated in the wide channel of the San Joaquin River. Existing mid-channel habitat can be augmented and new habitat created using Stockton Ship Channel dredge material and by encouraging natural sediment deposition.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Experiment with techniques to reduce erosion including the need to armor mid-channel islands.

- Relationship to Delta sediment transport and depositional processes.

- Identify species colonization and succession rates.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

CALFED FY 97 funds were provided for a Delta sediment transport and availability study and in-channel islands restoration demonstration projects (Little Tinsley, Webb Tract 3, 10 and 21).

- CALFED Levee Program

CENTRAL AND WEST DELTA STAGE 1 ACTIONS

Major features of the Central and West Delta are the flooded Frank's Tract and Big Break, the Sacramento and San Joaquin Rivers to Collinsville, and Delta islands, including many islands subsided over twenty feet in many places.

ACTION 1: Restore Frank's Tract to a mosaic of habitat types using clean dredge materials and natural sediment accretion. Control or eradicate introduced, nuisance aquatic plants.

RATIONALE: Frank's Tract is a flooded Delta island that can be restored to a mosaic of habitat types with no impact to agriculture. Frank's Tract levees were breached and the island has been flooded since the early 1900s. The deep bed of the island does not provide good quality habitat for native fish. Parts of the island bed could be elevated through a combination of dredge material placement, natural sediment accretion, and peat accumulation. Frank's Tract will be a functional component of the San Joaquin River corridor, a major fish rearing and migration area, as well as provide continuity with existing and proposed habitats in the western Delta. Developing the tract must also occur in conjunction with the control or eradication of introduced, nuisance aquatic plants for restoration to be most beneficial to native species.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Use multiple techniques to restore tidal habitats, including physical creation and natural sediment accretion.
- Use of dredge material to build wetlands.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

CALFED FY 98 funds were provided for planning and design of a 45 acre pilot tidal wetland restoration project in Frank's Tract. CALFED FY 97 funds were provided for a Delta sediment transport and availability study and in-channel islands restoration demonstration projects (Little Tinsley, Webb Tract 3, 10 and 21).

- CALFED Water Quality Program.

ACTION 2: Restore Decker Island to tidal wetlands.

RATIONALE: Restoration of tidal wetlands on Decker Island will provide habitat along the Sacramento River for migrant Sacramento salmon, for delta smelt, and many other fishes. Some or all of the dredge spoils located on Port of Sacramento half of the island may have to be removed to return the island to tidal elevations.

ACTION 3: Restore seasonal wetlands on Twitchell Island.

RATIONALE: Restoration of seasonal wetlands on Twitchell Island will provide habitat for migratory birds.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

CALFED FY 97 funds were provided for a tidal wetland and shaded riverine habitat demonstration project on Twitchell Island.

ACTION 4: Restore seasonal wetlands on Sherman Island.

RATIONALE: Restoration of seasonal wetlands on Sherman Island will provide habitat for migratory birds.

ACTION 5: Restore mid-channel islands in the Central and Western Delta.

RATIONALE: Mid-channel islands are important habitats that do not require acquisition of easements or land. Natural sediment transport processes can be used to create and maintain these habitats.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Use multiple techniques to protect existing habitats from boat wakes and use natural processes to create and maintain mid-channel habitats.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

CALFED FY 97 funds were provided for a Delta sediment transport and availability study and in-channel islands restoration demonstration projects (Little Tinsley, Webb Tract 3, 10 and 21).

- CALFED Levee Program and Conveyance element.

TARGETED RESEARCH: Evaluate species utilization of tidal wetlands on Big Break.

RATIONALE: Big Break is a flooded Delta tract with a large expanse of shallow-water habitat. The region can serve as a reference site for species utilization of shallow-water habitat.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

Evaluate the utilization, residence time, and rearing of San Joaquin River salmon, delta smelt, and other native species.

GENERAL DELTA STAGE 1 ACTIONS

ACTION 1: Prevent introductions of exotic species throughout the Bay-Delta system through multiple strategies including: educating the public of harmful impacts, outlawing the sale or transportation of nuisance species .

RATIONALE: Introduced species have had a profound, adverse impact on the entire Bay-Delta watershed and its species.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

CALFED FY 98 funds were provided to help develop the California State Management Plan for Aquatic Nuisance Species.

ACTION 2: Develop and implement control strategies for nuisance aquatic plants in the Delta.

RATIONALE: Introduced plants such as water hyacinth, Egeria, and Elodia have taken over large areas of the Delta, clogging water diversion intakes, hampering navigation, and providing vegetative cover preferred by non-native, predatory fishes. Control of these plants will have benefits to multiple beneficial uses of the Delta and may create conditions more favorable to native species.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Ability to control nuisance aquatic plants.
- Extent to which non-native plants favor non-native fishes over natives.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

- California Department of Boating and Waterways hyacinth and Egeria control programs.

ACTION 3: Evaluate the feasibility of re-vegetating levees on the Sacramento River between Verona and Collinsville (also listed under Sacramento Basin actions).

RATIONALE: Current levee maintenance operations remove vegetation from levees to maintain channel capacities. Providing riparian habitat along the levees could benefit several wildlife species and provide valuable SRA habitat for aquatic species. Because riparian vegetation reduces channel capacity by increasing roughness, re-vegetation must proceed with improved flood management that reduces peak flows in the basin, or with setback levees that increase channel capacity.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Evaluate local water temperatures in levee reaches with restored riparian habitat versus levee reaches without riparian habitat.
- Compare the quantity and quality of aquatic and riparian habitat for levee reaches with restored riparian habitat versus levee reaches without riparian habitat.

TARGETED RESEARCH: Evaluate the feasibility of propagating special-status Delta plants species.

RATIONALE: There are numerous plants in the Delta, including many endemic species, which are listed as threatened, endangered or other special-status. In many cases the ecological requirements of the plants are unknown. Experimental propagation may identify the species' ecological requirements. It may be more feasible to reintroduce propagated plants rather than replicate the habitat requirements to encourage natural recruitment of the plants.

TARGETED RESEARCH/PILOT PROJECT: Develop a sediment budget (fine and coarse sediments) for the Delta. Monitor the effects of different flow events and other upstream events on sediment transfer to the Delta.

RATIONALE: Sediment supply to the Delta has decreased due to a loss of coarse sediment supply caused by dams, gravel mining, disconnection of floodplains, and water quality improvement actions. This loss of sediment may contribute to diminishment of Delta wetland habitats.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

CALFED FY 97 funds were provided for a Delta sediment transport and availability study.

TARGETED RESEARCH/PILOT PROJECT: Determine the relationship between turbidity, primary productivity and potential eutrophication in the Bay and Delta.

RATIONALE: The relationship between turbidity, primary productivity and potential eutrophication in the Bay and Delta is not well understood. One hypothesis suggests that the decrease in turbidity from water quality improvement actions may increase light penetration, potentially leading to eutrophication.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

CALFED FY 97 Restoration Coordination Program funds were provided for an assessment of the capacity of different Delta habitats to support the nutritional requirements of the invertebrate biota that sustain upper trophic level organisms. Tasks include sampling to measure the quantity and quality of organic matter available among the different habitats and the amount derived from the primary sources, describing the nutritional budgets in the Delta, and developing nutrient-phytoplankton dynamic models.

TARGETED RESEARCH: Evaluate the effectiveness of pulse flows from the San Joaquin River to improve salmon outmigration and to move juvenile salmon away from the South Delta pumps.

RATIONALE: There are conflicting hypotheses as to survival of outmigrant San Joaquin salmon. Current management emphasizes pulse flows intended to reduce entrainment in South Delta pumps. Conversely, pulse flows may reduce juvenile salmon survival rates by pushing them away from rearing areas too quickly.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Track indicator of salmon smolt survival through CWT (paired) experiments to assess baseline survival and survival after pulse flows.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

VAMP is experimenting with pulse flows.

TARGETED RESEARCH/PILOT PROJECT: Evaluate residence time of rearing and outmigration of San Joaquin River juvenile salmon.

RATIONALE: The relationship of habitat quality, quantity and distribution to the residence time of chinook salmon on the San Joaquin River is unknown. Determining impact of additional habitat to residence time will help determine to what extent habitat restoration will benefit salmon and how restoration efforts can be optimized.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Conduct a distribution survey.
- Conduct a habitat preference and utilization survey.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

- VAMP

TARGETED RESEARCH/PILOT PROJECT: Evaluate the need to screen small diversions in the Delta.

RATIONALE: Unlike in riverine environments where unscreened diversions may affect a large portion of fish, the benefit of screening small diversions throughout the Delta is unknown. An evaluation should be undertaken to identify diversion effects on species and locations in the Delta where screening small diversions is a high priority.

DRAFT SUISUN MARSH AND NORTH SAN FRANCISCO BAY STAGE 1 ACTIONS

SUISUN MARSH STAGE 1 ACTIONS

ACTION 1: Restore tidal wetlands in Suisun Marsh and Van Sickle Island.

RATIONALE: Restoration of tidal wetlands can provide habitat for native fishes, rare plants and wildlife.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Evaluate the effects of tidal marsh restoration on estuarine productivity.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

CALFED FY 98 Restoration Coordination Program funds have been provided for planning for tidal restoration in Hill Slough West. FY 97 funds were also provided for restoration planning at the Martinez Regional Shoreline and for public outreach to reduce the use and disposal of toxic pesticides in Suisun Bay.

ACTION 2: Develop and implement control strategies for nuisance marsh and upland plants in the Suisun Marsh and North Bay.

RATIONALE: Introduced plants such as *Lepidium latifolium*, and English cordgrass have invaded the marshes of North Bay and Suisun Bay, displacing native plants and animals. Control of these plants may create conditions more favorable to native species.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Ability to control nuisance plants.
- Extent to which non-native plants favor non-native fishes over natives.

TARGETED RESEARCH: Develop and implement a plan to analyze the mechanisms underlying the X2 relationships.

RATIONALE: Current management of the Bay-Delta system is based largely on a salinity standard (the "X2" standard). This standard is based on empirical relationships between various species of fish and invertebrates and X2 (or freshwater flow in the estuary). As with all empirical relationships, these are not very useful to predict how the system will respond after it has been altered by various actions in the Delta, including altered conveyance facilities. This implies a need to determine the underlying mechanisms of the X2 relationships so that the effectiveness of various actions in the Delta can be put in context with this ecosystem-level restorative measure.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

IEP Estuarine Ecology Team conducts ongoing studies of the relationship of fish and X2.

TARGETED RESEARCH: Study the effects of *Potamocorbula amurensis* on the foodweb and, as appropriate, develop and implement control strategies.

RATIONALE: *Potamocorbula* have decreased estuarine primary productivity, the effects of which have traveled throughout the foodweb, including upper trophic level species. Restoration of marshes may offset some of this lost productivity, but may not be great enough to overcome the effects of the clam unless its population abundance is reduced. There are presently no known, viable control methods for this species.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Extent to which *Potamocorbula* are limiting to restoration of native species.
- Extent to which effects of *Potamocorbula* can be overcome with other measures.
- Ability to control *Potamocorbula*.

NORTH BAY STAGE 1 ACTIONS

ACTION 1: Develop and implement a ballast water management program to halt the introduction of introduced species into the estuary.
RATIONALE: The single largest source of nuisance species in the Bay-Delta is from ship ballast water discharged to San Francisco Bay.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

CALFED FY 97 funds were provided for an education and outreach program to prevent introduction of introduced species from ballast water.

ACTION 2: Acquire and restore floodplains and tidal marsh along the Napa/Sonoma Marsh.

RATIONALE: Protection, enhancement and restoration of North Bay tidal marsh and floodplain will benefit clapper rail, black rail, salt marsh harvest mouse and other salt marsh species. In high outflow years, Delta fishes also utilize North Bay habitats.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Evaluate species utilization of restored habitats.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

CALFED FY 97 Restoration Coordination Program funds were provided for management support and assist in implementing restoration actions in the Sonoma Creek Watershed and the Napa River watershed.

ACTION 3: Acquire and restore floodplains and tidal marsh along the Petaluma Marsh.

RATIONALE: Protection, enhancement and restoration of North Bay tidal marsh and floodplain will benefit clapper rail, black rail, salt marsh harvest mouse and other salt marsh species. In high outflow years, Delta fishes also utilize North Bay habitats.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Evaluate species utilization of restored habitats.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

CALFED FY 97 and 98 Restoration Coordination Program funds were provided for the acquisition, protection and restoration of 181 acres of tidal wetlands adjacent to the Petaluma River and for restoration planning on the Hamilton Wetland near Novato. Funds were also provided for Petaluma River watershed restoration planning.

ACTION 4: Acquire and restore floodplains and tidal marsh along the Napa River.

RATIONALE: Protection, enhancement and restoration of North Bay tidal marsh and floodplain will benefit clapper rail, black rail, salt marsh harvest mouse and other salt marsh species. In high outflow years, Delta fishes also utilize North Bay habitats.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Evaluate species utilization of restored habitats.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

CALFED FY 97 and 98 Restoration Coordination Program funds were provided for acquisition and restoration of over 1,000 acres of wetlands adjacent to the Napa River and for management support and assist in implementing restoration actions in the Sonoma Creek Watershed and the Napa River watershed.

ACTION 5: Develop and implement control strategies for nuisance marsh and upland plants in the Suisun Marsh and North Bay.

RATIONALE: Introduced plants such as *Lepidium latifolium*, and English cordgrass have invaded the marshes of North Bay and Suisun Bay, displacing native plants and animals. Control of these plants may create conditions more favorable to native species.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Ability to control nuisance aquatic plants.
- Extent to which non-native plants favor non-native fishes over natives.

TARGETED RESEARCH/PILOT PROJECT: Study the effects of *Potamocorbula amurensis* on the foodweb and, as appropriate, develop and implement control strategies.

RATIONALE: *Potamocorbula* have decreased estuarine primary productivity, the effects of which have traveled throughout the foodweb, including upper trophic level species. Restoration of marshes may offset some of this lost productivity, but may not be great enough to overcome the effects of the clam unless its population abundance is reduced. There are presently no known, viable control methods for this species.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Extent to which *Potamocorbula* are limiting to restoration of native species.
- Extent to which effects of *Potamocorbula* can be overcome with other measures.
- Ability to control *Potomocorbula*.

DRAFT SACRAMENTO RIVER BASIN STAGE 1 ACTIONS

SACRAMENTO RIVER BASIN DESCRIPTION

The Sacramento River and its tributaries are a vital component of the Bay-Delta ecosystem. As California's largest river, the Sacramento River provides the bulk of the Bay-Delta water supply, and it contributes approximately 80% of the inflow to the Delta. Despite human disturbances that have disrupted ecological processes in the basin, the Sacramento River and its tributaries continue to provide important spawning, rearing, nesting, and wintering habitat for a variety of species.

Factors most influencing the ecological health of tributaries in the Sacramento River Basin include:

1. Reductions in the magnitude, frequency, duration, and variability of river flows because of dam construction and diversions.

2. Reductions in the amount of coarse sediment available to create and maintain important aquatic and riparian habitat because of dam construction, aggregate mining in active river channels, and relatively narrow levees that increase shear stress applied to channel bed sediments.

3. Reductions in the amount of spawning and rearing habitat available to anadromous fish because of dams that block access to historical habitat ranges.

4. Reductions in the amount and contiguity of riparian habitat because of urban and agricultural encroachment and levee construction.

5. Elevated water temperatures because of dam construction, diversions, return flows, and the loss of riparian habitat.

6. Degradation of spawning and rearing habitat because of excessive loads of fine sediments and urban, industrial, and agricultural discharges of pollutants.

7. Loss of river-floodplain interactions because of levee construction.

8. Stranding of adult and juvenile anadromous and resident fish because of straying and the lack of hydraulic connectivity to river channels as flood waters recede.

9. Loss of seasonal wetlands because of levee construction and urbanization.

STAGE 1 APPROACH

Local watershed groups are active in many of the tributary watersheds of the upper Sacramento River basin. The ERP will work with these local watershed groups—as well as local, state and federal agency personnel—to implement and monitor Stage 1 actions.

Since many of the tributaries in the Sacramento River basin are regulated by large dams, it will be necessary to conduct targeted research and to monitor Stage 1 actions to determine the optimal combinations of flow and sediment that will best restore aquatic and riparian habitat in light of the regulated flow regime.

The primary species that will benefit from Stage 1 actions implemented in the upper Sacramento River basin are spring-run chinook salmon, fall-run chinook salmon, and steelhead trout. Both spring-run chinook salmon and steelhead trout have relatively stringent habitat requirements that upper basin tributaries can satisfy. Fall-run chinook salmon populations are distributed more widely throughout the Central Valley because of their less stringent habitat requirements. Populations of white and green sturgeon, American shad, striped bass and splittail will benefit primarily from actions implemented in lower Sacramento River Basin tributaries.

Stage 1 actions also focus on two tributaries that have been selected as demonstration streams: Clear Creek and Deer Creek. The objective for each demonstration stream is to fully restore the tributary within existing constraints (such as large dams) so that each becomes a healthy, resilient haven of continuous riparian and aquatic habitat to optimize endemic plant and animal populations. Restoring these two tributaries into healthy riparian corridors during Stage 1 will help recover and maintain large populations of fish species to endure severe ecological conditions such as droughts. Both of these tributaries offer high-quality habitat in upstream reaches to satisfy the relatively stringent habitat requirements of spring-run chinook salmon and steelhead trout. Both creeks also provide habitat for fall-run chinook salmon in their lower reaches.

MAINSTEM SACRAMENTO RIVER STAGE 1 ACTIONS

ACTION 1: Protect, enhance and restore the meander belt between Red Bluff and Chico Landing.

RATIONALE: The Sacramento River still meanders freely for more than 50 miles between Red Bluff and Chico Landing, dynamically eroding existing banks and forming new banks. Meandering rivers help to sustain several critical ecological processes including gravel recruitment and transport, riparian succession, and the creation of diverse and valuable aquatic habitat such as cutbanks, pools, and spawning riffles. The SB 1086 planning process has developed the Upper Sacramento River Fisheries and Riparian Habitat Management Plan and the Sacramento River Conservation Area Handbook, which delineates a conservation area and provides guidelines for preserving and restoring riparian and aquatic habitat in the upper Sacramento River. Purchasing fee title, flood easements, or conservation easements on riparian lands within the conservation area will provide the river with room to meander and help to reduce flood damage by relocating economic activities and development from vulnerable floodplains.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Compare the quantity and quality of aquatic and riparian habitat for freely meandering river reaches and reaches protected by rip-rap.
- Determine the rate of gravel recruitment to the river from eroding banks.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

FY '97 and '98 CALFED Restoration Coordination Program funds have been provided to allow the acquisition of fee title or easement on several hundred acres of riparian land along the upper Sacramento River. Additional funds have been provided to actively restore riparian habitat on selected lands.

ACTION 2: In conjunction with the USACE and Reclamation Board Comprehensive Study, evaluate the feasibility of setting back levees on the Sacramento River between Chico Landing and Verona.

RATIONALE: The Army Corps of Engineers, in conjunction with DWR and the State Reclamation Board, is currently engaged in a comprehensive study to enhance flood management in the Central Valley by evaluating alternative flood management strategies such as floodplain storage. Setting back levees along the Sacramento River could reconnect the river with a portion of its floodplain, with the attendant ecological benefits, while simultaneously reducing flood risk. Setting back levees would enlarge the channel capacity to transport flood flows and provide floodplain storage, thereby reducing flood risk by reducing the pressure placed upon levees and by reducing peak flows.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

If it is feasible to setback levees, then:

- monitor and compare the amount and quality of aquatic and riparian habitat available in reaches narrowly confined by levees and reaches where the creek can meander within setback levees.
- monitor rates of gravel recruitment, transport, and retention in leveed vs. non-leveed reaches.
- compare flood stage levels and associated flood risk with historical levels for a given amount of inflow.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

The U.S. Army Corps of Engineers, California Reclamation Board and the Department of Water

Resources are conducting the Sacramento and San Joaquin River Basins Comprehensive Study to reduce flood damage and integrate ecosystem restoration. The measures that will be identified through the Comprehensive Study may have the potential to help meet or be compatible with the goals and objectives for the Ecosystem Restoration Program.

ACTION 3: Evaluate the feasibility of re-vegetating levees on the Sacramento River between Verona and Collinsville (also listed under Delta actions).

RATIONALE: Current levee maintenance operations remove vegetation from levees to maintain channel capacities. Providing riparian habitat along the levees could benefit several wildlife species and provide valuable SRA habitat for aquatic species. Because riparian vegetation reduces channel capacity by increasing roughness, re-vegetation must proceed with improved flood management that reduces peak flows in the basin, or with setback levees that increase channel capacity.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Evaluate local water temperatures in levee reaches with restored riparian habitat versus levee reaches without riparian habitat.
- Compare the quantity and quality of aquatic and riparian habitat for levee reaches with restored riparian habitat versus levee reaches without riparian habitat.

ACTION 4: Evaluate the need to screen all diversions smaller than 100 cfs on both the mainstem Sacramento River and selected tributaries.

RATIONALE: There are numerous small diversions of water from the Sacramento River and its tributaries. While many large diversions have fish screens to reduce the entrainment of fish, many small diversions are unscreened. The individual and cumulative losses of fish from these small diversions are unknown. Estimating the entrainment losses at small diversions, and comparing the effectiveness of fish screens with changes in the timing or location of small unscreened diversions will help to quantify and balance the benefits of potentially reduced entrainment with the costs of fish screening facilities. (CVPIA actions include screening all diversions on the Sacramento River greater than 250 cfs.)

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Evaluate the effectiveness of timing diversions to reduce impacts upon juvenile anadromous fish
- Study the loss of juvenile anadromous fish to entrainment in smaller diversions

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

FY '98 CALFED Restoration Coordination Program funds have been provided to study entrainment losses at twin diversions (20 cfs each) in which one diversion is screened and the other is unscreened.

ACTION 5: Evaluate and implement alternative structural and operational actions to reduce or prevent fish from straying into the Colusa Basin Drain with low habitat value.

RATIONALE: Agricultural return flows draining from the Colusa Drain into the Sacramento River can attract adult anadromous fish migrating upstream to spawn. There is no spawning habitat in the Colusa Drain, so adults that stray into the Colusa Drain subsequently become stranded and are lost to the spawning population. Creating a migration barrier will prevent adult anadromous fish from straying into the Drain.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Compare numbers of anadromous fish stranded in Colusa Drain before and after implementation of various alternatives.

DEER CREEK STAGE 1 ACTIONS

Deer Creek has the potential to be a demonstration stream, representative of northern Sacramento Valley tributaries that drain the Cascade and Sierra Nevada Ranges. Demonstration streams will be selected for large-scale implementation of restoration actions to significantly restore ecological processes and resources while simultaneously testing restoration hypotheses as part of an adaptive management approach. The objective for demonstration streams is to fully restore the tributary within existing constraints (such as large dams) by accounting for all major stressors that affect the ecological health of the tributary. Lessons learned restoring Deer Creek will help the design and refinement of future restoration actions on the Deer Creek and other Bay-Delta tributaries.

Deer Creek has potential as a demonstration stream for several reasons. It has a relatively undeveloped watershed, which reduces human impacts upon the ecosystem. Deer Creek also provides habitat for a number of special-status species including, spring-run and fall-run chinook salmon and steelhead trout; indeed Deer Creek presents one of the best opportunities for recovering populations of spring-run chinook salmon because of the amount of holding and spawning habitat available in the upstream reaches. Deer Creek may also provide an opportunity to demonstrate the value of restoring habitat by restoring ecological processes rather than continued management intervention. Levees border the lower 10 miles of the creek channel, inhibiting channel meander, disrupting sediment transport, preventing floodplain inundation, and reducing riparian and aquatic habitat. Setting back or breaching levees could yield valuable information about restoring fluvial processes and associated habitats. Deer Creek may also demonstrate the benefits of alternative flood management if it is feasible to setback Deer Creek levees, thereby providing more floodplain storage of flood flows.

Such restoration of ecological processes will require broad public support from local stakeholders. CALFED will work with the local watershed conservancy and local landowners to pursue restoration opportunities in Deer Creek.

ACTION 1: Evaluate the feasibility of setting back levees along portions of Deer Creek to re-connect the creek channel with a portion of its floodplain and to allow the creak to meander more freely. Set back levees if feasible.

RATIONALE: In the interest of flood control, the Army Corps of Engineers channelized and constructed levees along Deer Creek in the 1940s. These levees, in addition to private levees, separate the creek channel from its floodplain, prevent the creek from meandering, and prevent the formation of valuable aquatic habitat associated with naturally meandering streams. The relatively narrow levees also concentrate flow and increase shear stress on the channel bed so that spawning gravels are often flushed from the creek channel during high flows. During the '97 floods, Deer Creek levees were breached in several places, which provided floodplain storage of flood flows that attenuated downstream flood peaks. Setting back levees along Deer Creek could improve aquatic and riparian habitat by providing the creek more room to meander, which helps to create diverse aquatic habitat such as cutbanks (valuable to rearing juvenile fish), pools (valuable to spring-run chinook salmon and steelhead trout holding through warm summer temperatures), and point bar deposits (valuable for colonization by riparian plant species). Setback levees could also increase the amount of floodplain available to store floodflows, helping to reduce downstream flood risk by reducing the height of flood peaks. It will be necessary to study the feasibility of setting back Deer Creek levees to determine the expense and potential impacts to flood management in the lower reaches. The feasibility study would also need to account for the need to purchase floodplain land or flood easements from private landowners in the vicinity of the setback levees.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- If it is feasible to setback levees, then monitor and compare the amount and quality of aquatic and riparian habitat available in reaches narrowly confined by levees and reaches where the creek can meander within setback levees.
- If it is feasible to setback levees, then monitor rates of gravel recruitment, transport, and retention in leveed vs. non-leveed reaches.
- If it is feasible to setback levees, then compare flood stage levels and associated flood risk with historical levels for a given amount of inflow.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

The Deer Creek Watershed Conservancy received FY 97 Funds to develop a Deer Creek watershed strategy.

There is a potential future linkage with the Comprehensive Study.

ACTION 2: Re-connect the creek channel with a portion of its floodplain by purchasing flood easements from willing sellers.

RATIONALE: Levees along Deer Creek were breached during the flood of 1997. Purchasing flood easements from willing sellers along Deer Creek could help reconnect the stream with a portion of its floodplain while simultaneously providing flood storage to attenuate downstream peaks.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- If it is feasible to re-connect the stream channel with a portion of its floodplain through setback levees or flood easements, then monitor the amount of floodplain storage and rates of water percolation to groundwater.
- Monitor the flow of nutrients from floodplain lands to the stream channel.
- Determine the extent to which anadromous fish species use floodplain land for refuge, spawning, or rearing.
- Monitor the level of stranding of adult and juvenile anadromous fish.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

The Deer Creek Watershed Conservancy received FY 97 Funds to develop a Deer Creek watershed strategy.

There is a potential future linkage with the Comprehensive Study.

ACTION 3: Acquire water from willing sellers or develop alternative water supplies to provide sufficient instream flows to allow the upstream migration of adult anadromous fish. (Note: this water will be part of the 100 TAF of water purchased to improve flows in the Sacramento and San Joaquin Basins.)

RATIONALE: In the past, water diversions from lower Deer Creek have de-watered the stream channel and prevented the upstream migration of adult anadromous fish. In recent years, landowners have worked with DFG and DWR to provide instream flows, in part by developing alternative water supplies for the water diverters. To ensure long-term water supplies that will provide adequate passage flows of suitable temperatures, it will be necessary to acquire water from willing sellers or to work with local diverters to develop alternative water supplies that will allow more water to stay in the channel.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Determine the flows necessary to provide fish passage over obstacles
- Evaluate the relationship between flows and water temperatures
- Determine the flows necessary to transport and cleanse spawning gravels.

ACTION 4: Protect and restore riparian habitat to create a continuous riparian corridor in the valley reach of Deer Creek.

RATIONALE: In addition to providing habitat for a variety of wildlife species, riparian buffers can help to trap fine sediments from reaching the stream channel. Riparian vegetation can also help reduce stream temperatures by providing shading, especially for pools that adult spring-run chinook salmon and steelhead trout use for holding during the summer. Riparian vegetation also helps create cutbanks that provide important rearing habitat for juvenile salmonids. Riparian vegetation also provides nutrients and woody debris to the creek channel, helping to stimulate food production and to provide diverse aquatic habitat.

Riparian vegetation can also help to retain stormwater runoff, helping to reduce peak flows in the channel and the concomitant flood risk to downstream reaches. Retention of stormwater runoff can also help increase the amount of water that percolates into groundwater aquifers, which can in turn help to increase groundwater discharge to the stream channel that enhances base flows.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

FY '97 and '98 CALFED Restoration Coordination Program funds were provided to allow the purchase of fee title or conservation easement on riparian properties that will protect existing riparian habitat or allow restoration of degraded or absent riparian habitat.

ACTION 5: In conjunction with the local watershed conservancy and local, state, and federal agencies, develop an implement a watershed management plan to reduce the transport of fine sediments to the creek channel, to protect and restore riparian habitat to improve base flows, to reduce water temperatures, and to reduce the ecological risk associated with catastrophic events.

RATIONALE: Activities in the Deer Creek watershed can increase erosion rates and introduce excessive loads of fine sediments to the creek channel. Untimely pulses of fine sediments can clog or bury spawning gravels, suffocating the incubating eggs of anadromous fish or preventing salmonid fry from emerging from the gravels. Fine sediments can also fill in the deep water pools that adult spring-run chinook salmon and steelhead trout require to survive high summer temperatures. Developing a watershed management plan to manage road construction, timber harvest and cattle grazing in the watershed can help prevent the introduction of too many fine sediments to the creek channel. Managing the fuel load in the watershed can also help prevent catastrophic wildfires that can denude vast areas of vegetation.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- determine the relative contribution of fine sediments to the channel from natural and human disturbances in the watershed
- evaluate how the restoration of upland and riparian habitat affects the transport of fine sediments to the stream channel
- as riparian vegetation is restored, evaluate the volume of stormwater runoff retained, rates of water percolation to groundwater, and groundwater discharge to the channel during base flow
- as riparian vegetation is restored, evaluate its effects upon water temperatures

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

FY '97 and '98 CALFED Restoration Coordination Program funds were provided to help manage erosion caused by road construction in the watershed. Funds have also been provided for the development of a watershed management plan that includes:

- managing grazing and meadow restoration to help prevent erosion in the watershed,
- managing of fuel loads to help prevent catastrophic wildfires, and
- developing a contingency plan to address spills of hazardous material into the creek channel.

CLEAR CREEK STAGE 1 ACTIONS

Clear Creek has the potential to be a demonstration stream, representative of northern Sacramento Valley tributaries that drain the Coast Range. Demonstration streams will be selected for large-scale implementation of restoration actions to significantly restore ecological processes and resources while simultaneously testing restoration hypotheses as part of an adaptive management approach. The objective for demonstration streams is to fully restore the tributary within existing constraints (such as large dams) by accounting for all major stressors that affect the ecological health of the tributary. Lessons learned restoring Clear Creek will help the design and refinement of future restoration actions on Clear Creek and other Bay-Delta tributaries.

Clear Creek has potential as a demonstration stream for several reasons. Clear Creek provides habitat for several special-status species, including spring-run and fall-run chinook salmon and steelhead trout. Whiskeytown Reservoir offers the potential to release flows of cold water, which is important for providing fish passage and maintaining holding and rearing habitat for special-status fish species. Much of the land surrounding lower Clear Creek is publicly owned and managed by state and federal agencies, which generally provides greater restoration opportunities by minimizing conflicts with private land use. For instance, there is relatively little development along lower Clear Creek so that allowing the creek to meander across a portion of its floodplain will not require displacing homes or infrastructure. Clear Creek may also offer the opportunity to release channel maintenance flows that reactivate fluvial processes as a means of sustaining habitat conditions. Clear Creek also has an active watershed group composed of local landowners and local, state and federal agency personnel, which can help to catalyze restoration efforts.

ACTION 1: Remove the McCormick-Saeltzer diversion dam to provide greater access to upstream habitat, to restore sediment transport processes, and to reduce predator habitat.

RATIONALE: Saeltzer Dam is located on Clear Creek roughly 6 miles upstream of the confluence with the Sacramento River, and approximately 10 miles downstream of the much larger Whiskeytown Reservoir. The dam is approximately 15 feet tall, so during periods of low flow, it impedes the upstream migration of adult anadromous fish. In the past, the dam has been equipped with fish ladders to provide upstream passage, but they have been largely ineffective. The dam also interrupts the transport of sediment by trapping coarse sands and gravels derived from upstream reaches, thereby depriving lower Clear Creek of important spawning gravels. Purchasing the water right and removing the dam, or replacing the dam with a screened diversion, can restore fish access to upstream habitat and the transport of coarse sediments to downstream reaches.

The upstream reaches of Clear Creek between Whiskeytown Dam and Saeltzer Dam provide habitat that can meet the relatively stringent needs of adult spring-run chinook salmon and steelhead trout, two species that require deep cold-water pools to survive high summer temperatures as they hold in the creek waiting to spawn. Since there are few streams in the Central Valley that can provide the summer holding habitat that spring-run chinook and steelhead trout need, improving access to nearly 10 miles of upstream habitat in Clear Creek is an important opportunity.

Fall-run chinook salmon generally spawn in the lower reaches of Clear Creek downstream of Saeltzer Dam, so the dam does not impede their access to spawning habitat. However, the dam does degrade downstream spawning habitat by trapping gravel that would otherwise help replenish and maintain spawning habitat in lower Clear Creek. Replacing the current dam with an alternative diversion structure that allows the transport of sediment will allow gravels that have accumulated behind the dam to be transported to downstream reaches of the creek and eventually to the Sacramento River.

By impounding water at low flows, the dam can also provide warm water habitat that favors non-native or invasive species that prey upon rearing or emigrating juvenile salmonids.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Compare use of available spawning habitat upstream of the dam by anadromous fish before and after re-configuration of the diversion facilities.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

Both CVPIA and FY '97 CALFED Restoration Coordination Program funds have been provided to allow the evaluation, design and construction of an alternative water diversion that would allow removal of Saeltzer Dam.

ACTION 2: Augment the supply of spawning-sized gravel in the Clear Creek channel.

RATIONALE: Clear Creek has been deprived of its historical sediment load by dams that trap coarse sediment from upstream sources and by extensive gravel mining in the lower reaches of the creek. In recent years, gravel mining operations have been moved from the active channel by a county ordinance, which has improved downstream aquatic habitat. However, Whiskeytown Reservoir will continue to trap all of the coarse sediment derived from the upper watershed. Several gravel augmentation projects have been completed or proposed for Clear Creek; however, as high flows transport introduced gravels down the creek channel into the Sacramento River, it will be necessary to introduce additional gravels to the channel. During Stage 1, it will be important to monitor the availability of spawning gravels and to augment gravel supplies as needed.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Monitor the transport and deposition of spawning gravels.
- Evaluate introduced spawning gravels to see if they are suitably sized for spawning habitat for anadromous fish.

ACTION 3: Fill instream mining pits and isolate floodplain gravel mining pits from the active channel.

RATIONALE: The extraction of gravel from instream and floodplain deposits has formed large pits that can strand juvenile salmonids emigrating from the creek and eliminate a clearly defined channel for adult upstream migration. The instream pits and captured floodplain pits provide warm water habitat for non-native and invasive species that prey upon juvenile salmonids attempting to emigrate from the creek. Filling instream and captured floodplain pits, or bolstering levees and berms that protect floodplain mining pits, will reduce the warm water habitat that favors predators.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Monitor the transport and deposition of spawning gravels.
- Evaluate introduced spawning gravels to see if they are suitably sized for spawning habitat for anadromous fish.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

FY '98 CALFED Restoration Coordination Program funds were provided to fill in and isolate downstream gravel pits to prevent the predation and stranding of juvenile anadromous fish by using dredger tailings from upstream reaches which will allow the restoration or riparian habitat on the upper reach.

ACTION 4: Provide sufficient scouring flows to periodically remove vegetation that has encroached within the active channel in lower Clear Creek, and mechanically remove vegetation if necessary.

RATIONALE: Whiskeytown Dam has altered the Clear Creek flow regime by reducing peak flows. As a result, riparian vegetation has encroached into the active creek channel since the reduced peak flows are insufficient to naturally scour the vegetation. The encroaching vegetation helps to prevent the creek from meandering much like levees do. A naturally meandering river helps to create and maintain important aquatic habitat such as cutbanks and pools (valuable to rearing juvenile fish) and point bar deposits (valuable for colonization by riparian plant species). Periodically increasing peak flows in the downstream channel will provide the energy required to drive channel migration and to restore the natural process of riparian succession, which can provide more diverse aquatic and riparian habitat. Much like levees, vegetation that has encroached upon the active channel can confine flows to a relatively narrow channel, thereby increasing water velocity and the shear stress applied to sediments on the channel bed. This increased shear stress can flush spawning gravels downstream, thereby depriving the local reach of important habitat material.

Since years of reduced peak flows have allowed vegetation to firmly establish in the active channel, it may be necessary to mechanically remove encroaching vegetation to assist the natural scouring process.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Determine flows necessary to scour encroaching vegetation from the active channel.
- Determine channel maintenance flows necessary to scour and transport sediment to provide surfaces for riparian vegetation succession.

ACTION 5: Refine and implement a watershed management plan to reduce the transport of fine sediment to the creek channel and to protect and restore riparian habitat in conjunction with local landowners and local, state and federal agencies active in the watershed.

RATIONALE: Activities in the Clear Creek watershed can increase erosion rates and introduce excessive loads of fine sediments to the creek channel. Untimely pulses of fine sediments can clog or bury spawning gravels, suffocating the incubating eggs of anadromous fish or preventing salmonid fry from emerging from the gravels. Fine sediments can also fill in the deep water pools that adult spring-run chinook salmon and steelhead trout require to survive high summer temperatures. Developing a watershed management plan to manage road construction, timber harvest and cattle grazing in the watershed can help prevent the introduction of too many fine sediments to the creek channel. Managing the fuel load in the watershed can also help prevent catastrophic wildfires that can denude vast areas of vegetation.

Current land use practices in the upper watershed increase rates of erosion, introducing excessive loads of fine sediments that degrade habitat in the upper tributaries of Clear Creek. Re-introducing steelhead trout above Whiskeytown Reservoir will require better management of activities to decrease the transport of fine sediments to stream channels.

Developing a watershed management plan that protects and restores riparian vegetation can provide several ecological benefits. In addition to providing habitat for a variety of wildlife species, riparian buffers can help to trap fine sediments from reaching the stream channel. Riparian vegetation can also help reduce stream temperatures by providing shading, especially for pools that adult spring-run chinook salmon and steelhead trout use for holding during the summer. Riparian vegetation also helps create cutbanks that provide important rearing habitat for juvenile salmonids. Riparian vegetation also provides nutrients and woody debris to the creek channel, helping to stimulate food production and to provide diverse aquatic habitat.

Riparian vegetation can also help to retain stormwater runoff, helping to reduce peak flows in the channel and the concomitant flood risk to downstream reaches. Retention of stormwater runoff can also help increase the amount of water that percolates into groundwater aquifers, which can in turn help to increase groundwater discharge to the stream channel that enhances base flows.

An active watershed management group, the Lower Clear Creek Watershed Conservancy, has already developed a watershed management plan that will help to guide restoration efforts in lower Clear Creek.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- determine the relative contribution of fine sediments to the channel from natural and human disturbances in the watershed
- evaluate how the restoration of upland and riparian habitat affects the transport of fine sediments to the stream channel
- as riparian vegetation is restored, evaluate the volume of stormwater runoff retained, rates of water percolation to groundwater, and groundwater discharge to the channel during base flow
- as riparian vegetation is restored, evaluate its effects upon water temperatures

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

NRCS conducted an evaluation of the Lower Clear Creek watershed.

ACTION 6: Evaluate the need to augment flows in Clear Creek and acquire water from willing sellers. (This water will be part of the 100 TAF acquired to improve streamflow in the Sacramento and San Joaquin Basins.)

RATIONALE: Whiskeytown Reservoir provides a source of water to help provide minimum instream flows necessary to allow fish passage over obstacles and to reduce stream temperatures. CVPIA provides for flows necessary to maintain ecological resources. It may be necessary to augment these flows to achieve more optimal conditions by purchasing water from willing sellers.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Determine the flows necessary to provide fish passage over obstacles
- Evaluate the relationship between flows and water temperatures
- Determine the flows necessary to transport and cleanse spawning gravels

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

CVPIA allocates flow releases from Whiskeytown and Clair Hill Reservoirs.

MILL CREEK STAGE 1 ACTIONS

Mill Creek is a relatively healthy tributary since its upper reaches flow through an inaccessible, undeveloped canyon. Since it drains volcanic lands surrounding Mount Lassen, Mill Creek has relatively higher flows throughout the summer and fall because it is fed by underground springs of cold water, which helps to provide important holding habitat for spring-run chinook salmon and steelhead trout. Indeed, Mill Creek is one of the few Central Valley streams that provides appropriate habitat conditions for spring-run chinook salmon and steelhead trout.

ACTION 1: Reduce or eliminate the need to reconstruct Clough Dam by providing an alternative diversion structure that does not impede the migration of anadromous fish.

RATIONALE: Clough Dam is one of three diversion structures on Mill Creek that can delay or impede the migration of anadromous fish. Clough Dam was breached during the floods of '97, providing an opportunity to remove the dam by developing an alternative diversion structure that does not impede fish migration.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

Since the dam has already been breached naturally, there is relatively little opportunity to design an adaptive management experiment to improve our knowledge of local ecological relationships and functions related to fish obstruction, other than continuing to monitor escapement rates and compare against historical data.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

FY '98 CALFED Restoration Coordination Program Funds have been provided for the design, evaluation and construction of an alternative diversion structure that will eliminate the need to reconstruct the dam.

ACTION 2: Acquire water from willing sellers or develop alternative water supplies to provide sufficient instream flows to allow the upstream migration of adult anadromous fish. (Note: this water will be part of the 100 TAF of water purchased to improve stream flows in the Sacramento and San Joaquin Basins.

RATIONALE: In the past, water diversions from lower Mill Creek have de-watered the stream channel and prevented the upstream migration of adult anadromous fish. In recent years, landowners have worked with DFG and DWR through the Four Pumps Agreement to provide instream flows, in part by developing alternative water supplies for the water diverters. To ensure long-term water supplies that will provide adequate passage flows of suitable temperatures, it will be necessary to acquire water from willing sellers or to work with local diverters to develop alternative water supplies that will allow more water to stay in the channel.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Determine the flows necessary to provide fish passage over obstacles
- Evaluate the relationship between flows and water temperatures
- Determine the flows necessary to transport and cleanse spawning gravels

ACTION 3: In conjunction with the local watershed conservancy and local, state, and federal agencies, develop and implement a watershed management plan to reduce the transport of fine sediments to the creek channel, to protect and restore riparian habitat to improve base flows, and to reduce water temperatures.

RATIONALE: Activities in the Mill Creek watershed can increase erosion rates and introduce excessive loads of fine sediments to the creek channel. Untimely pulses of fine sediments can clog or bury spawning gravels, suffocating the incubating eggs of anadromous fish or preventing salmonid fry from emerging from the gravels. Fine sediments can also fill in the deep water pools that adult spring-run chinook salmon and steelhead trout require to survive high summer temperatures. Developing a watershed management plan to manage road construction, timber harvest and cattle grazing in the watershed can help prevent the introduction of too many fine sediments to the creek channel. Managing the fuel load in the watershed can also help prevent catastrophic wildfires that can denude vast areas of vegetation.

Developing a watershed management plan that protects and restores riparian vegetation can provide several ecological benefits. In addition to providing habitat for a variety of wildlife species, riparian buffers can help to trap fine sediments from reaching the stream channel. Riparian vegetation can also help reduce stream temperatures by providing shading, especially for pools that adult spring-run chinook salmon and steelhead trout use for holding during the summer. Riparian vegetation also helps create cutbanks that provide important rearing habitat for juvenile salmonids. Riparian vegetation also provides nutrients and woody debris to the creek channel, helping to stimulate food production and to provide diverse aquatic habitat.

Riparian vegetation can also help to retain stormwater runoff, helping to reduce peak flows in the channel and the concomitant flood risk to downstream reaches. Retention of stormwater runoff can also help increase the amount of water that percolates into groundwater aquifers, which can in turn help to increase groundwater discharge to the stream channel that enhances base flows and helps reduce water temperatures.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- determine the relative contribution of fine sediments to the channel from natural and human disturbances in the watershed
- evaluate how the restoration of upland and riparian habitat affects the transport of fine sediments to the stream channel
- as riparian vegetation is restored, evaluate the volume of stormwater runoff retained, rates of water percolation to groundwater, and groundwater discharge to the channel during baseflow
- as riparian vegetation is restored, evaluate its effects upon water temperatures

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

FY '97 and '98 CALFED Restoration Coordination Program funds were provided to help manage erosion caused by road construction in the watershed, and to purchase fee title or conservation easements for riparian properties that will protect or restore riparian habitat.

BATTLE CREEK STAGE 1 ACTIONS

ACTION 1: Improve fish migration by removing diversion dams, upgrading fish passage facilities, and screening diversions.

RATIONALE: PG&E owns and operates two small reservoirs and seven unscreened diversions on Battle Creek and its tributaries. The facilities can impede the migration of juvenile and adult anadromous fish, and the unscreened diversions can entrain juvenile anadromous fish. Before hydropower development, Battle Creek was one of the most important spawning streams in the Central Valley for several species of chinook salmon. Various species of chinook salmon and steelhead trout still utilize spawning habitat in lower Battle Creek; however, generally there is too little habitat available for the available populations of fish. Removing diversion dams or upgrading their fish ladders can provide access to upstream habitat and relieve pressure on the over-utilized downstream reach of the creek. Battle Creek is one of the few Central Valley streams that provides the cold-water pool habitat that spring-run chinook and steelhead trout require for surviving high summer temperatures.

As greater access to upstream habitat is provided to adult anadromous fish, it will be necessary to screen the several unscreened diversions that can entrain juvenile salmonids.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Compare escapement rates and use of spawning habitat upstream of diversion facilities before and after removal.
- Compare use of available spawning habitat above hydropower facilities before and after construction of fish passage facilities.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

FY '97 CALFED Restoration Coordination Program funds were provided for the evaluation and design of several screened diversions on Battle Creek and its tributaries.

ACTION 2: Improve instream flows in lower Battle Creek to provide adequate passage flows.

RATIONALE: The PG&E hydropower facilities on Battle Creek were capable of diverting up to 98% of the streamflow, which impeded fish passage and elevated stream temperatures. An interim agreement provided for re-operation of the hydropower facilities to provide a greater volume of flow. It is important to provide a long-term solution to ensure adequate streamflows downstream of the hydropower facilities.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Determine the flows necessary to provide fish passage over obstacles
- Evaluate the relationship between flows and water temperatures
- Determine the flows necessary to transport and cleanse spawning gravels

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

CVPIA funds have helped to provide interim flows until a long-term flow agreement is reached.

ACTION 3: Develop and implement a watershed management plan to reduce the amount of fine sediments introduced to the creek channel, to protect and restore riparian habitat, to improve base flows, and to reduce water temperatures

RATIONALE: Activities in the Battle Creek watershed can increase erosion rates and introduce excessive loads of fine sediments to the creek channel. Untimely pulses of fine sediments can clog or bury spawning gravels, suffocating the incubating eggs of anadromous fish or preventing salmonid fry from emerging from the gravels. Fine sediments can also fill in the deep water pools that adult spring-run chinook salmon and steelhead trout require to survive high summer temperatures. Developing a watershed management plan to manage road construction, timber harvest and cattle grazing in the watershed can help prevent the introduction of too many fine sediments to the creek channel. Managing the fuel load in the watershed can also help prevent catastrophic wildfires that can denude vast areas of vegetation.

Developing a watershed management plan that protects and restores riparian vegetation can provide several ecological benefits. In addition to providing habitat for a variety of wildlife species, riparian buffers can help to trap fine sediments from reaching the stream channel. Riparian vegetation can also help reduce stream temperatures by providing shading, especially for pools that adult spring-run chinook salmon and steelhead trout use for holding during the summer. Riparian vegetation also helps create cutbanks that provide important rearing habitat for juvenile salmonids. Riparian vegetation also provides nutrients and woody debris to the creek channel, helping to stimulate food production and to provide diverse aquatic habitat.

Riparian vegetation can also help to retain stormwater runoff, helping to reduce peak flows in the channel and the concomitant flood risk to downstream reaches. Retention of stormwater runoff can also help increase the amount of water that percolates into groundwater aquifers, which can in turn help to increase groundwater discharge to the stream channel that enhances base flows.

Creating a watershed management group can help bring together private landowners and local stakeholders with local, state, and federal agency personnel to help develop and coordinate watershed management activities. The watershed group can provide a focused forum for the exchange of ideas and for building consensus among stakeholders, helping to provide a structure for continued public participation in decision making and to help build public support for long-term ecosystem restoration and management.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

Category III funds were provided to help establish a Battle Creek Watershed Conservancy.

ACTION 4: Improve the fish passage facilities at the Coleman National Fish Hatchery.

RATIONALE: Coleman National Fish Hatchery has a weir equipped with a fish ladder. The fish ladder provides access to upstream spawning habitat for spring-run and winter-run chinook salmon. The weir is designed to prevent fall-run chinook salmon from migrating upstream to spawn to prevent hybridization of the species. Improving the weir to better block upstream access to fall-run chinook salmon will help to preserve the genetic integrity of Battle Creek salmonids.

ACTION 5: Improve hatchery management and release practices at the Coleman National Fish Hatchery to better protect the genetic integrity of wild anadromous fish populations.

RATIONALE: Fish hatcheries in the Central Valley help to mitigate for fisheries losses attributed to dams that block access to historical spawning grounds and the degradation of habitat. Hatcheries can provide a valuable function by helping to maintain commercial and sport fisheries and by augmenting wild populations of fish that decline during adverse conditions such as droughts, thereby helping to ensure the survival of the species. However, hatchery produced fish can compete with wild populations for available resources such as food and spawning and rearing habitat. Hatchery produced fish may also prey upon wild populations of juvenile anadromous fish. The selection of fish used as hatchery stock may not represent an appropriate cross section of the population, which can reduce genetic diversity. Hatchery-produced fish also spawn with wild populations, reducing threatening the genetic integrity of wild populations of fish.

Reducing the number of hatchery-produced fish released into Bay-Delta tributaries in years when the natural production of fish is high can help prevent competition among wild and hatchery-reared fish and help populations of wild fish to rebound naturally. It can also help to reduce inter-breeding and the genetic contamination of the wild population. Selecting an appropriate cross section of adult spawners can also help to preserve genetic diversity in the species. Tagging hatchery-produced fish could allow for selective commercial and sport fishery harvest, reducing the impacts of harvest upon wild populations of fish.

COTTONWOOD CREEK STAGE 1 ACTIONS

ACTION 1: Relocate gravel mining operations from the active channel and nearby floodplain to higher terraces.

RATIONALE: Since the completion of Shasta Dam, Cottonwood Creek has become the single greatest source of coarse sediment for the Sacramento River, supplying approximately 85% of the gravel introduced into the river between Redding and Red Bluff. Cottonwood Creek drains a portion of the Coast Range, which is composed of geologic deposits that generally produce greater quantities of coarse sediment per unit of area than the Sierra Nevada or Cascade Ranges. Cottonwood Creek also provides the cold water pool habitat that spring-run chinook salmon and steelhead trout require.

Instream and floodplain gravel mining in the lower reaches of Cottonwood Creek represent the greatest stressor upon ecological processes in the creek's watershed. The removal of sand and gravel from the creek channel deprives the Sacramento River of important gravels necessary to create and maintain spawning habitat for anadromous fish. Dams on the mainstem Sacramento River (Shasta) and Clear Creek tributary (Whiskeytown and Clair Hill) prevent the transport of coarse sediment; however, there are no major dams on Cottonwood Creek or its tributaries. Relocating gravel mining operations from the active channel and nearby floodplain will restore the important ecological process of sediment transport and allow Cottonwood Creek to contribute a greater load of coarse sediment to the gravel-starved Sacramento River.

Gravel mining practices on lower Cottonwood Creek can also prevent or delay the upstream migration of adult anadromous fish. Gravel mining operations can spread gravel over a wide area to reduce the velocity of streamflow, which encourages greater deposition of coarse sands and gravels, thereby making more material available for mining. Spreading the flow over a larger area often eliminates the low-flow channel and reduces water surface elevations so that adult anadromous fish are impeded from migrating upstream to valuable holding and spawning habitat. Relocating gravel mining operations from the active channel and nearby floodplains will allow a low-flow channel to form, providing greater access to upstream habitat.

The extraction of gravel from floodplain deposits can form large pits that are separated from the main river channel by relatively narrow levees or berms. High flows can often breach the levees or berms and capture the deep gravel pits, which then provide warm water habitat for non-native and invasive species that prey upon juvenile salmonids attempting to emigrate from the creek. Relocating gravel mining operations from the nearby floodplain will help prevent the capture of mining pits and thereby reduce the risk of predation for emigrating juvenile salmonids.

By disturbing and removing the gravel substrate of the channel, instream gravel mining operations can also reduce the production of aquatic invertebrates that are an important component of the foodweb.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Evaluate rates of gravel recruitment to the channel from channel erosion of bank deposits and events in the watershed such as wildfires and landslides

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ACTION 2: Develop and implement a watershed management plan in concert with local stakeholders and local, state, and federal public agencies to reduce the amount of fine sediments introduced to the creek channel, to protect and restore riparian habitat, to improve base flows, and to reduce water temperatures.

RATIONALE: Activities in the Cottonwood Creek watershed can increase erosion rates and introduce excessive loads of fine sediments to the creek channel. Untimely pulses of fine sediments can clog or bury spawning gravels, suffocating the incubating eggs of anadromous fish or preventing salmonid fry from emerging from the gravels. Fine sediments can also fill in the deep water pools that adult spring-run chinook salmon and steelhead trout require to survive high summer temperatures. Developing a watershed management plan to manage road construction, timber harvest and cattle grazing in the watershed can help prevent the introduction of too many fine sediments to the creek channel. Managing the fuel load in the watershed can also help prevent catastrophic wildfires that can denude vast areas of vegetation.

Developing a watershed management plan that protects and restores riparian vegetation can provide several ecological benefits. In addition to providing habitat for a variety of wildlife species, riparian buffers can help to trap fine sediments from reaching the stream channel. Riparian vegetation can also help reduce stream temperatures by providing shading, especially for pools that adult spring-run chinook salmon and steelhead trout use for holding during the summer. Riparian vegetation also helps create cutbanks that provide important rearing habitat for juvenile salmonids. Riparian vegetation also provides nutrients and woody debris to the creek channel, helping to stimulate food production and to provide diverse aquatic habitat.

Riparian vegetation can also help to retain stormwater runoff, helping to reduce peak flows in the channel and the concomitant flood risk to downstream reaches. Retention of stormwater runoff can also help increase the amount of water that percolates into groundwater aquifers, which can in turn help to increase groundwater discharge to the stream channel that enhances base flows.

Creating a watershed management group can help bring together private landowners and local stakeholders with local, state, and federal agency personnel to help develop and coordinate watershed management activities. The watershed group can provide a focused forum for the exchange of ideas and for building consensus among stakeholders, helping to provide a structure for continued public participation in decision making and to help build public support for long-term ecosystem restoration and management.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- determine the relative contribution of fine sediments to the channel from natural and human disturbances in the watershed
- evaluate how the restoration of upland and riparian habitat affects the transport of fine sediments to the stream channel
- as riparian vegetation is restored, evaluate the volume of stormwater runoff retained, rates of water percolation to groundwater, and groundwater discharge to the channel during base flow
- as riparian vegetation is restored, evaluate its effects upon water temperatures

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

In the FY '98 round of funding for CALFED Restoration Coordination Program, funds were provided to assist the formation of a Cottonwood Creek Watershed Group. It is anticipated that this group will help to stimulate the development of a watershed management plan.

FY '98 Category III funds have been provided to allow the formation of the Cottonwood Creek Watershed Group.

BUTTE CREEK STAGE 1 ACTIONS

ACTION 1: Improve fish passage at diversion dams either by providing alternative diversion structures that will allow removal of existing dams or by upgrading fish ladders and screen diversions.

RATIONALE: Several diversion dams on Butte Creek currently delay or impede the upstream migration of adult anadromous fish and entrain juvenile salmonids emigrating from the system in unscreened diversions. Improving fish passage and reducing entrainment at each of the diversions will help provide better access to upstream spawning habitat and increase the number of juvenile escaping to the Sacramento River.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

FY '97 CALFED Restoration Coordination Program funds, as well as earlier Category III funds, have been provided to help fund the design, evaluation, and construction of alternative diversion structures or upgraded fish ladders, as well as screened diversions, at the Adams Dam and Gorrill Dam diversions. Earlier Category III funds helped to finance alternative diversion structures, upgraded fish ladders, and screened diversions at the Durham Mutual Dam, Parrot-Phelan Dam, and Western Canal Water District diversions.

ACTION 2: Improve instream flows by purchasing water from willing sellers or providing alternative water supplies that will allow diverters to reduce diversions. (Note: this water will be part of the 100 TAF of water purchased to improve stream flows in the Sacramento and San Joaquin Basins.

RATIONALE: In dry years, insufficient flows in Butte Creek can impede the upstream migration of adult anadromous fish because there is too little water in the channel to provide passage over obstacles or because elevated water temperatures create a temperature barrier. Low flows and elevated water temperatures can also stress or kill juvenile salmonids rearing or emigrating through Butte Creek. To ensure long-term water supplies that will provide adequate passage flows of suitable temperatures, it will be necessary to acquire water from willing sellers or to work with local diverters to develop alternative water supplies that will allow more water to stay in the channel during dry years. It will also be necessary to balance the ecological benefits of water diverted from Butte Creek for seasonal wetlands on state and federal refuges and private duck clubs with the benefits of water left in Butte Creek to benefit salmonids.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Determine the flows necessary to provide fish passage over obstacles
- Evaluate the relationship between flows and

water temperatures
- Determine the flows necessary to transport and cleanse spawning gravels

ACTION 3: Develop and implement a watershed management plan to reduce the amount of fine sediments introduced to the creek channel, to protect and restore riparian habitat to improve base flows, and to reduce water temperatures.

RATIONALE: Activities in the Butte Creek watershed can increase erosion rates and introduce excessive loads of fine sediments to the creek channel. Untimely pulses of fine sediments can clog or bury spawning gravels, suffocating the incubating eggs of anadromous fish or preventing salmonid fry from emerging from the gravels. Fine sediments can also fill in the deep-water pools that adult spring-run chinook salmon and steelhead trout require to survive high summer temperatures. Developing a watershed management plan to manage road construction, timber harvest and cattle grazing in the watershed can help prevent the introduction of too many fine sediments to the creek channel. Managing the fuel load in the watershed can also help prevent catastrophic wildfires that can denude vast areas of vegetation.

Developing a watershed management plan that protects and restores riparian vegetation can provide several ecological benefits. In addition to providing habitat for a variety of wildlife species, riparian buffers can help to trap fine sediments from reaching the stream channel. Riparian vegetation can also help reduce stream temperatures by providing shading, especially for pools that adult spring-run chinook salmon and steelhead trout use for holding during the summer. Riparian vegetation also helps create cutbanks that provide important rearing habitat for juvenile salmonids. Riparian vegetation also provides nutrients and woody debris to the creek channel, helping to stimulate food production and to provide diverse aquatic habitat.

Riparian vegetation can also help to retain stormwater runoff, helping to reduce peak flows in the channel and the concomitant flood risk to downstream reaches. Retention of stormwater runoff can also help increase the amount of water that percolates into groundwater aquifers, which can in turn help to increase groundwater discharge to the stream channel that enhances base flows and helps reduce water temperatures.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- determine the relative contribution of fine sediments to the channel from natural and human disturbances in the watershed
- evaluate how the restoration of upland and riparian habitat affects the transport of fine sediments to the stream channel
- as riparian vegetation is restored, evaluate the volume of stormwater runoff retained, rates of water percolation to groundwater, and groundwater discharge to the channel during base flow
- as riparian vegetation is restored, evaluate its effects upon water temperatures.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

FY '97 and FY '98 CALFED Restoration Coordination Program funds have been provided for the acquisition and restoration of riparian habitat along Butte Creek as well as watershed planning. Earlier Category III funds were provided for the development of the Butte Creek Watershed Management Strategy.

BIG CHICO CREEK

ACTION 1: Develop and implement a watershed management plan to reduce the amount of fine sediments introduced to the creek channel, to protect and restore riparian habitat, to improve base flows, to reduce water temperatures, and to balance recreational uses with plant and wildlife requirements.

RATIONALE: Activities in the Big Chico Creek watershed can increase erosion rates and introduce excessive loads of fine sediments to the creek channel. Untimely pulses of fine sediments can clog or bury spawning gravels, suffocating the incubating eggs of anadromous fish or preventing salmonid fry from emerging from the gravels. Fine sediments can also fill in the deep water pools that adult spring-run chinook salmon and steelhead trout require to survive high summer temperatures. Developing a watershed management plan to manage road construction, timber harvest and cattle grazing in the watershed can help prevent the introduction of too many fine sediments to the creek channel. Managing the fuel load in the watershed can also help prevent catastrophic wildfires that can denude vast areas of vegetation.

The Big Chico Alliance is developing a watershed management plan for protecting and restoring riparian vegetation to provide several ecological benefits. In addition to providing habitat for a variety of wildlife species, riparian buffers can help to trap fine sediments from reaching the stream channel. Riparian vegetation can also help reduce stream temperatures by providing shading, especially for pools that adult spring-run chinook salmon and steelhead trout use for holding during the summer. Riparian vegetation also helps create cutbanks that provide important rearing habitat for juvenile salmonids. Riparian vegetation also provides nutrients and woody debris to the creek channel, helping to stimulate food production and to provide diverse aquatic habitat.

Riparian vegetation can also help to retain stormwater runoff, helping to reduce peak flows in the channel and the concomitant flood risk to downstream reaches. Retention of stormwater runoff can also help increase the amount of water that percolates into groundwater aquifers, which can in turn help to increase groundwater discharge to the stream channel that enhances base flows.

Existing and future recreational uses of Big Chico Creek must be balanced with the needs of plant and animal species. Recreational areas should be located away from sensitive or important fish habitat.

Current or Recent Restoration Activities or Investigations:

FY '97 CALFED Restoration Coordination Program funds were provided to help develop the Big Chico Watershed Plan. The Big Chico Watershed Alliance is facilitating the development of this plan and is hosting a series of public workshops to prioritize watershed goals and issues and concerns.

Feather River Stage 1 Actions

Action 1: Screen the Sunset Pumps diversion to prevent entrainment of juvenile salmonids.

Rationale: Several species of anadromous fish spawn in the Feather River. Juvenile salmonids attempting to emigrate from the river can be entrained by unscreened or poorly screened diversions. Upgrading the Sunset Pumps diversion screens will help reduce entrainment losses for several species of anadromous fish.

Action 2: Improve hatchery management and release practices at the Feather River Hatchery to better protect the genetic integrity of wild anadromous fish populations.

Rationale: Fish hatcheries in the Central Valley help to mitigate for fisheries losses attributed to dams that block access to historical spawning grounds and the degradation of habitat. Hatcheries can provide a valuable function by helping to maintain commercial and sport fisheries and by augmenting wild populations of fish that decline during adverse conditions such as droughts, thereby helping to ensure the survival of the species. However, hatchery produced fish can compete with wild populations for available resources such as food and spawning and rearing habitat. Hatchery produced fish may also prey upon wild populations of juvenile anadromous fish. The selection of fish used as hatchery stock may not represent an appropriate cross section of the population, which can reduce genetic diversity. Hatchery-produced fish also spawn with wild populations, reducing threatening the genetic integrity of wild populations of fish.

Reducing the number of hatchery-produced fish released into Bay-Delta tributaries in years when the natural production of fish is high can help prevent competition among wild and hatchery-reared fish and help populations of wild fish to rebound naturally. It can also help to reduce inter-breeding and the genetic contamination of the wild population. Selecting an appropriate cross section of adult spawners can also help to preserve genetic diversity in the species. Tagging hatchery-produced fish could allow for selective commercial and sport fishery harvest, reducing the impacts of harvest upon wild populations of fish.

YUBA RIVER STAGE 1 ACTIONS

ACTION 1: Evaluate options to improve fish passage upstream and downstream of Daguerre Point Dam. Conduct a feasibility study of removing or modifying Daguerre Point Dam.

RATIONALE: Daguerre Point Dam is a debris dam constructed primarily to trap excessive sediment caused by upstream mining operations. The dam can delay or impede the upstream migration of adult anadromous fish, thereby reducing reproductive success. The dam has been equipped with fish ladders in the past, but their success in providing access has been minimal. The dam can also disrupt the downstream migration of emigrating juvenile salmonids, which are subject to predation by non-native and invasive fish species in the warm water habitat created by the dam's impoundment of water. Removing the dam could improve access to nearly 12.5 miles of river channel and reduce predation losses of juvenile anadromous fish.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- If it is feasible to remove Daguerre Point Dam, compare escapement rates and use of spawning habitat upstream of the dam before and after removal.
- Compare rates of predation of juvenile anadromous fish downstream of the dam before and after removal.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

There is a potential future linkage with the Comprehensive Study.

ACTION 2: Evaluate options to reintroduce steelhead and spring-run chinook salmon upstream of Englebright Dam.

RATIONALE: Englebright Dam is a debris dam constructed primarily to trap excessive sediment caused by upstream mining operations, though the dam also provides for important re-regulation of hydropower releases from upstream reservoirs. The dam is currently the upstream limit of anadromous fish migration. The feasibility study would need to evaluate the potential quantity and quality of upstream habitat that would be provided, as well as the potential mercury contamination of sediments behind Englebright Dam.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Evaluate the suitability of upstream habitats.
- Evaluate mercury levels in the sediments behind the dam.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

There is a potential future linkage with the Comprehensive Study.

AMERICAN RIVER STAGE 1 ACTIONS

ACTION 1: Control or eradicate non-native riparian plants and re-vegetate with native plants.

RATIONALE: *Arundo donax* (giant reed) has become established in the American River. Arundo can alter ecological processes by inducing greater deposition, by evapotranspiring greater quantities of water than native riparian vegetation, and by altering soil chemistry. Arundo provides little habitat for native wildlife species, and because it grows vertically and doesn't overhang the stream channel, it doesn't provide the SRA habitat for aquatic species that native riparian vegetation does. Replacing Arundo with native riparian vegetation may also enhance base flows. Another non-native plants of concern is scarlet wisteria.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Evaluate different removal and re-vegetation techniques to identify the most effective and cost-effective methods for controlling or eradicating non-native or invasive riparian plant species.
- Monitor the rate of re-colonization by native, non-native, and invasive species.
- Determine the ecological conditions or processes that favor native species over non-native species.

- Determine invertebrate and wildlife use of non-native riparian plant species.
- Determine the extent to which non-native riparian species alter ecological processes.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

SWRCB funds have been provided for erosion and sediment control demonstration project on Cache Creek.

ACTION 2: In balance with public safety, manage the removal of or introduce instream woody debris on selected river reaches to enhance aquatic habitat for salmonids.

RATIONALE: Woody debris is cleared from the American River channel for recreational and public safety purposes. However, woody debris provides important rearing and resting habitat for salmonids. Allowing woody debris to stay in selected reaches of the channel may enhance patches of salmonid rearing habitat without affecting recreation significantly.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Compare salmonid use of aquatic habitat in reaches with woody debris and reaches cleared of woody debris.

ACTION 3: Improve hatchery management and release practices at the Nimbus Hatchery to better protect the genetic integrity of wild anadromous fish populations.

RATIONALE: Fish hatcheries in the Central Valley help to mitigate for fisheries losses attributed to dams that block access to historical spawning grounds and the degradation of habitat. Hatcheries can provide a valuable function by helping to maintain commercial and sport fisheries and by augmenting wild populations of fish that decline during adverse conditions such as droughts, thereby helping to ensure the survival of the species. However, hatchery produced fish can compete with wild populations for available resources such as food and spawning and rearing habitat. Hatchery produced fish may also prey upon wild populations of juvenile anadromous fish. The selection of fish used as hatchery stock may not represent an appropriate cross section of the population, which can reduce genetic diversity. Hatchery-produced fish also spawn with wild populations, reducing threatening the genetic integrity of wild populations of fish.

Reducing the number of hatchery-produced fish released into Bay-Delta tributaries in years when the natural production of fish is high can help prevent competition among wild and hatchery-reared fish and help populations of wild fish to rebound naturally. It can also help to reduce inter-breeding and the genetic contamination of the wild population. Selecting an appropriate cross section of adult spawners can also help to preserve genetic diversity in the species. Tagging hatchery-produced fish could allow for selective commercial and sport fishery harvest, reducing the impacts of harvest upon wild populations of fish.

CACHE CREEK STAGE 1 ACTIONS

ACTION 1: Control or eradicate non-native riparian plants and re-vegetate with native plants.

RATIONALE: Tamarisk has become established in the Cache Creek watershed. Tamarisk can alter ecological processes by inducing greater deposition, by evapotranspiring greater quantities of water than native riparian vegetation, and by altering soil chemistry. Tamarisk provides little habitat for native wildlife species, and because it grows vertically and doesn't overhang the stream channel, it doesn't provide the SRA habitat for aquatic species that native riparian vegetation does. Controlling or eradicating tamarisk from the Cache Creek watershed will help prevent its spread into Yolo Bypass and the Delta. Replacing tamarisk with native riparian vegetation may also enhance base flows.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Evaluate different removal and re-vegetation techniques to identify the most effective and cost-effective methods for controlling or eradicating non-native or invasive riparian plant species.
- Monitor the rate of re-colonization by native,

non-native, and invasive species.

- Determine the ecological conditions or processes that favor native species over non-native species.
- Determine invertebrate and wildlife use of non-native riparian plant species.
- Determine the extent to which non-native riparian species alter ecological processes.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

SWRCB Proposition 204 funds have been provided for a demonstration project to control soil erosion in the Cache Creek watershed to help prevent the release of contaminants into the stream channel.

GENERAL SACRAMENTO BASIN STAGE 1 ACTIONS

ACTION 1: Restore seasonal wetlands and encourage wildlife-friendly agricultural practices to support the Central Valley Habitat Joint Venture restoration goals for resident and migratory birds in Sutter, Colusa, Butte, and American Basins.

RATIONALE: The ERP embraces the goals of the Central Valley Habitat Joint Venture, which has a goal of protecting, enhancing, and restoring seasonal wetlands for the benefit of migratory bird species. The ERP will focus on actions to enhance existing but degraded seasonal wetland habitat and in promoting wildlife-friendly agricultural practices.

ACTION 2: Acquire at least 100,000 acre-feet of water from willing sellers for environmental uses in the Sacramento Basin, San Joaquin Basin and the Delta. (Note: action also listed as San Joaquin Basin action.)

RATIONALE: Alteration of the flow regime in Bay-Delta tributaries and changes in Bay-Delta hydrodynamics have contributed to ecosystem degradation. Purchasing water from willing sellers will provide water that can be used to:

- Provide passage flows for adult anadromous fish;
- Provide pulse flows for emigrating juvenile salmonids;
- Improve habitat conditions by reducing water temperatures;
- Prevent diversion effects on fish through exchange agreements with diverters;
- Provide flushing flows to maintain the quality of aquatic habitat;
- Provide flows for riparian habitat maintenance, regeneration, and succession;
- Provide flows to inundate floodplains.

This 100 TAF is not a part of CVPIA flows; rather, it is additional water necessary to meet the broader objectives of the CALFED Ecosystem Restoration Program and will be coordinated with the Environmental Water Account.

DRAFT SAN JOAQUIN RIVER BASIN STAGE 1 ACTIONS

SAN JOAQUIN RIVER BASIN DESCRIPTION

The San Joaquin River and its tributaries are an important component of the Bay-Delta ecosystem. The tributaries in the basin can be restored to provide important spawning, rearing, nesting, and wintering habitat for a variety of species.

Factors most influencing the ecological health of tributaries in the San Joaquin River Basin include:

1. Reductions in the magnitude, frequency, duration, and variability of river flows because of dam construction and diversions.

2. Reductions in the amount of coarse sediment available to create and maintain important aquatic and riparian habitat because of dam construction, aggregate mining in active river channels, and relatively narrow levees that increase shear stress applied to channel bed sediments.

3. Disruption of sediment transport and expansion of habitat that favors non-native and invasive species from excavation pits formed by aggregate mining operations.

4. Reductions in the amount and contiguity of riparian habitat because of urban and agricultural encroachment and levee construction.

5. Elevated water temperatures because of dam construction, diversions, return flows, captured excavation pits, and the loss of riparian habitat.

6. Degradation of spawning and rearing habitat because of excessive loads of fine sediments and urban, industrial, and agricultural discharges of pollutants.

7. Loss of river-floodplain interactions because of levee construction.

STAGE 1 APPROACH

Since most of the tributaries in the San Joaquin River basin are regulated by large dams, it will be necessary to conduct targeted research and to monitor Stage 1 actions to determine the optimal combinations of flow and sediment that will best restore aquatic and riparian habitat in light of the regulated flow regime.

The primary species that will benefit from Stage 1 actions implemented in the San Joaquin River basin are fall-run chinook salmon.

Stage 1 actions also focus on the Tuolumne River as a demonstration stream. The objective for each demonstration stream is to fully restore the tributary within existing constraints (such as large dams) so that each becomes a healthy, resilient haven of continuous riparian and aquatic habitat to optimize endemic plant and animal populations. Restoring the Tuolumne River into a healthy riparian corridor during Stage 1 will help recover and maintain large populations of fall-run chinook salmon to endure severe ecological conditions such as droughts. The Tuolumne River was selected as a demonstration stream because it generally offers the best habitat conditions in the basin for fall-run chinook salmon, and it has a well-organized stakeholder group to help implement restoration actions.

TUOLUMNE RIVER STAGE 1 ACTIONS

The Tuolumne River has potential to be a demonstration stream representative of tributaries of the San Joaquin Basin. Demonstration watersheds will be selected for large-scale implementation of restoration actions to significantly restore ecological processes and resources while simultaneously testing restoration hypotheses as part of an adaptive management approach. Lessons learned restoring the Tuolumne River will help the design and refinement of future restoration actions on the Tuolumne River and other Bay-Delta tributaries.

The Tuolumne has potential to be a demonstration stream for several reasons. It generally has the highest volume of inflow (1.9 MAF) of the three tributaries to the San Joaquin River; therefore it generally provides greater opportunity to release flows for ecological benefits. Historically, the Tuolumne River also contributed a larger percentage to Central Valley salmon escapement than the other tributaries to the San Joaquin River, so emphasizing restoration in this river has the potential to provide more benefits to stabilizing populations of anadromous fish. The Tuolumne River also has an organized watershed group, Tuolumne River Technical Advisory Committee (TRTAC), to facilitate implementation of restoration actions. TRTAC has already begun preparing the site-specific environmental documentation and acquiring permits for several restoration actions; consequently, it may be feasible to implement a larger number of actions in the first seven years of implementation as compared to other watersheds.

ACTION 1: Fill in in-channel excavation pits.

RATIONALE: Past aggregate mining operations excavated deep pits in the Tuolumne River channel. The size of the excavation pits reduces the velocity of water flow and increases ambient water temperatures, creating conditions that favor both non-native (large- and small-mouth bass) and native (Sacramento pikeminnow) species that prey upon juvenile anadromous fish. Since most of the spawning habitat for anadromous fish in the Tuolumne River is located upstream of these excavation pits, juvenile anadromous fish emigrating to the Bay-Delta and ocean are subject to increased risk of predation. The excavation pits also serve as sediment traps by capturing coarse bedload material transported from upstream reaches, thereby depriving downstream reaches of important spawning gravels. Filling in the excavation pits will eliminate habitat that favors non-native or invasive fish species and reduce the risk of predation upon juvenile anadromous fish, and it will also be a prerequisite to restoring sediment transport processes

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- As in-channel excavation pits are filled in, monitor the number of large-mouth bass (the principal predator for juvenile anadromous fish) and the number of juvenile anadromous fish that escape from the river to help assess the relative effect of predation upon population size.
- Monitor ambient water temperatures to assess the relative contribution of excavation pits to elevated water temperatures in the Tuolumne River.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

CALFED Restoration Coordination funds have been provided to fill one of the larger instream excavation pits on the Tuolumne River.

ACTION 2: Fill in floodplain excavation pits and remove or setback protective berms and levees that isolate floodplain excavation operations.

RATIONALE: Aggregate mining activities on floodplains of the Tuolumne River excavate deep pits that are usually separated from the main river channel by relatively narrow berms and levees. Relatively moderate flood flows can breach these protective levees and berms, allowing the river to capture the floodplain pits that provide habitat for non-native and invasive fish species that prey upon juvenile anadromous fish. The berms and levees that isolate floodplain excavation pits from the main river channel can also concentrate flows and increase the shear stress applied to the channel bed, thus scouring important spawning gravels and incising the channel. Filling floodplain excavation pits in danger of being captured by peak flows will help eliminate potential habitat for non-native and invasive fish species that prey upon juvenile anadromous fish. Filling the pits will also allow confining levees and berms to be removed or set back, which will re-connect the river with a portion of its floodplain, thereby increasing flood storage and conveyance capacity and providing room for the river channel to meander. Removing or setting back the protective levees and berms will also reduce shear stress on the channel bed and help prevent spawning gravels from being flushed from the system. Strengthening setback levees and berms will also help to better protect continuing aggregate mining operations.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Monitor the availability and distribution of spawning-sized gravel in reaches where levees are removed or set back.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

CALFED Restoration Coordination funds have been provided to fill floodplain excavation pits and to set back protective levees and berms along one section of the Mining Reach of the Tuolumne River.

ACTION 3: Introduce spawning-sized gravel to the Tuolumne River channel.

RATIONALE: Dams in the Tuolumne River watershed trap all of the gravel derived from upstream reaches, thereby depriving downstream reaches of important material required to maintain aquatic and riparian habitat. Introducing spawning-sized gravel into the river channel will help to improve and increase the amount of spawning habitat available for anadromous fish by compensating for the coarse sediment load trapped behind dams.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Restoring spawning habitat in the river will likely require the introduction of a large supply of spawning-sized gravel initially to compensate for past deficits caused by sediment trapping behind dams and past aggregate mining activities in the active channel. It will be necessary to determine the amount of gravel required for this initial infusion of gravel in light of the regulated flow regime of the river.

- Long-term river management will require balancing the river's sediment budget in light of the regulated flow regime of the river, which will require periodic infusions of gravel to compensate for sediment trapped behind dams. It will be necessary to determine the amount of gravel to be introduced periodically, as well as a schedule for gravel augmentation, to restore the river's sediment budget.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

CALFED Restoration Coordination funds have been provided to place spawning-sized gravel in the Tuolumne River channel between La Grange Dam and Basso Bridge.

ACTION 4: Purchase flood easements or floodplain land from willing sellers.

RATIONALE: Re-connecting the river channel with a portion of its floodplain can provide several ecological benefits. In conjunction with sufficient flows to mobilize fine sediments, restored floodplains can trap fine sediments, thereby preventing them from being stored in the river channel where they can degrade spawning habitat. Floodplains also contribute woody debris and organic material to the river channel, helping to create diverse aquatic habitat and to stimulate food web production. The purchase of flood easements or floodplain lands can also provide room for the river to meander by eliminating or setting back levees and by eliminating bank protection activities that degrade riparian habitat. The purchase of conservation easements or floodplain land can also allow the protection and restoration of riparian habitat.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Monitor floodplain storage of flood flows.
- Monitor the introduction of nutrients and organic material to the channel downstream of restored floodplains.
- Compare groundwater levels and groundwater discharges to the channel in reaches with restored floodplains with reaches confined by relatively narrow levees.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

CALFED Restoration Coordination funds have been provided to purchase 42 acres of floodplain land and a conservation easement on 140 acres of floodplain land on the Tuolumne River downstream of La Grange Dam to protect riparian habitat.

ACTION 5: Purchase water from willing sellers to increase the magnitude of fall flows. (Note: this water will be part of the 100 TAF of water purchased to improve stream flows in the Sacramento and San Joaquin Basins.)

RATIONALE: The Tuolumne River contributes a significant portion of the Central Valley's fall-run chinook salmon. The FERC Settlement Agreement for the New Don Pedro Project establishes a schedule for releasing minimum streamflows throughout the year, based upon the type of water year. Scheduled releases during the adult migration period include a 2-3 day attraction pulse flow (except in critically dry and dry water years) followed by fall base flows ranging from 100 cfs in critically dry water years to 300 cfs in above normal and wet water years. The superimposition of redds—the creation of spawning nests on top of already created spawning nests—suggest that the fall base flows are inadequate to distribute spawning throughout the channel, especially in dry and critically dry years. Increasing fall base flows by purchasing water from willing sellers will expand the wetted perimeter of the channel and make more aquatic habitat available for spawning. It will also allow fall-run chinook salmon to use spawning gravels located further away from the center of flow in the channel (the thalweg), which will make the redds less susceptible to scour during moderate floods while the eggs are incubating.

Adaptive Management Considerations:

- As fall base flows are increased, monitor the rate of redd superimposition and the distribution of spawning habitat used.
- Monitor the proportion of redds scoured by moderate floods.

Current or Recent Restoration Activities or Investigations:

The FERC Settlement Agreement has established a schedule of minimum flow releases based upon the type of water year, which has increased the amount of flow released to the lower Tuolumne River and helped to improve habitat conditions.

Action 6: Explore actions to reduce ambient water temperatures, including increasing flows by purchasing water from willing sellers or developing new water supplies, as well as protecting and restoring riparian habitat.

Rationale: Elevated ambient water temperatures in the Tuolumne River can be stressful or lethal to the early life stages of anadromous fish. Filling or isolating instream and floodplain excavation pits will help to reduce ambient water temperatures, but additional measures may be necessary to further reduce water temperatures. Purchasing water from willing sellers or developing new water supplies will allow increasing flows to reduce water temperatures during periods of egg incubation and juvenile anadromous fish emigration. Protecting and restoring riparian habitat will also help to increase the amount of shaded pool habitat, which is important temperature refugia for juvenile anadromous fish.

Adaptive Management Considerations:

- Evaluate the effectiveness of filling or isolating excavation pits on ambient water temperatures and determine if they are still stressful or lethal to anadromous fish.
- Evaluate the role of temperature refugia created by riparian habitat in reducing the effects of elevated water temperatures on anadromous fish.
- Evaluate the relative contribution of agricultural return flows upon elevated water temperatures.
- Evaluate the effectiveness of increased groundwater discharge associated with restored floodplains upon elevated water temperatures.

Current or Recent Restoration Activities or Investigations:

The Vernalis Adaptive Management Program (VAMP) includes provisions to release water from San Joaquin River tributaries to evaluate the effects of flow upon San Joaquin River water quality.

Action 7: Evaluate entrainment rates at small diversions and assess their affect upon population size of native and anadromous fish.

Rationale: DFG has identified 36 diversions on the lower Tuolumne River; however, it is unknown if these diversions significantly affect, both individually and cumulatively, the population size of anadromous fish species. Evaluating entrainment rates at these small diversions will help assess their relative impact upon populations of anadromous fish species. If it is determined that the individual or cumulative impact of these diversions is significant, then ERP managers will work with willing local diverters to change the timing of diversions and to evaluate its effectiveness in reducing entrainment rates. If these diversions still produce a significant individual or cumulative impact upon fish populations, then ERP managers will work with willing diverters to consolidate, relocate, or screen the diversions.

Adaptive Management Considerations:

- Determine the individual and cumulative effects of diversions upon population size of fish species.
- Evaluate the effectiveness of changing the timing of diversions upon reducing entrainment rates.
- Evaluate the effectiveness of consolidating diversions or relocating diversions to areas less sensitive to fish species.

Action 8: Increase enforcement to reduce illegal harvest of fish.

Rationale: Several factors affect the population of adult anadromous fish that return to the Tuolumne River to spawn each year, including hydrologic conditions in previous years, ocean conditions, and harvest rates. Illegal harvest of fish reduces the number of adult spawners. Especially during years when the population of adult spawners is already low, poaching can constitute a significant threat to the viability of a species. Increasing enforcement can help discourage poaching.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Determine the relative impact of poaching upon the population size of anadromous fish species.

TARGETED RESEARCH : Conduct a feasibility study of expanding the reservoir release capacity of New Don Pedro Dam.

RATIONALE: The current reservoir release capacity of New Don Pedro Reservoir is 14,500 cfs. Expanding the release capacity of New Don Pedro Reservoir could increase the flexibility of managing the flood pool. In addition to enhancing flood protection, expanding the release capacity could also provide greater energy to initiate downstream channel migration in conjunction with restoration actions intended to re-connect the river channel with its floodplain (such as setback levees or levee removal, and the purchase of floodplain land or flood easements).

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Determine the flow necessary to drive channel migration in the lower Tuolumne River, and use this flow as a target release capacity for the feasibility study.

TARGETED RESEARCH: Evaluate the feasibility of re-operating flood releases from New Don Pedro Reservoir to improve channel maintenance flows, in balance with downstream flood protection.

RATIONALE: Threshold flows of a certain magnitude are required to mobilize and distribute coarse sediments, to scour vegetation that has encroached into the active channel, and to flush fine sediments onto floodplains. Re-operating flood releases from New Don Pedro Reservoir may be able to provide flows sufficient to sustain these important ecological processes without significantly affecting water supply.

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- The magnitude of channel maintenance flows will vary based upon changing conditions in: the amount and size of coarse sediments (both natural and introduced sources) available for transport and distribution; the age and density of encroaching vegetation; and the amount of fine sediments stored in the channel.

MERCED RIVER STAGE 1 ACTIONS

ACTION 1: Isolate dredger pits from the active river channel.

RATIONALE: Old gravel mining operations created large pits in Merced River floodplains. Insufficient levees designed to separate the mining pits from the river have been breached during high flow events. The dredger pits can elevate water temperatures, and they provide habitat for both native and exotic fish species that prey upon juvenile anadromous fish. Isolating these pits from the active channel could help to reduce water temperatures and the loss of juvenile fish to unnaturally high levels of predation

ADAPTIVE MANAGEMENT CONSIDERATIONS:

- Estimate rates of predation upon juvenile anadromous and resident fish species by non-native, warm water fish species.
- Evaluate water temperatures in the channel before and after dredger pits are isolated from the main channel.
- Evaluate rates of gravel recruitment and transport before and after dredger pits are isolated from the main channel.
- Compare interaction between surface flow and groundwater flow in vicinity of isolated dredger pits with reaches not bordered by dredger pits to estimate the amount of surface water lost from the stream channel to dredger pits.

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:

FY' 97 Category III funds were provided to help fill in or isolate gravel mining pits

MAINSTEM SAN JOAQUIN RIVER STAGE 1 ACTIONS

ACTION 1: Improve instream flows by purchasing water from willing sellers or providing alternative water supplies that will allow diverters to reduce diversions. (Note: this water will be part of the 100 TAF of water purchased to improve stream flows in the Sacramento and San Joaquin Basins.)

RATIONALE: Additional water is needed to augment flows on the San Joaquin River below the Merced River to provide attraction flows for adult salmonids and out-migration flows for juvenile salmonids. Additional flows may also have the benefit of diluting pollutants and reducing diversion effects in the South Delta.

ADAPTIVE MANAGEMENT CONSIDERATIONS:
- VAMP

CURRENT OR RECENT RESTORATION ACTIVITIES OR INVESTIGATIONS:
- VAMP

ACTION 2: Develop a cooperative strategy to acquire floodplain easements along the lower San Joaquin River consistent with the Sacramento and San Joaquin River Basins Comprehensive Study.

RATIONALE: The U.S. Army Corps of Engineers, the California Reclamation Board and the Department of Water Resources is conducting the Comprehensive Study to develop a strategy to reduce flood damage while incorporating ecosystem restoration through structural and non-structural measures. This is an opportunity to cost-effectively restore large expanses of ecologically important floodplains while improving flood protection by through cost sharing and integrated project design and implementation. A variety of measures including levee setbacks and riparian restoration on the mainstem San Joaquin River would meet objectives of the Comprehensive Study and the Ecosystem Restoration Program.

GENERAL SAN JOAQUIN BASIN STAGE 1 ACTIONS

ACTION 1: Acquire at least 100,000 acre-feet of water from willing sellers for environmental uses in the Sacramento Basin, San Joaquin Basin and the Delta. (Note: action also listed as Sacramento Basin action..)

RATIONALE: Alteration of the flow regime in Bay-Delta tributaries and changes in Bay-Delta hydrodynamics have contributed to ecosystem degradation. Purchasing water from willing sellers will provide water that can be used to:
- Provide passage flows for adult anadromous fish;
- Provide pulse flows for emigrating juvenile salmonids;
- Improve habitat conditions by reducing water temperatures;
- Prevent diversion effects on fish through exchange agreements with diverters;
- Provide flushing flows to maintain the quality of aquatic habitat;
- Provide flows for riparian habitat maintenance, regeneration, and succession;
- Provide flows to inundate floodplains.

This 100 TAF is not a part of CVPIA flows; rather, it is additional water necessary to meet the broader objectives of the CALFED Ecosystem Restoration Program and will be coordinated with the Environmental Water Account.

Appendix E: Strategic Plan for Managing Nonnative Invasive Species:

A CALFED Bay-Delta Program Strategic Plan for Managing Nonnative Invasive Species in the San Francisco Bay-Delta Estuary/Sacramento-San Joaquin Rivers and Associated Watersheds

July 2000

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Appendix E: Strategic Plan for Managing Nonnative Invasive Species in the San Francisco Bay-Delta Estuary/ Sacramento-San Joaquin Rivers and Associated Watersheds

SUMMARY

The purpose of this Non-native Invasive Species (NIS) Strategic Plan is to provide guidance for management actions to prevent introductions, provide control and mitigate impacts of non-native species that have invaded or may invade the ecosystems of the San Francisco Bay-Delta, the Sacramento/San Joaquin Rivers and their watersheds. This document has been developed for the CALFED Bay-Delta Program. It is an important first step in the coordinated response to this serious problem and communicates the scope of activities necessary to effectively deal with NIS.

The plan discusses the problem and identifies the goals and major issues relevant to feasible, cost-effective management practices and measures to be taken by federal, state, local and other programs to prevent and control NIS infestations in a manner that is environmentally sound. It is important to note that the information developed by NIS activities will be provided to the CALFED Program Managers and the Comprehensive Monitoring, Assessment and Research Program in order to assist these CALFED elements to more effectively achieve CALFED goals and objectives.

The focus of this plan is directed at the San Francisco Bay-Delta estuary, the Sacramento-San Joaquin Rivers and the associated watersheds in California, though it is recognized that the solution area may be statewide and beyond.

This strategic management plan is based on the following three goals:

- Goal I: Preventing new introductions and establishment of NIS into the ecosystems of the San Francisco Bay-Delta, the Sacramento/San Joaquin Rivers and their watersheds.
- Goal II: Limiting the spread or, when possible and appropriate, eliminating populations of NIS through management.
- Goal III: Reducing the harmful ecological, economic, social and public health impacts resulting from infestation of NIS through appropriate management.

The template for much of this document comes from the efforts to develop a State Plan for California. Contributions for that effort came from the California Resources Agency, California Department of Food and Agriculture, US Fish and Wildlife Service, US Department of Agriculture - Agricultural Research Service and US Army Corps of Engineers. Also contributing to this document were staff from the CALFED agencies and participants from academia, non-profit groups, stakeholder groups and individuals with technical experience with NIS. The information contained in the Strategic Plan for the Ecosystem Restoration Program (September 30, 1998) and the draft Ecosystem Restoration Program Plan, Volume I (October 1, 1998), both CALFED Bay-Delta Program documents, provided further information for this plan. Public comments also will be solicited from local governments and regional entities, and public and private organizations that have expertise in the control of NIS. Comments will be considered and revisions made to the plan, as appropriate.

While this plan provides guidance, it does not stand alone as an instrument to deal with the problem. With this coordinated effort, California will have a more efficient approach for implementing California NIS strategies. Besides the CALFED Bay-Delta Program, California entities should find the document useful for designing projects,

preparing proposals, and prioritizing activities related to the NIS issue.

INTRODUCTION

Most often, the suitability of environmental conditions determines a species range. Normal changes in a species range can also occur over great distances as a result of transport mechanisms such as wind and ocean currents and dispersion by migrating species. Some NIS establish new ranges with little effect on their new surroundings. However, some NIS have established themselves, spread unimpeded and caused substantial negative economic and ecological impacts.

Over the past one hundred years, many NIS have been introduced to the San Francisco Bay-Delta. Within the last few decades, the frequency of intra- and international transfer has been greatly accelerated by various human activities. Some scientists fear that the international trend is toward species homogeneity. Some of the species introductions have been intentional, such as ornamental plants, certain agricultural crops and livestock. Others have been inadvertent; introduced through releases from the horticulture trade, pet trade, aquaculture activities, dumping of ballast water, escapees, etc.

NIS affect ecosystems in several ways that are of concern. The extinction of native species can be attributed first to habitat destruction and secondly to introduced species, whose impacts may include habitat alteration, trophic alteration, community spatial alteration, gene pool deterioration, introduction of diseases and parasites, and contaminant dynamics (Kohler and Courtenay).

One of the many underestimated affects of NIS is the potential for contaminants to be consumed, resuspended and incorporated into the food chain by organisms that have been introduced. In the Great Lakes, there are reports that PCBs and cadmium are being cycled from the water column and sedimented to the bottom of the lakes due to the presence of zebra mussels. In a similar fashion, Asian clams are bioaccumulating contaminants at a remarkable level (Cd and Se in particular) in northern San Francisco Bay. Since its arrival, there are much higher levels of Se in the livers of demersal feeders (diving ducks and sturgeon) in Northern San Francisco Bay.

Genetic pollution refers to the process by which NIS threaten natives with alien genes. Though this is not a new phenomenon, comprehensive treatments of invasion ecology in the mid-1980s did not include genetic competition as a threat. Increasing numbers of NIS and their inter-fertility mean that hybridization is a substantial threat to native biotas.

Ecological engineers are species with particularly great habitat effects; they change the physical and chemical environment through various means. This often results in rendering the habitat unsuitable for historic use, often leading to habitat loss for native species. A good example of this is the plant *Spartina alterniflora*, which invades mudflats and converts them into extensive stands of cordgrass. This alteration disturbs sediment dynamics and reduces shorebird feeding and reproduction habitat.

Some species may find themselves adapting to NIS as a matter of necessity. When riparian habitats are taken over by giant reed or aquatic habitats are taken over by water hyacinth or Egeria, the animals that use these environments to reproduce, feed or escape predation must develop the means to utilize the diminished habitats to survive. This can complicate strategies to remove or otherwise manage non-native invasive plant species, especially if listed wildlife species are observed using the undesirable vegetation.

Strategies to remove or control NIS must consider possible conflicts of this nature to avoid causing unnecessary, significant harm to special status species or other species of concern.

THE PROGRAM

This Strategic Plan has been made possible through the funding of CALFED and the support of CALFED agency, academic, non-profit and stakeholder participants. As CALFED has developed the goals and objectives of their program, they have come to recognize that NIS is a significant stressor of the Bay-Delta. The result has been the initiation of a CALFED NIS Program charged with the responsibility to develop a long-term Strategic Plan, an Implementation Plan, directed projects, an open solicitation for proposals, and coordination of the resulting projects. The U. S. Fish and Wildlife Service has agreed to develop and coordinate this program, in cooperation with CALFED programs and members. The initial funding is $1.25 million, which will be allocated over FY99 and FY 00. It is anticipated that at least $1,050,000 will be available for on-the-ground work over this two year period and that CALFED funding will become available in future years to continue with implementation actions as identified in the Plans.

In May 1995, the CALFED Bay-Delta Program was established to Arestore the ecological health and improve water management for beneficial uses in the Bay-Delta system. To accomplish this, a draft Ecosystem Restoration Program Plan has been developed to increase aquatic and terrestrial habitats, improve ecosystem functions and reduce the effects of stressors, which includes non-native invasive species.

Management actions of this Strategic Plan will be consistent with the objectives identified in the **STRATEGIC PLAN FOR ECOSYSTEM RESTORATION PROGRAM** (ERP) dated September 30, 1998. Goal 5 of the ERP plan is "Prevent establishment of additional non-native invasive species and reduce the negative biological and economic impacts of established non-native species."

The ERP objectives identified for this goal are to:

Objective 1: Eliminate further introductions of new species in ballast water of ships.

Objective 2: Eliminate the use of imported marine baits.

Objective 3: Halt the introduction of freshwater bait organisms into the waters of Central California.

Objective 4: Halt the deliberate introduction and spread of potentially harmful species of fish and other aquatic organisms in the Bay-Delta and the Central Valley.

Objective 5: Halt the release of fish and other organisms from aquaculture operations into Central California waters, especially those imported from other regions.

Objective 6: Halt the introduction of invasive aquatic and terrestrial plants into Central California.

Objective 7: Halt the release and spread of aquatic organisms from the aquarium and pet trades into the waters of Central California.

Objective 8: Reduce the impacts of exotic mammals on native birds and mammals.

Objective 9: Develop focused control efforts on those introduced species for which control is most feasible and of greatest benefit.

Objective 10: Prevent the invasion of the zebra mussel into California.

The NIS program will work to develop close linkages with the CALFED Program Elements and CMARP. These linkages will enable those programs to take advantage of the information generated by the NIS program activities and facilitate recognition of the special issues and concerns that NIS present to the estuary in general and to specific Program Elements. This insight will allow development of a better understanding of effective ways to address NIS as the work to accomplish the CALFED goals and objectives proceeds.

The purpose of this strategic plan is to provide a planned approach for management actions to address prevention, eradication, control and impacts of NIS that have invaded or may invade the ecosystems of the San Francisco Bay-Delta estuary, the Sacramento/San Joaquin Rivers and their watersheds. This plan should serve as a basic model for resource managers responsible for implementing programs to protect and enhance ecosystems in California.

THE MISSION

The mission of the CALFED Nonnative Invasive Species Program:

PREVENT ESTABLISHMENT OF ADDITIONAL NON-NATIVE SPECIES AND REDUCE THE NEGATIVE ECOLOGICAL AND ECONOMIC IMPACTS OF ESTABLISHED NON-NATIVE SPECIES.

The mission is consistent with Goal #5 of the ERP Strategic Plan.

THE GOALS

Following are the three goals of the CALFED NIS Program with a brief explanation of the problem and some insight into the issues, current activities and necessary actions.

GOAL I: PREVENT NEW INTRODUCTIONS OF NIS INTO THE ECOSYSTEMS OF THE SAN FRANCISCO BAY-DELTA, THE SACRAMENTO/SAN JOAQUIN RIVERS AND THEIR WATERSHEDS.

PROBLEM: The introduction of NIS into California, including inland state waters, frequently causes environmental, socioeconomic, and public health impacts. The severity of these impacts is not widely known or recognized which impedes the investment of resources needed to prevent new NIS introductions. Also, a delayed "crisis-response" approach often limits the vision and opportunity for the prevention of new introductions, leaving California with NIS management problems that are economically costly, technically challenging, if not infeasible to solve, and frequently irreversible. Although numerous NIS already have been introduced into California ecosystems, new introductions continue to occur. The prevention of new introductions is critical in the amelioration of NIS problems in California.

California has a long and successful history of preventing the introduction of exotic invasive pests that threatened California agricultural and natural resources. The strategy of CDFA's Pest Prevention System is consistent with the strategies of the Aquatic Nuisance Species Plans currently developed by other states (Washington, Ohio, New York, etc.) and regions (Colorado River Basin). A major component of CDFA's Pest Prevention systems is the Pest Exclusion Program which includes a statewide network of border station and port inspection activities. Although these areas of inspection concentrate on agricultural pests, they have intercepted non-native aquatic species. For example, California border station employees have intercepted 18 vessels, from eastern and mid-western states, that contained zebra mussels. Three of these vessels contained live zebra mussels. A fourth vessel was so heavily infested that live specimens were probably present and treatment was recommended prior to allowing the vessel into California waters.

Detection of zebra mussels and other NIS at the border stations has potentially saved hundreds of millions of dollars in economic losses associated with impacts to water conveyance systems, hydroelectric power plants and loss or alteration of natural aquatic habitats. California will benefit by expanding CDFA's Exclusion Program to include NIS. The US Department of Agriculture and US Department of Interior should enter into partnership with CDFA and the California Resource Agency to identify ways to expand CDFA's Exclusion Program and obtain the needed funding to accomplish this task. The CALFED Program could play a vital role in facilitating this effort.

Multiple mechanisms transport NIS into California's waters and some mechanisms transcend the authority of a single state to control. A prime example is ballast water discharge from transoceanic shipping, the largest source of nonindigenous aquatic species invasions worldwide {Carlton 1985}. Cooperative efforts are necessary between state, federal (i.e., Coast Guard and USDA), and international agencies to promulgate and enforce regulations to ensure that ballast management practices and other related transport mechanisms are employed to prevent NIS introductions. There is much attention currently directed at the efforts in the San Francisco Bay to encourage responsible ballast water management practices through the use of existing regulations. There is more extensive discussion of these activities in the Policy Background section.

Current technology is frequently inadequate to prevent new introductions of NIS into California ecosystems. Research on prevention strategies to minimize NIS transport, such as innovative ballast water management technology, is critical in the effective prevention of NIS introductions. Ongoing studies by the U.S. and Canadian Coast Guards indicate that it is especially important to deal with the difficult problem posed by vessels entering the coastal and major navigable waters with residual unpumpable ballast water and sediment in their tanks. This medium, potentially harboring a variety of NIS, is often mixed with California's fresh water and discharged at another California location or port. In order to achieve more effective emptying or flushing of these tanks, the feasibility of altering the current design of ballast tanks needs to be examined. Other significant transport mechanisms increasing the potential for new introduction of NIS into California include the aquaculture business, commercial barge traffic, recreational boating, the bait industry, the pet shop trade, plant nurseries, and fish stocking activities- all of which have the potential to introduce NIS as well as associated parasites and other disease organisms. The pet shop and aquatic plant nurseries trade are quite problematic, offering increasing numbers of easily introduced aquatics like Hydrilla. In some cases, such activities are subject to little or no regulation. In cases where laws and regulations do exist, they are frequently not well publicized or enforced. There are often gaps in the current laws. There is further explanation of the existing laws in the Policy section. An extensive effort must be made to reach out to user groups that could potentially introduce NIS into California and are generally not adequately informed of NIS prevention practices.

GOAL II: LIMIT THE SPREAD OR, WHEN POSSIBLE AND APPROPRIATE, ELIMINATING POPULATIONS OF NIS THROUGH MANAGEMENT.

PROBLEM: The spread of established populations of NIS into uninfested areas is often via human activity, such as boat transfers, ballast exchange, bait handling, water transport, intentional introduction by anglers, and ornamental and landscape practices. Limiting the spread of such populations is problematic due to the numerous pathways of dispersal, the complex ecological characteristics associated with NIS populations, and the lack of technology that is needed to limit the spread.

Many public and private resource user groups are not aware of existing infestations of NIS in San Francisco Bay, Sacramento-San Joaquin Estuary, or the inland waters of California, and why they cause problems. The probability of NIS spread to other waters can increase when resource user groups are not aware of the consequences of illegal introductions of NIS, or how their routine activities can cause the dispersal of NIS into uninfested areas. An information and education program is needed to provide information on why the spread of NIS populations needs to be limited, how the NIS populations can be reduced, and also the value of healthy ecosystems that support a diverse native community. Information and education is also critical to strengthening public and private support for statewide participation in NIS management strategies.

It is also difficult to manage the spread of NIS since infestation frequently occurs in watersheds that occupy more than one county. Cooperation among all counties in California sharing NIS infested watersheds is needed to implement consistent management strategies that will effectively limit the spread of NIS populations.

GOAL III: REDUCE THE HARMFUL ECOLOGICAL, ECONOMICAL, SOCIAL AND PUBLIC HEALTH IMPACTS RESULTING FROM INFESTATION OF NIS THROUGH APPROPRIATE MANAGEMENT.

PROBLEM: The NIS infestations in California can have ecological, economic, social and public health impacts. Strategies to control NIS and efforts to abate their impacts are not always known or technically and/or economically feasible. It should be recognized that these efforts are no substitute for prevention, which should always be the highest priority.

The NIS infestations in California's aquatic ecosystems can alter or disrupt existing ecological processes. Without co-evolved parasites and predators, some NIS out-compete and even displace native plant or animal populations. As part of this process, the invading species can also influence the foodwebs, nutrient dynamics, and biodiversity of the ecosystems. To abate the ecological impacts of the invading organism, it is necessary to understand the mechanisms by which the species disrupts the natural balance of the ecosystem.

Some introduced NIS to California have provided economic benefits, such as those supporting the aquaculture business and sportfishing industry. However, several NIS have been found to cause adverse economic impacts. Organisms invading California's waters can threaten public health through the introduction of disease, concentration of pollutants, contamination of drinking water, and other harmful human health effects. An extensive abatement system for these NIS needs to be established to prevent human health problems from occurring in California.

It is often difficult to assess the ecological, socio-economic and public health impacts of NIS in terms that are meaningful to decision makers and the general public. Actions to abate NIS impacts through control strategies are frequently impeded by circumstances, such as the absence of political support and the lack of resources needed to effectively develop and implement control strategies.

The strategic approach to this plan recognizes prevention as the most practical, economic and environmentally safe method for dealing with new or incipient infestations. An effective prevention program must include an exclusion component to prevent introductions into California, a detection component to identify incipient infestations and an integrated pest management component to eradicate or control species with minimal or transitory impact to the habitat and nontarget species. All three components need to have strong research, public information and awareness support to be effective, timely and responsive. For NIS already widely established and distributed, this plan emphasizes an ecosystem approach to management, (as opposed to a species by species approach) utilizing integrated pest management methods that are flexible and environmentally sound.

NIS in the Bay-Delta

In the last one hundred years, there have been over 212 introductions of species into the Sacramento-San Joaquin Estuary. Many of these species are believed to have traveled here via ballast water of ships. The incidence grows with the increase in trade between Pacific Rim nations because many species are carried in the ballast water of ocean-crossing vessels. Since 1970, many new species of zooplankton, clams, amphipods, crabs and fish have become established in the Sacramento-San Joaquin Estuary (Cohen and Carlton, 1995).

Aquatic ecosystems such as the Sacramento-San Joaquin Delta are comprised of many interrelated organisms which include phytoplankton (algae), macrophytes (vascular plants), invertebrates, fish, birds and mammal. These organisms require a certain set of chemical and physical conditions to exist, such as oxygen, light, nutrients adequate movement of water and adequate space.

Scientists and other NIS experts have recognized the fact that healthy ecosystems are impacted by the establishment and spread of exotic species. A habitat that is disturbed seems to be at even higher risk for establishment and negative impacts due to introduced species. The CALFED program includes an aggressive and expensive effort to increase shallow water habitats in the Delta, as well as restore the health of those already in existence. Failure to identify and develop a comprehensive strategic approach to the problem associated with invasive aquatic species could negate or undermine benefits gained from these efforts (increasing flows, reclaiming agricultural lands and eliminating or redistributing levees) to improve and expand habitat for native, beneficial, and endangered aquatic species.

In the last hundred years, human mobility has greatly accelerated and with this movement plants and animals have been introduced, either deliberately or accidentally into new environments with unforeseen consequences. Starlings, the boll weevil, rats in Hawaii, the zebra mussel and sea lamprey in the Great Lakes, and water hyacinth in California's Sacramento-San Joaquin Delta are some of the infamous cases of species becoming pests when introduced into new environments. The Nature Conservancy in a recent report entitled "America's Least Wanted" details how approximately 4000 exotic plant and 2300 exotic animal species have threatened native species and how some of these exotics have ended up costing the economy an estimated $97 billion.

Aquatic Plants

Submersed, emersed, and floating aquatic plants are natural and important components of aquatic ecosystems. In a well balanced aquatic ecosystem, aquatic plants provide protective cover for fish as well as habitat and a source of food for organisms consumed by fish. Aquatic plants also provide nesting sites and food for birds and other animals. In addition, aquatic plants can increase water clarity and quality and improve the appearance of a water body.

The spread of nonnative flowering aquatic plants has increased dramatically over the past 25 years in California and has created many economic and ecological impacts. Demands on the state's water resources, which include irrigation water delivery, recreational and domestic (drinking) uses, and fisheries and waterfowl habitats, have exacerbated these impacts. The introductions of NIS have consistently upset the delicate ecological balance of many aquatic systems. Furthermore, large-scale infestations of aquatic NIS have proven to be a severe impediment to boating, fishing, swimming, water delivery, and generation of hydroelectric power. The hallmark of aquatic invaders is their ability to grow in low light levels and their rapid, prolific, and varied reproductive abilities.

According to the California Department of Food and Agriculture, the aquatic plant species causing most of the problems in California are: *Eichhornia crassipes* (water hyacinth), *Egeria densa* (Egeria), and *Myriophyllum spicatum* (Eurasian water milfoil). There is also an intensive *Hydrilla verticullata* (Hydrilla) control program underway to limit the spread and reduce the impacts from this aquatic plant. This program intends to contain this pest and prevent it from causing widespread problems.

Water hyacinth has been under management for 15 years, and a bill authorizing the management of Egeria passed the state legislature in 1996. The combined costs of these efforts to control fewer than 25% of the infestations will probably equal or exceed the $1 million annual Hydrilla eradication expenditures. Management of water hyacinth and Egeria by using biological control agents may be the long-term goal, yet safe and effective herbicides and mechanical control strategies need to be used in the interim to prevent further spread of these weeds.

WETLAND PLANTS

Several invasive plant species on the California Exotic Pest Plant Council's (CALEPPC) list of plants of greatest ecological concern threaten the wetland habitats of the Bay-Delta system. Cordgrass introduced from the Atlantic coast has spread very rapidly in Pacific estuaries in northern California, Oregon, Washington, and British Columbia and now invades the San Francisco Estuary. The introduction of smooth cordgrass (*Spartina alterniflora)* has led to dense coverage of about 30% of the intertidal area in Willapa Bay, Washington. The introduction to San Francisco Bay has resulted in rapid colonization of the south end of the bay. It is now known to hybridize with *Spartina foliosa*, the native cordgrass, which confounds the problem of identification and eradication.

Spartina alternaflora and *S. densiflora* are the introduced cordgrass species of greatest concern (Grossinger and Cohen,1998). *Spartina patens* and *S. anglica* are of secondary concern according to this report based on input from regional wetland scientists and managers.

Smooth cordgrass is a substantial threat to wildlife, fisheries, and traditional uses of Pacific estuaries. Replacing the naturally open mud of Pacific estuaries with monospecific grass prairie, the dense canopy and tightly interlocked rootmats of these weeds exclude shorebirds, native vegetation, fish, and many invertebrates. Scientists that study and document these impacts, sometimes refer to NIS which invade in this manner, altering the physical characteristics of the habitat, as ecological engineers.

Other wetland invasive species include those found in upland-wetland transitions, but are now invading high-marsh terraces. Pepperweed (*Lepidium latifolium*) is a particularly aggressive invader and is proving difficult to eradicate. Its rhizomes can be resistant to herbicide applications and it is fairly euryhaline. *Salsola soda*, a member of the Chenopodiaceae family, is another plant that threatens native pickleweed marshes. In a recent survey Tamasi (1998) reports *S. soda* in the Bay-Delta system from Calhoun Cut near Hastings Tract down to the southern end of the South Bay. Grossinger and Cohen (1998) cite both of these species as needing attention.

RIPARIAN PLANTS

Recent introduction and spread of purple loosestrife *(Lythrum salicaria)* threaten the state's riparian systems. It has recently been observed invading some Delta levees (e.g. White Slough). According to CALEPPC's 1996 list of exotic pest plants of greatest concern, purple loosestrife status is red alert. Giant reed (*Arundo donax*) is another species that is receiving considerable attention both nationally and in California. There are now five regional teams dedicated to control and eradication of giant reed in the state. This plant is known to aggressively displace native riparian vegetation and is so disruptive that it affects water quality and quantity, exacerbates flooding, and alters the geomorphology of the waterway it invades. Giant reed is widespread throughout the CALFED problem and solution areas.

Other plants that threaten our riparian or wetland systems include blue gum eucalyptus (*Eucalyptus globulus*), salt cedar (*Tamarix* spp.), Russian olive (*Eleagnus angustifolia*), Himalayaberry (*Rubus discolor*), Cape ivy (*Delairea odorata*; formerly known as German ivy, *Senecio mikanioides*), hoary cress (*Cardaria draba*), tree of heaven (*Ailanthus altissima*), thistles (*Cirsium arvense* and *C. vulgare*), and periwinkle (*Vinca major*).

The above species are only a few of the approximately 80 species listed as Aproblem exotic plants reported in California wetlands from a survey of resource managers representing six bioregions of the state (Dudley,1998). Clearly, much work remains to be done in identifying the threats to wetland and riparian habitats posed by these invasions, prioritizing research and eradication, and monitoring progress.

Clams and Zooplankton

One species having a major impact is the small Asian clam, *Potamocorbula amurensis*. After it first appeared in 1986, the clam rapidly colonized the brackish water portion of the estuary throughout San Francisco Bay to the western edge of the Delta. It was the dominant bivalve south of San Mateo Bridge by 1991. The clam has affected the base of the food web by removing much of the algae, which is food for zooplankton. This clam is so abundant that calculations indicate that the population can filter a volume of water equal to the entire water column in 24 hours. It has apparently greatly reduced abundance of the native copepod *Eurytemora affinis*, a dominant zooplankton species providing food for many larval fish. Ironically, some recently accidentally introduced zooplankton species now provide food for young fish and may help fill the void caused by the decline in *Eurytemora affinis*. The mysid *Acanthomysis bowmani* was first reported here in 1993 and has increased in abundance, while the native mysid *Neomysis mercedis*, another important food item for young fish may have been greatly reduced in abundance through competition for food with the Asian clam.

Crabs

Two exotic crabs, the Chinese mitten crab *Eriocheir sinensis* from Asia and the green crab *Carcinus maenas* native to Europe, have also become established in the Estuary. The mitten crab, first found in South San Francisco Bay in 1992, was collected in the Delta in the fall of 1996 and since then has traveled upstream in the Sacramento River north of Colusa and upstream in the San Joaquin to Gustine. The mitten crab may have been deliberately and illegally introduced or it may have been introduced via ballast water. It is known to damage rice crops in China, and it is a potential competitor of crayfish, which supports a commercial fishery and is an important forage species for fish in the Delta. The mitten crab potentially could burrow into and weaken the levee system in the Delta if it becomes more abundant. The green crab is non-burrowing but inhabits the intertidal zone in San Francisco Bay, San Pablo Bay and has been found in Suisun Bay where it may compete with shorebirds and other crabs for food. The green crab is a voracious predator of shellfish and native shore crabs, and it is believed that it could fundamentally alter Bay-Delta invertebrate species distributions, and imperil aquaculture such as oyster farming. It has apparently spread rapidly from San Francisco Bay, where it was first captured in 1989 or 1990 (Cohen and Carlton, 1995), up the coast of California to Willapa Bay and Grays Harbor, Washington.

Fish

It is well known that a number of introduced fish have become established in this estuary over the past one hundred years. They include striped bass, catfish and several members of Centrarchidae. Some of these fish now support popular fisheries and are considered by many to be a valued recreational feature of the watershed. Outside of the Sacramento-San Joaquin Delta, unauthorized planting of the Inland silverside, *Menidia beryllina*, into Clear Lake occurred in 1967, and it was likely dispersed into the Delta from Clear Lake by high winter flows. The fish was established in the estuary by 1975. It is suspected to prey upon larvae of other fish and may compete for food with the delta smelt, *Hypomesus transpacificus*, a threatened species. The delta smelt is also faced with the threat of hybridization and competition with a morphologically similar smelt species, the wakasagi, *Hypomesus nipponensis*. A growing problem in California is ill-advised anglers who desire and introduce exotic species. Intentional illegal introductions can have great economic consequences. The white bass, *Morone americana*, a species native to the Midwest, was eradicated from Kaweah Reservoir in Tulare County with rotenone in 1987. Northern pike, *Esox lucius*, another species native to the Midwest, was illegally stocked into Frenchman Reservoir, Plumas County, in the 1980s. In March 1991, the Department of Fish and Game treated Frenchman Reservoir and successfully eradicated northern pike. A similar program was conducted in 1997 to eradicate northern pike from Lake Davis in Plumas County. Biologists were concerned that if these two predatory fish species became established throughout the watershed, they would decimate populations of salmon, trout and other fish, including some that are threatened or endangered. These eradication efforts cost over one million dollars each. These expenditures are necessitated by the irresponsible behavior of a few individuals who either do not understand or do not care about the environmental and economic consequences of their illegal actions.

Nonnative Wildlife

Nonnative wildlife is present throughout the Sacramento-San Joaquin Valleys in a variety of habitats. These include aquatic, riparian scrub, woodland and forest habitats; valley oak woodland; grassland and agricultural land. Non-native wildlife species negatively impact native organisms mainly through predation or competition. These nonnatives often have a competitive advantage because of their location in hospitable environments where the normal controls of disease and natural enemies are missing. The result is diminished abundance of native species. Some of the common but harmful species found in the Bay-Delta area are:

- The European red fox, which threatens many native endangered wildlife species, such as the clapper rail and several other San Joaquin Valley animals.
- The Norway rat, which threatens ground-nesting wildlife, has experienced large increases in the populations living along the bay shores.
- The feral cat which is a major predator to bird and mammal populations in the wetland areas of the Bay-Delta estuary.

Implementation Issues

The development of this Plan has led to the conclusion that there is one element that is necessary to the success of any program which addresses the prevention, management and eradication of NIS. That essential element is a group of individuals that come together to form an advisory council to monitor and coordinate the efforts of the program. For this Plan, the formation of this group is identified as a Programmatic Action below.

Programmatic Action

Programmatic Action: Formation of an Interagency Non-Native Invasive Species Advisory Council (NISAC) to monitor management efforts and assure effective coordination of this program with CALFED and other NIS programs.

California natural and man made water conveyance and impoundment systems are available and utilized for multiple purposes. In addition, there is a complex mosaic of federal, state and local laws and regulations which not only address intended use of these resources but will impact efforts to prevent the introduction, establishment and management of NIS. To facilitate accomplishment of the strategic goals, this program must coordinate with jurisdictions within and outside the state and build tasks and actions upon sound science. Therefore, mechanisms will be established to ensure that all prevention, control and abatement tasks and actions developed and implemented by this program under this plan are (1) done in cooperation with federal agencies, local governments, interjurisdictional organizations and other entities, as appropriate (2) based upon the best scientific information available, (3) conducted in an environmentally-sound and conscientious manner and (4) coordinated through NISAC.

As presented in the Implementation Section on page 7, there are also a number of major issues critical to achieving the goals as presented in this plan. These issues are discussed below and will be addressed as objectives of the Implementation Plan with specific Tasks and Actions.

Leadership, Authority and Organization

As the program develops, one of the components essential to actual implementation will be to identify the leadership, authority and organization that are necessary to accomplish each goal. In some cases, there will be existing organizations that have the leadership and authority to carry out the actions identified in the plan. The CALFED NIS Program will develop relationships and support the efforts of these organizations. It may be that other tasks and actions determined to be essential to the success of the program do not have the leadership, authority or organization in place. In these instances, we will work to identify and/or develop the appropriate component needed to carry out the work as a part of the CALFED NIS Program.

Coordination, Cooperation and Partnership

For all of the work undertaken as part of this program, the value and necessity of the elements of coordination, cooperation and partnership to the success of the program can not be overstated. At all times and in all aspects of the work, priority will be given to these ideals and we will strive to incorporate them into every aspect of plans made and actions taken. There are many entities and organizations developing or operating programs to address NIS, including local, regional, state and national. The programs and organizations that deal with the issues and organisms that are of concern to the CALFED objectives will be identified and cooperative relationships will be developed with these entities. Emphasis will be given to projects where partnerships can be developed to improve efficiency, support and effectiveness of activities. There is further discussion of this issue in the Policy Background section.

Education and Outreach

A comprehensive awareness and education program is critical for an effective NIS management program. Except for isolated cases that have attracted substantial media attention, the general public does not understand how NIS negatively impact the environment, the economy and the use of the natural aquatic resources that are important to them. Therefore, a strategic approach to NIS must include an education and awareness component for all actions and tasks presented. Developing and implementing a coordinated and comprehensive information program will expand understanding by all California citizens of the impacts and risks associated with the introduction and spread of NIS.

Information about the nature, characteristics, and the impacts of NIS on the environment, economy, and quality of life needs to be made more available. This information should be presented concurrently with information about related issues such as threatened and endangered species, water quality, habitat restoration, and ecosystem health. An important aspect of this program will be developing outreach to inform and educate not only the public, but also private entities that may be contributing to the problems and/or may be affected by project actions. The need for understanding and managing NIS should be institutionalized in public and environmental education curricula. A well-coordinated effort is needed because of the costs and complexities associated with developing and delivering a comprehensive, high caliber outreach program.

A successful education and information program must utilize individuals and institutions with expertise on raising public awareness and influencing attitudes towards NIS management. Public information specialists can be utilized to develop, distribute and coordinate information statewide. In addition, information specialists can enhance public interest and improve citizen and organizational involvement to reduce the spread of NIS. Raising awareness can be achieved via television spots, ad campaigns, outreach to schools, and public service announcements.

An increased awareness and concern of California citizens should precipitate an increased level of commitment by elected officials toward NIS management. Many federal and state legislators have little understanding of the risks associated with NIS and this has had a negative impact on obtaining sufficient long-term funding. An immediate priority should be the development of briefing packages and presentations for national, state, and local officials and interest groups.

FUNDING AND RESOURCES

In California, the funding for management of NIS is not reliable or consistent and in many cases is inadequate or nonexistent. This is especially true in the areas of exclusion, education, emergency response, research and management. Funds are generally available on a reactive basis and do not effectively deal with infestations before they become unmanageable. Except for the Hydrilla Program conducted by California Department of Food and Agriculture, or the Northern Pike Program conducted by California Department of Fish and Game, funds for NIS are usually provided only after the problems become widespread, provide resources for only limited control efforts and do very little to prevent further spread to uninfested areas.

Costs associated with this management plan and associated implementation plans must be identified. The CALFED Program has provided initial funding for development of the NIS Program and to begin high priority projects. It is the intent of the CALFED Program that as future funding becomes available, the CALFED NIS Program will continue to receive support to carry out the NIS projects that will contribute to the success of the CALFED Program objectives. Also, traditional sources of financial support which will be pursued include the US Fish and Wildlife Service, ANS Task Force, US Army Corps of Engineers, US Environmental Protection Agency, Natural Resource Conservation Service and the National Fish and Wildlife Foundation. For federal agencies, allocations of discretionary funds will likely be inadequate. It is necessary to acquire dedicated funding to assure the continuity and viability of this Program. At the state level, one or more agencies may have to submit Budget Change Proposals to obtain long-term funding in support of a statewide management program. It should be recognized that discretionary funding would not be adequate to address the full scope of this problem. Funding needs are substantive and appropriations will be necessary to carry out this Plan.

In addition to traditional funding sources, a working group within the NISAC, should develop a number of nontraditional funding options for NISAC consideration and recommendation. These funding options should recognize that management of NIS benefits all Californians and will actually prove cost-effective over the long term.

Other nontraditional sources of revenue and resources involve cooperative agreements and partnerships. Federal, state, local agencies and private organizations with NIS management responsibilities should be encouraged to coordinate, share, or pool resources. This can include shared purchase of supplies and use of equipment, savings for bulk purchases of chemical supplies, use of staff and other human resources, sharing of mapping and monitoring data and expertise, biological control and educational materials.

MONITORING, MAPPING AND ASSESSMENT

As part of the CALFED program, a Comprehensive Assessment, Monitoring and Research Program (CMARP) is under development to address the needs of CALFED's common programs and related agency programs regarding monitoring, research and assessment. The CALFED NIS Program will communicate and coordinate with all pertinent CMARP programs and activities.

Ecosystems infested with NIS are not consistently identified and delineated. Complete up- to-date maps, displaying the distribution and severity of NIS infestation are available in only a few areas. Knowledge of which species are located where is paramount for: 1) increasing public awareness and concern, 2) obtaining support and funding for developing a strategic program, 3) accurately predicting where new infestation may occur from already infested areas and, 4) developing effective integrated management and prevention plans with specific actions to mitigate or prevent NIS impacts.

Risk assessment involves identifying geographic areas that may be at risk for successful establishment of particular species. This type of assessment can be an essential element of a successful prevention program by identifying areas of specific concern and affording the opportunity to direct resources in the most beneficial and efficient manner.

A georeferenced ecosystem inventory, mapping and monitoring system will be based on standards which allow for easy exchange of information among federal, state and local agencies as well as private organizations and form the basis of a Bay-Delta GIS for NIS.

An integral component of the goals to prevent and limit spread of NIS is early detection monitoring and rapid response. It is important to identify and monitor susceptible areas on a regular basis in an effort to detect invasions early and allow the best possible chance of successful management for the least cost and disruption. Examples of areas more susceptible to invasions include those in close proximity to ports with ballast water discharges and areas of physical ecosystem disturbance such as newly restored areas.

RESEARCH AND TECHNOLOGY TRANSFER

A strong commitment to research and information/technology transfer is critical towards achieving the goals presented in this management plan. The CALFED NIS Program will communicate and coordinate with CMARP, the coordinating entity for the common programs of monitoring, research and assessment, in their efforts to identify research needs. A subcommittee within NISAC will meet annually to review and prioritize research needs already identified by various entities, as well as newly identified research gaps relative to the goals and objectives of the plan. A report and recommendations, including suggested opportunities for funding critical research should be submitted to the NISAC and other interested groups following the annual review. This commitment also extends to the transfer of information to a wide audience through many venues to assure coordination and cooperation with others involved in the same type of endeavors.

ENFORCEMENT AND COMPLIANCE

In those areas where enforcement and compliance are identified as an issue, this program will develop the information base to illustrate and define the issue, describe possible approaches, and make recommendations to appropriate agencies to enhance the adherence to regulations. As programs to prevent, control, and manage NIS are cooperatively developed, certain practices or prohibitions may emerge as mandatory requirements for specific entities in order for the three management goals to be accomplished. It will be necessary for responsible agencies to monitor the compliance with such requirements. In these cases, enforcement mechanisms will be essential to encourage compliance with recognized standard practices.

PROGRAM EVALUATION

To be effective and responsive this management program and associated implementation plans must include an evaluation component to identify progress, evaluate implementation problems and needs, and make necessary corrections at any time. The adaptive management strategy will be highlighted. The evaluation process will include:

1. Develop a peer review process for program evaluation using the technical expertise and experience of the national, regional, and local groups identified in this report as entities familiar with the issues of NIS.

2. Coordinate and communicate with CMARP for the CALFED program evaluation process.

3. Establishment of an evaluation subcommittee within NISAC responsible for reviewing performance measures, conducting the evaluation efforts, reporting the results to NISAC and others if required, and identifying program or plan adjustments that address projected outcomes.

4. The three program goals, as previously presented, provide the focal point for evaluation. Quantifiable milestones for each goal and objective will be developed and have realistic, feasible time frames.

5. The evaluation process will involve those with implementation responsibility, resource user groups, and others affected by the program implementation.
6. An annual report highlighting progress and achievements will be prepared and distributed. The annual report will include evaluation of the efficacy of the program strategies and tasks and identify revisions as needed. The annual report will be readily available on the Internet and distributed to local and federal agencies and

legislative decision-makers and CALFED program managers.

POLICY BACKGROUND

The complex environmental and economic impacts posed by the intrusion of NIS require policies and programs to address prevention and control at various levels of government. In addition, improved coordination of new and existing policies could more effectively focus attention on the problems and achieve more positive results. The following overview describes the basic role of the federal, regional and state governments in implementation of efforts to address NIS. The contents of this section includes:

- The CALFED role in implementing restoration of the San Francisco Bay-Delta estuary and Sacramento-San Joaquin Rivers and their watersheds and the objectives of that program with regard to nonnative invasive species.
- The federal Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA, Public Law 101-646) and the reauthorization of The National Invasive Species Act of 1996 (NISA).
- Executive Order on Invasive Species issued by President Clinton in February of 1999 which was intended to coordinate a federal strategy to address the growing environmental and economic threat of NIS.
- An assessment of California's existing laws and programs that address prevention and control of NIS.

Immediate and strategic coordinated federal and state action is critical for effective NIS prevention and control in North American waters. For example, over 212 aquatic nuisance species have already become established in the San Francisco Bay-Delta estuary watershed alone. The rate of invasion appears to be increasing due in part to expanded national trade and travel. Reducing the acceleration of invasions will require managing transport mechanisms including the discharge of ship ballast water, aquaculture activities, global trade in aquarium organisms, live seafood and live bait. Prevention of new NIS introductions coupled with long-term research on control strategies are priorities.

CALFED ROLE

The CALFED Bay-Delta Program was established to develop a long-term solution to the problems affecting the Bay-Delta system. Building on the spirit of cooperation reflected in the December 1994 Bay-Delta Accord, a group of state and federal agencies have come together to work cooperatively at developing and implementing a long-term comprehensive plan that will restore the ecological health and improve water management for beneficial uses of the Bay-Delta system.

The Ecosystem Restoration Program (ERP) is the principal Program component designed to restore the ecological health of the Bay-Delta ecosystem. The ERP represents one of the most ambitious and comprehensive ecosystem restoration projects ever undertaken in the United States. The goal of the ERP is to restore or mimic ecological processes and to increase and improve aquatic and terrestrial habitats to support stable, self-sustaining populations of diverse and valuable species.

As part of the ERP, the U.S. Fish and Wildlife Service has accepted the responsibility of developing, implementing, managing, and coordinating a non-native invasive species program in the San Francisco Bay-Delta estuary which will include terrestrial as well as aquatic species. This program, with the contributions of CALFED staff, agencies, academia, non-profits and interested stakeholders, will focus on the San Francisco Bay-Delta, the Sacramento and San Joaquin Rivers and their watersheds.

CALFED MEMBER AGENCIES:

STATE:

The Resources Agency
- Department of Fish and Game
- Department of Water Resources

California Environmental Protection Agency
- State Water Resources Control Board

Department of Food and Agriculture

FEDERAL:

Environmental Protection Agency

Department of the Interior
- Fish and Wildlife Service
- Bureau of Reclamation
- U.S. Geological Survey
- Bureau of Land Management

U.S. Army Corp of Engineers
Department of Agriculture
Natural Resources Conservation Service
Department of Commerce
National Marine Fisheries Service
Western Area Power Administration

FEDERAL ROLE

INVASIVE SPECIES COUNCIL

The expanded federal effort to address NIS includes the Executive Order on Invasive Species signed by President Bill Clinton on February 3, 1999. This action is intended to build upon existing laws such as the National Environmental Policy Act, NANPCA, The Lacy Act, Federal Plant Pest Act, Federal Noxious Weed Act, and the Endangered Species Act. The order creates an Invasive Species Council which has eighteen months to develop a comprehensive plan to minimize the economic, ecological, and human health impacts of invasive species and determine the steps necessary to prevent the introduction and spread additional invasive species. This council will be co-chaired by Secretary of the Interior, Secretary of Agriculture, and Secretary of Commerce and will work in cooperation with the Secretary of State, Department of Defense, Secretary of Transportation, the Administrator of the Environmental Protection Agency, states, tribes, scientists, universities, shipping interests, environmental groups and farm organizations to combat invasive plants and animals. In addition, the President's fiscal year 2000 budget proposes an additional $29 million to support these efforts.

NONINDIGENOUS AQUATIC NUISANCE PREVENTION AND CONTROL ACT

NANPCA was primarily a federal response to the Great Lakes invasion of the zebra mussel which has caused extensive ecological and socioeconomic impacts. Although the zebra mussel issue played a key role in prompting passage of the legislation, NANPCA clearly was established to prevent the occurrence of new unintentional introductions of aquatic nuisance species (ANS) and to limit the dispersal and adverse impacts of invasive species currently in United States waters.

The actions identified in NANPCA are a first line of defense against aquatic nuisance invasions. The Act provides an institutional framework that promotes and coordinates research, develops and applies prevention and control strategies, establishes national priorities, educates and informs citizens, and coordinates public programs. The Act calls upon states to develop and implement comprehensive state management plans to prevent introduction and control the spread of aquatic nuisance species (ANS). Section 1002 of NANPCA outlines five objectives of the law, as follows:

- To prevent further unintentional introductions of nonindigenous aquatic species;
- To coordinate federally funded research, control efforts and information dissemination;
- To develop and carry out environmentally sound control methods to prevent, monitor, and control unintentional introductions;
- To understand and minimize economic and ecological damage; and
- To establish a program of research and technology development to assist state governments.

Section 1201 of the Act established the national Aquatic Nuisance Species Task Force (ANSTF), co-chaired by the U.S. Fish and Wildlife Service (USFWS) and the National Oceanic and Atmospheric Administration (NOAA). The Task Force is charged with coordinating governmental efforts related to prevention and control of ANS. The ANSTF (consisting of seven federal agency representatives and eight ex-officio members representing nonfederal governmental agencies) has adopted the ANS program under Section 1202 of NANPCA. This program recommends the following elements:

- Prevention: Establish a systematic risk identification, assessment and management process to identify and modify pathways by which ANS spread.
- Detection and Monitoring: Create a national ANS information center to coordinate efforts to detect the presence and monitor the distributional changes of all nonindigenous ANS,

identify and monitor the impacts to native species and other effects, and serve as a repository for that information.

- Control: The Task Force or any other potentially affected entity may recommend initiation of a nonindigenous ANS control program. If the Task Force determines that the species is a nuisance and control is feasible, cost effective and environmentally sound, a control program may be approved.

The ANSTF recommends research, education and technical assistance as strategies to support the elements listed above. The Task Force also provides national policy direction as a result of protocols and guidance that have been developed through the efforts of working committees. The ANSTF currently has two regional panels, the Great Lakes Panel and the Western Regional Panel. The latter was added as part of a 1996 amendment to NANPCA. The new law of 1996 (NISA) expanded the focus of the original legislation from zebra mussels to all potential ANS and enlarged the area of concern from the Great Lakes/Hudson River to all of the U.S. In addition, NISA requires that the Coast Guard (USCG) draft regulations to implement a ballast water management program nation-wide. This new program was to be patterned after the program established under NANPCA for the Great Lakes/Hudson River.

The USCG regulations will apply to all vessels with ballast on board that enter U.S. waters from outside the Exclusive Economic Zone (EEZ). These vessels will be encouraged to *voluntarily* comply with the International Maritime Organization=s (IMO) guidelines for ballast exchange at sea, and will be *required* to submit a report form to the USCG documenting where, when and how they dealt with their ballast.
Ballast procedures allowed under the proposed regulations:

1. open ocean exchange in at least 500 meters of water, or
2. retain ballast on board, or
3. obtain approval for using an alternate method in a given situation, or
4. discharge ballast in an approved Aalternate exchange zone.

Reporting requirements under the new regulations:

1. record ballast procedures on the IMO form;
2. fax the information to the USCG upon arrival in port;
3. retain records on board for at least 2 years.

The USCG regulations have been circulated for public review and comment. It is anticipated that the rule will become final in April 1999. The voluntary guidelines will become mandatory if vessels fail to comply with ballast exchange procedures or fail to submit the report forms to the USCG. The statute requires the USCG to report to Congress within 18 months of the effective date of the regulations, providing information on the level of voluntary compliance. It is anticipated that a mandatory program, if needed, would be implemented in 2000 or 2001.
The USCG will establish a Clearinghouse to retain the report forms and to be a central repository for ballast management-related information/studies. Such information will include; patterns of invasion, measures of compliance and effectiveness of IMO procedures, a national database of exotic species, the economic and environmental impacts of the invaders, and the economic impacts of control measures. The Smithsonian Environmental Research Center (SERC) will maintain the Clearinghouse.

Locally, the proposed federal project to deepen the Oakland Harbor Channel to allow larger ships into the Port of Oakland has raised concerns about increases in ballast water releases. San Francisco Baykeeper and the Center for Marine Conservation have been actively encouraging the Port of Oakland, the Army Corp. of Engineers and the consulting agencies, (U.S. Fish and Wildlife Service and the National Marine Fisheries Service) to fully evaluate the potential impacts of non-native species introduction into the San Francisco Bay. The Port of Oakland has agreed to require that all ships calling at the Port exchange their ballast water at sea, except in emergencies. While applauding this step as a positive effort to reduce introductions, a full consultation under the Endangered Species Act is desired by these groups, as they feel that it may result in more information and more effective and stable control measures.

CLEAN WATER ACT

The objective of the Clean Water Act (CWA) is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters, and where attainable, to achieve a level of water quality that provides for the protection and propagation of fish, shellfish, and wildlife, and for recreation in and on the water.

Discharges of pollutants and fill material to waters of the United States are regulated under various sections of the CWA. In California, the U.S. Environmental Protection Agency (EPA) has delegated the authority to implement the CWA to the State Water Resources Control Board (SWRCB), which in turn has designated the nine Regional Water Quality Control Boards (RWQCBs), established under the State's Porter-Cologne Water Quality Control Act, as the implementing agencies.

The mission of RWQCBs, under the State's Porter-Cologne Act, is consistent with the objective of the CWA, namely, to protect beneficial uses of waters of the state. To accomplish this objective, RWQCBs use various planning and permitting programs authorized under the CWA. Section 402 authorizes the National Pollutant Discharge Elimination System (NPDES), which is a permit program intended to reduce and eliminate the discharge of pollutants from point sources that threaten to impair beneficial uses of water bodies. The State's Waste Discharge Requirements, discussed below, incorporate the authority of the federal NPDES permitting program for discharges of wastes to surface waters.

The CWA defines point sources to include vessels (Section 502(14)); and prohibits all point source discharges of pollutants into U.S. waters unless a permit has been issued either under Section 402 (NPDES) or Section 404 (dredge and fill activities). The CWA provides a narrow exemption from the usual CWA regulations for certain discharges (including ballast water) only for Armed Forces vessels (Section 502(6)(A)). However, these discharges are to be regulated by an EPA- and DOD-sponsored proposed rule under Section 312(n) of the CWA, Uniform Discharge Standards for Vessels of the Armed Forces.

Under Section 305(b) of the CWA, RWQCBs are required to assess water bodies for attainment of beneficial uses every two years, and report to the EPA. In cases where beneficial uses of water bodies are shown to be impaired, Section 303(d) requires the RWQCBs to list the impaired water bodies and "establish a priority ranking for such waters, taking into account the severity of the pollution and the uses to be made of such waters." Section 502(6) defines "pollutant" as dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water.

Ballast water is considered to be a "waste" by the RWQCBs, based on the above definition and definitions in the State Water Code, described below. Based on these federal and state definitions and scientific evidence, the San Francisco Bay RWQCB has made a finding that ballast water has created "pollution" in the estuary. In February 1998, the San Francisco Bay RWQCB listed the waters of the San Francisco Bay-Delta Estuary as impaired under Section 303(d) because of introductions of NIS.

Section 303(d) of the CWA requires implementing agencies to establish and allocate "a total maximum daily load (TMDL) for those pollutants which the (EPA) Administrator identifies under Section 304(a)(2) as suitable for such calculation." This section of the CWA was developed to support a water quality-based system of effluent limits for chemical pollutants, and the interpretation of what an allowable load of invasive species has not been defined. Historically, for instance for sewage treatment plants, the regulations of the CWA have supported a permitting sequence of (1) technology-based effluent limits, and (2) water quality-based effluent limits. Water quality-based limits, of which TMDL is an example, are considered necessary if technology-based limits do not lead to attainment of adequate water quality to protect beneficial uses.

100TH MERIDIAN INITIATIVE

The U.S. Fish and Wildlife Service is developing the 100th Meridian Initiative: A Control Plan to Prevent the Westward Spread of Zebra Mussels and other

Aquatic Species. The goal of this initiative is to prevent the spread of zebra mussels and other ANS west of the 100th meridian. It is comprised of 6 components: 1) information and education 2) voluntary boat inspections and boater surveys 3) commercial boat hauling 4) monitoring 5) rapid response 6) evaluation. This initiative will be coordinated with the jurisdictions that straddle the 100th meridian and those further west, tribes and private entities such as water and power companies.

The CALFED NIS Program will work with the 100th Meridian Initiative in an effort to address the CALFED Strategic Plan Objective #10) Prevent the invasion of zebra mussel into California.

Federal agencies with regulatory authority over introduction and transport of aquatic species which may be invasive or noxious include, US Department of Agriculture Animal Plant Health Inspection Service (USDA-APHIS), USDA Agricultural Marketing Service (USDA-AMS), US Fish and Wildlife Service (USFWS), US Department of Commerce (USDC) and US Coast Guard (USCG).

Regional Role

On July 8 and 9, 1997 the Western Regional Panel on Aquatic Nuisance Species held their first organizational meeting. The general goals of the WRP are to prevent nuisance species introductions, coordinate activities of the western states among federal, local, and tribal agencies and organizations and minimize impacts of already established nuisance species. Though much emphasis to date has been on the zebra mussel, there is a general recognition of the need to limit introductions of all non-native species.

The WRP will eventually include representatives from the 17 western states, several federal agencies, native Americans and Canada. The panel which meets annually, is chaired by an executive committee consisting of a state, federal, and at-large representatives. The basic structure of the Panel reflects the varying interests and concerns of the western states and is comprised of two elements, the Coastal committee and the Inland committee. It appears that the potential for this group to help California minimize impacts of introduced aquatic species is could be substantial. The purposes of the WRP are to:

- identify western region priorities for responding to aquatic nuisance species;
- make recommendations to the Task Force regarding an education, monitoring (including inspection), prevention, and control program to prevent the spread of the zebra mussel west of the 100th Meridian;
- coordinate, where possible, other aquatic nuisance species program activities in the West not conducted pursuant to the Act;
- develop an emergency response strategy for Federal, State, and local entities for stemming new invasions of aquatic nuisance species in the region;
- provide advise to public and private individuals and entities concerning methods of preventing and controlling aquatic nuisance species infestations;
- submit an annual report to the Task Force describing activities within the western region related to aquatic nuisance species prevention, research and control.

State Role

State and regional management plans for ANS are addressed in Section 1204 of NANPCA. The intent of this Strategic Plan is to focus on the identification of feasible, cost-effective management practices and measures to be taken by various entities to prevent and control NIS infestations of the San Francisco Bay-Delta and its watersheds in an environmentally sound manner. Section 1204 also states that in the development and implementation of the management plans, the state or region needs to involve appropriate local, state, and regional entities as well as public and private organizations that have expertise in ANS prevention and control. These management plans should also identify federal activities dealing with prevention and control measures, including direction of how these activities should be coordinated with state and local efforts. This CALFED NIS Strategic Plan and the Implementation Plan which will follow will be submitted to the ANS Task Force as a Regional Management Plan for the San Francisco Bay-Delta estuary and its watersheds. It is anticipated that a State Management Plan will also be developed and submitted that will include and expand upon the information in this document. There is a Colorado River Basin Regional Plan currently under development as well.

The State of California currently has several statutory and regulatory authorities that address or potentially can address the issue of prevention and control of NIS that impact aquatic and riparian ecosystems. All of these authorities have been developed over time in response to individual target species and their associated concerns. Therefore, no comprehensive, coordinated and vigorously enforced policy framework to deal with problem species and their impacts exists. Clearly, gaps must be identified within the state's policies and statutes and recommendations made. Such improvements may entail developing methods for improving enforcement, coordination, and information dissemination regarding new or existing authorities.

The following existing authorities and policies have been identified relative to California's management of NIS that impact aquatic and riparian ecosystems. Some of these deal more broadly with all species that may invade terrestrial or transitional ecosystem, as well as aquatic ecosystems.

PORTER-COLOGNE WATER QUALITY CONTROL ACT (CALIFORNIA WATER CODE)

The Porter-Cologne Act (also known as the California Water Code or CWC) establishes the system of water quality regulation for the State, including the State Water Resources Control Board (SWRCB) and the nine Regional Water Quality Control Boards (RWQCBs). The Porter-Cologne Act establishes the authority of these agencies to develop statewide water quality control plans and regional basin plans. These plans designate the beneficial uses for specific water bodies, the water quality objectives to protect those uses, and the implementation plans for the attainment of uses and associated water quality objectives. NPDES permits, described above under Clean Water Act, are an important element of the implementation plans of all California basin plans.

Section 13260 of the CWC authorizes RWQCBs to issue waste discharge requirements (WDR) to dischargers of waste into waters of the state, which include ground waters. For discharges to surface waters, WDR are federal NPDES permits, discussed above, which implement both the Clean Water Act and the Porter-Cologne Water Quality Control Act.

Section 13050(l) of the Porter-Cologne Act defines "pollution" as "an alteration of the quality of the waters of the state by waste to a degree which unreasonably affects either beneficial uses or facilities which serve the beneficial uses." Section 13050(d) defines "waste" as sewage and any and all other waste substances, liquid, solid, gaseous, or radioactive, associated with human habitation, or of human or animal origin, or from any producing, manufacturing, or processing operation of whatever nature, including waste placed within containers of whatever nature prior to, and for the purposes of, disposal."

Ballast water is considered to be a "waste" by the RWQCBs, based on the above definitions and definitions in the Clean Water Act. Based on these federal and state definitions and scientific evidence, the San Francisco Bay RWQCB has made a finding under its Clean Water Act authority that ballast water has created "pollution" in the estuary and that it threatens beneficial uses. Therefore, vessels discharging ballast water could be required to obtain WDR/NPDES permits which may contain conditions that could result in requirements for open ocean exchange or treatment of ballast water.

CALIFORNIA ENVIRONMENTAL QUALITY ACT

Requires that agencies adopt feasible mitigation measures in order to substantially lessen or avoid the otherwise significant environmental impacts of a proposed project. This act could be used to ensure appropriate mitigation of projects which result in increased discharges of ballast water.

CODE REGULATIONS

IMPORTATION, TRANSPORTATION AND POSSESSION OF WILD ANIMALS (PROHIBITED SPECIES) (Sections 671-671.7, Title 14, California Code of Regulations, Sections 2116-2118, Fish and Game Code)

Sections 2116-2118 define wild animals, provide a list of prohibited wild animals, provide specific restrictions regarding Atlantic salmon in the Smith

River, extend authority to the Fish and Game Commission to prohibit animals not listed in Sections 2116-2118 and to adopt certain other restrictions which appear in Sections 671-671.7, Title 14, CCR.

Section 671 Title 14, CCR, lists animals designated by the Fish and Game Commission as members of one of two classes of animals which are prohibited: AW or welfare animals (listed to prevent their depletion and/or to assure their welfare), and AD, or detrimental animals (listed because they pose a threat to native wildlife, the agricultural interests of the State, or to public health or safety). Live animals listed in Section 671 may not be imported, transported or possessed, except under special permits issued pursuant to Sections 671.1 through 671.7.

IMPORTATION OF LIVE AQUATIC PLANTS AND ANIMALS (Section 236, Title 14, California Code of Regulations)

Section 236 requires an importation permit for the importation of live aquatic plants and animals, except:
(1) Mollusks and crustaceans intended directly for the live seafood market, and which will not be introduced to waters of the State nor held in waters discharged to waters of the State,

(2) Live ornamental tropical plants or animals not utilized for human consumption or bait, which are maintained in closed systems for personal, pet industry or hobby purposes, and which will not be placed into waters of the State, and

(3) Brine shrimp.

The Department regulates importation of live aquatic plants and animals through review and approval or disapproval of permit applications. Permit applications must be submitted at least ten day before the proposed date of importation. When importation's are approved by the Department they are permitted by either a Standard Importation Permit or a Long-Term Importation Permit. The type of permit issued is determined by the species and by its proposed use.

Standard Importation Permits are issued for importations which are normally inspected by Department of Fish and Game pathologists. Examples are salmon, trout, largemouth bass and other species destined for stocking into aquaculture facilities. An approved Standard Importation Permit permits only one shipment, and the date of shipment and inspection scheduling information is on the permit.

Long-Term Importation Permits are issued for importations which are not normally inspected by Department pathologists and which generally represent little environmental risk. Examples include largemouth bass or Sacramento blackfish destined for direct sale in the live food markets. Long-Term Permits are issued for a period of up to one year, and the number of shipments permitted is normally unlimited.

STOCKING (Sections 6400 and 6431, Fish and Game Code)

Section 6400 prohibits the stocking of plants or animals into State waters without permission of the Department. Amendments to this section in 1998 provided new, severe penalties for violation of this section. Penalties are more severe when the violation involves a nuisance species. Section 6431 defines Anuisance species.

ASSEMBLY BILL 1625 (Sections 12023, 12024, and 12026, Fish and Game Code)

Assembly Bill 1625: This Act, approved by the Governor on September 12, 1998, adds Sections 12023, 12023, and 12026 to the Fish and Game Code.

Section 12023: Any person that violates Section 6400 through the use of aquatic nuisance species, as defined in Section 6431, is guilty of a misdemeanor punishable by all of the following:

1) Imprisonment in county jail for not less than six months or more than one year, a fine of not more than fifty thousand dollars for each violation or both imprisonment and fine.

2) Revocation of all of the defendant's licenses and permits issues pursuant to this code.

A defendant is also liable to the owner of any private or publicly owned property for any monetary damages directly, indirectly and proximately caused by the violation. This also covers escape of aquatic nuisance species, but exempts release through discharge or exchange of ballast water. Also exempt are persons unaware that he or she is in possession of a plant.

Section 12024: A person that violates Section 6400 is liable for all public and private response, treatment, and remediation efforts resulting from the violation, including administrative, legal and public relations costs.

Section 12026: Any person that provides information or evidence leading to the arrest and conviction of a person or persons found guilty of violating Section 6400 is eligible to obtain a reward of up to fifty thousand dollars.

BALLAST WATER (Sections 6432, 6433, Fish and Game Code)

Section 6432: Requires the adoption of International Maritime Organization guidelines for ballast water exchange for all vessels prior to entering California waters.

Section 6433: Requires the department to adopt a ballast water control report form, consistent with the U. S. Coast Guard (USCG) to monitor compliance and shall assist with distributing these forms to vessels.

This has been deferred at the suggestion of USCG pending release of their regulations, expected in April 1999. The State of California (OSPR) and USCG have signed a cooperative agreement affecting various maritime programs; ballast water programs would be subject to such an agreement.

Sale And Transportation Of Aquatic Plants And Animals (Section 238, Title 14, California Code of Regulations)

Section 238 regulates the sale and transportation of live aquaculture products by requiring sales invoices and waybills and requiring that all aquaculture products be killed before leaving retail sale premises.

Stocking Of Aquaculture Products (Section 238.5, Title 14, California Code of Regulations)

Section 238.5 is designed to prevent the unwanted introduction of exotic species, by regulating the private stocking of live fish. It requires a stocking permit for the private stocking of all waters except (1) lakes operated under a Cooperative Stocking Agreement with the Department, and (2) private ponds in the central valley and southern California when the species are limited to certain species designated in this section (common game fish species already established in these parts of the State).

TRIPLOID GRASS CARP STOCKING (Section 238.6, Title 14, California Code of Regulations, Sections 6450-6458, Fish and game Code)

These regulations and statutes regulate the private stocking of triploid grass carp for the control of nuisance aquatic vegetation. Restrictions include stocking permit application review requirements to assure stocking only in safe areas, testing and verification of triploidy (sterility), tagging requirements, monitoring of stocked areas to prevent unauthorized movement of fish, and other restrictions.

BAIT FISH (Sections 4.00 through 4.30, 200, 200.10, 200.12, 200.13, 200.29 and 200.31, California Code of Regulations).

Sections 4.00 through 4.31 provide general statewide restrictions on the species allowed for use as live bait, specific restrictions by regulation district, and in some cases, specific restrictions by water body. Sections 200 through 200.12 provide license requirements for live freshwater bait dealers and restrictions on the transportation and sale of live bait. Sections 200.13 and 200.31 restrict the species sold by live bait. Section 200.29 provides restrictions by species and location on the sources of live bait.

CONTROL MEASURES FOR NON-NATIVE FLORA AS PART OF MANAGEMENT PLANS FOR DFG MANAGED ECOLOGICAL RESERVES AND WILDLIFE AREAS (FISH AND GAME COMMISSION POLICY; Ccr, Title 14 ' 550 AND 630)

Each ecological reserve and wildlife area is managed by the Department of Fish and Game by separate specific plan. The management plans are written in conformance with the California Environmental Quality Act, usually as mitigated Negative Declarations. The Department of Fish and Game's goals to manage and control impacts of prohibited/detrimental species on natural ecosystems in California through (a) leading efforts to eradicate detrimental animal and plant species from wildlife communities and (b) seeking legislation to reduce the number of exceptions in the law that allow prohibited species to be imported and to increase fines and penalties for the introduction of illegal species into the wild.

TAKING OF HARMFUL FISH (Section 5501, Fish and Game Code)

The department may, or prescribe the terms of a permit to, take any fish that is unduly preying upon any bird, mammal or fish or is harmful to other species and should be reduced in numbers.

HYDRILLA (Food And Agricultural Code Sections 6048-6049)

These code sections deal specifically with the aquatic plant Hydrilla (*Hydrilla verticullata*). The codes specifically prohibit the production, propagation, harvest, possession, selling or distribution of Hydrilla. Fines and penalties are described for unlawful activities. The director of CDFA is also required to conduct an ongoing survey and detection program for Hydrilla. When discovered, the director is directed to immediately investigate the feasibility of eradication and do so if determined feasible.

In cooperation with the University of California, the U.S. Department of Agriculture or other agencies, the director of CDFA may develop and implement biological control methods to eradicate or control Hydrilla in any area of the State and may conduct studies for these purposes.

In addition to exercising its statutory and regulatory authorities, the State also fosters research and education/outreach programs through various State and federal agencies and local organizations and institutions. Examples include the US Department of Agriculture-Agricultural Research Service, University of California and California State University system, the San Francisco Bay-Delta Interagency Ecological Program, the San Francisco Bay Institute and the Water Education Foundation. Implementation of this management plan is intended to assist the State in enhancing and better coordinating these programs and activities.

IMPLEMENTATION PLAN

A CALFED NIS Implementation Plan will be developed in accordance with this strategic management plan. Strategies will be identified to address prevention, management, control and eradication. The Implementation Plan will develop and define objectives for every applicable major issue identified above, as well as the tasks and activities necessary to address the major issues and achieve the three goals, including development of priorities and criteria. It will address these issues in a manner that identifies the who, what, when, where, and how for proposed tasks or actions.

Each year a new implementation plan will be developed to direct and focus future activities. These plans will adopt the adaptive management strategy identified by CALFED, reflecting an evaluation of progress made, new information learned, and necessary actions remaining as projects are completed.

Appendix F: Managing Nonnative Invasive Species

A CALFED Bay-Delta Program Implementation Plan for Managing Nonnative Invasive Species in the San Francisco Bay-Delta Estuary/Sacramento-San Joaquin Rivers and Associated Watersheds

JULY 2000

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Appendix F: Managing Nonnative Invasive Species: A CALFED Bay-Delta Program Implementation Plan for the San Francisco Bay-Delta Estuary/Sacramento-San Joaquin Rivers and Associated Watersheds

Summary

The purpose of this Nonnative Invasive Species (NIS) Implementation Plan is to provide guidance for the specific management actions necessary to address the prevention, control and impacts of nonnative invasive species that have invaded or may invade the ecosystems of the San Francisco Bay-Delta, the Sacramento/San Joaquin Rivers and their watersheds.

The content of this plan focuses on a detailed outline of the Tasks and Actions to be accomplished in an effort to achieve the goals and address the major issues identified in the **Strategic Plan for Managing Nonnative Invasive Species**, dated July, 2000.

The three goals on which the Strategic Plan and this Implementation Plan are based are as follows:

- Goal I: Preventing new introductions and establishment of NIS into the ecosystems of the San Francisco Bay-Delta, the Sacramento/San Joaquin Rivers and their watersheds.
- Goal II: Limiting the spread or, when possible and appropriate, eliminating populations of NIS through management.
- Goal III: Reducing the harmful ecological, economical, social and public health impacts resulting from infestation of NIS through appropriate mitigation.

Program implementation will be guided by the Implementation Plan. The plan focuses on the early period of implementation when needed actions are better known, but also provides a long-term vision for continuing implementation for future years. Adaptive management will adjust future implementation to accommodate what we learn about the system and the response to the early efforts of the NIS Program. It is important to note that, as the efforts to rehabilitate the estuary progress, they should include the establishment and stewardship of native populations.

Contributing to this document were the CALFED agencies and participants from academia, non-profits, stakeholder groups and individuals with technical experience with NIS. The information contained in the Strategic Plan for the Ecosystem Restoration Program (September 30, 1998) and the draft Ecosystem Restoration Program Plan, Volume I (October 1, 1998), both CALFED Bay-Delta Program documents, provided further information for this plan. Public comments also will be solicited from local governments and regional entities, and public and private organizations that have expertise in the control of NIS. Comments will be considered and revisions made to the plan, as appropriate.

While this plan provides guidance, it does not stand alone as an instrument to deal with the problem. With this coordinated effort, California will have a more efficient approach for implementing California NIS strategies. Besides the CALFED Bay-Delta Program, California entities should find the document essential for designing projects, preparing proposals, and prioritizing activities related to the NIS issue.

INTRODUCTION

The purpose of this implementation plan is to provide a standard approach for formulating management actions to address prevention, eradication, control and impacts of NIS that have invaded or may invade the ecosystems of the San Francisco Bay-Delta estuary, the Sacramento/San Joaquin Rivers and their watersheds. This plan will serve as a basic model for resource managers responsible for implementing programs to protect and restore natural and modified ecosystems in California.

The primary focus of this plan will be directed at the San Francisco Bay-Delta estuary/Sacramento-San Joaquin Rivers and associated watersheds in California, though actions may be identified that need to be taken on a statewide basis.

In May 1995, the CALFED Bay-Delta Program was established to restore the ecological health and improve water management for beneficial uses in the Bay-Delta system. The mission of CALFED is: to develop a long-term, comprehensive plan that will restore ecosystem health and improve water management for beneficial uses of the Bay-Delta system. CALFED addresses problems in four resource areas: ecosystem quality, water quality, levee system integrity and water supply reliability. The Nonnative Invasive Species Program has been developed under the Ecosystem Quality, Ecosystem Restoration Program, though we recognize that NIS negatively impact all of the CALFED resources areas.

Goal for Ecosystem Quality: The goal for ecosystem quality is to improve and increase aquatic and terrestrial habitats and improve ecological functions in the Bay-Delta system to support sustainable populations of diverse and valuable plant and animal species. To accomplish this, a draft Ecosystem Restoration Program Plan has been developed with goals to increase aquatic and terrestrial habitats, improve ecosystem functions and reduce the effects of stressors which included non-native invasive species. Management actions of this Implementation Plan will be consistent with the objectives identified in the **STRATEGIC PLAN FOR ECOSYSTEM RESTORATION PROGRAM** (ERP) dated September 30, 1998. Goal 5 of that plan is "Prevent establishment of additional nonnative invasive species and reduce the negative biological and economic impacts of established nonnative species." The objectives identified under this goal are:

Objective 1:	Eliminate further introductions of new species in ballast water of ships.
Objective 2:	Eliminate the use of imported marine baits.
Objective 3:	Halt the introduction of freshwater bait organisms into the waters of Central California.
Objective 4:	Halt the deliberate introduction and spread of potentially harmful species of fish and other aquatic organisms in the Bay-Delta and the Central Valley.
Objective 5:	Halt the release of fish and other organisms from aquaculture operations into Central California waters, especially those imported from other regions.
Objective 6:	Halt the introduction of invasive aquatic and terrestrial plants into Central California.
Objective 7:	Halt the release and spread of aquatic organisms from the aquarium and pet trades into the waters of Central California.
Objective 8:	Reduce the impacts of exotic mammals on native birds and mammals.
Objective 9:	Develop focused control efforts on those introduced species for which control is most feasible and of greatest benefit.
Objective 10:	Prevent the invasion of the zebra mussel into California.

THE MISSION

The mission of the CALFED non-native invasive species program:

PREVENT ESTABLISHMENT OF ADDITIONAL NON-NATIVE SPECIES AND REDUCE THE NEGATIVE BIOLOGICAL AND ECONOMIC IMPACTS OF ESTABLISHED NON-NATIVE SPECIES.

This mission is consistent with Strategic Goal 5 of the ERP Strategic Plan.

THE GOALS

The three goals on which this implementation plan is based are as follows:

- **GOAL I: PREVENTING NEW INTRODUCTIONS OF NIS INTO THE ECOSYSTEMS OF THE SAN FRANCISCO BAY-DELTA, THE SACRAMENTO/SAN JOAQUIN RIVERS AND THEIR WATERSHEDS.**

- **GOAL II: LIMITING THE SPREAD OR, WHEN POSSIBLE AND APPROPRIATE, ELIMINATING POPULATIONS OF NIS THROUGH MANAGEMENT.**

- **GOAL III: REDUCING THE HARMFUL ECOLOGICAL, ECONOMICAL, SOCIAL AND PUBLIC HEALTH IMPACTS RESULTING FROM INFESTATION OF NIS THROUGH APPROPRIATE MANAGEMENT.**

In development of the outline approach of this plan, it is recognized that prevention is the most practical, economic and environmentally safe method for dealing with new or incipient infestations. For NIS already widely established and distributed, this plan emphasizes an ecosystem approach utilizing integrated pest management methods that are flexible and environmentally sound. The long-term benefits of control or eradication must justify the short-term impacts. Supported research and information/awareness is critical toward maintaining a long-term control or containment program.

In order to achieve the goals set forth in this plan for NIS, a number of major issues must be addressed. These issues are critical to the establishment of a successful program. These issues as described in the **STRATEGIC PLAN FOR MANAGING NONNATIVE INVASIVE SPECIES**, July, 2000 are:

- Leadership, Authority and Organization
- Coordination, Cooperation and Partnership
- Education and Outreach
- Funding and Resources
- Monitoring, Mapping , Assessment
- Research
- Technology and Information Transfer
- Enforcement and Compliance
- Program Evaluation

Implementation plans developed in accordance with the CALFED NIS strategic management plan should identify the who, what, when, where, and how for the proposed tasks or actions. This CALFED NIS Implementation Plan will develop objectives from each of the major issues identified above for each of the three goals of the NIS Strategic Plan. The Implementation Plan will develop and expand detailed Tasks and Activities necessary to address the major issues and achieve the three goals.

Funding for this program has been provided through CALFED to the U.S. Fish and Wildlife Service in the amount of $1.25 million with fiscal year 1998 funds. The Service has agreed to develop and coordinate the development of a long-term Strategic Plan, an Implementation Plan and fund projects through three possible processes with this funding:

- Directed projects
- Expansion or extension of existing projects
- Proposal solicitation process

It is anticipated that at least $1.05 million will be available for actual on-the-ground work when the planning process is complete. The funding time period for funds already committed to this program is through fiscal year 2000. It is anticipated that this plan will continue to be supported and implemented through the continued contributions and support of the various agencies and entities responsible for rehabilitation of the San Francisco Bay-Delta, the Sacramento/San Joaquin rivers and their watersheds.

Implementation Issues

As presented, there are a number of major issues critical to achieving the goals as presented in this plan. These issues are discussed below and will be addressed as objectives of the Implementation Plan with specific Tasks and Actions.

California natural and man made water conveyance and impoundment systems are available and utilized for multiple purposes. In addition, there is a complex mosaic of federal, state and local laws and regulations which not only address intended use of these resources but will impact efforts to prevent the introduction, establishment and management of NIS. To facilitate accomplishment of the strategic goals, this program must coordinate with jurisdictions outside the state and build its tasks upon sound science. Therefore, mechanisms will be established to ensure that all prevention, control and abatement tasks developed and implemented by this program under this plan are (1) done so in cooperation with federal agencies, local governments, interjurisdictional organizations and other entities, as appropriate (2) based upon the best scientific information available, and (3) conducted in an environmentally-sound and conscientious manner and (4) coordinated through an interagency advisory council that will monitor management efforts and assure effective coordination of this program with CALFED, Comprehensive Assessment, Monitoring and Research Program (CMARP) and other NIS programs.

Leadership, Authority and Organization

As the program develops, one of the components essential to actual implementation will be to identify the leadership, authority and organization that is necessary to accomplish each of our goals. In some cases, there will be existing organizations that have the leadership and authority to carry out the actions identified in the plan. It may be that other tasks and actions determined to be essential to the success of the program do not have the leadership, authority or organization in place. In these instances, we will work to identify and/or develop the appropriate component needed to carry out the work as a part of this planning process. The formation of an interagency advisory council to monitor management efforts and assure effective coordination of this program with CALFED and other NIS programs is essential to the success of these efforts. This council will be referred to hereafter as the Nonnative Invasive Species Advisory Council (NISAC).

Coordination, Cooperation and Partnership

In all of the work undertaken as part of this program, the value and necessity of the elements of coordination, cooperation and partnership to the success of the program can not be overstated. At all times and in all aspects of the work, priority will be given to these ideals and we will strive to incorporate them into every aspect of the plans made and actions taken.

Education and Outreach

A comprehensive awareness and education program is critical for an effective NIS management program. Except for isolated cases that have attracted substantial media attention, the general public does not understand how NIS negatively impact the environment, the economy and the utilization of the natural aquatic resources that are important to them. Therefore, a strategic approach to NIS must include education and awareness component for all actions and tasks presented. Developing and implementing a coordinated and comprehensive information program will expand understanding by all California citizens of the impacts and risks associated with the introduction and spread of NIS.

Information about the nature, characteristics and the impacts of NIS on the environment, economy and quality of life needs to be made more available. This information should be presented concurrently with information about related issues such as threatened and native species, natural history, endangered species, water quality, habitat restoration, and ecosystem health. An important aspect of this program will be developing outreach to inform and educate public and private entities that may be affected by project actions. The need for understanding and managing NIS should be institutionalized in public and environmental education curricula. A well-coordinated effort is needed because of the costs and complexities associated with developing and delivering a comprehensive, high caliber outreach program.

A successful education and information program must utilize individuals and institutions with expertise on how to raise public awareness and influence attitudes towards NIS management. Public information specialists can be utilized to develop distribute and coordinate information state-wide. In addition, information specialists can enhance public interest and improve citizen and organizational involvement toward reducing the spread of NIS. Raising awareness can be achieved via television spots, ad campaigns and public service announcements. All of these efforts will make extensive use of existing agencies and pursue cost-effective strategies.

An increased awareness and concern of California citizens should precipitate an increase in level of commitment by elected officials toward NIS management. Many federal and state legislators have little understanding of the risks associated with NIS and this has had a negative impact on obtaining sufficient long term funding. An immediate priority should be the development of briefing packages and presentations for national, state, and local official and interest groups.

FUNDING AND RESOURCES

Reliable consistent funding in California for management of NIS is generally fragmented and in many cases inadequate or nonexistent. This is especially true in areas of exclusion, education, emergency response, research and management. Funds are generally available on a reactive basis and do not effectively deal with infestations before they become unmanageable. Except for the Hydrilla Program conducted by California Department of Food and Agriculture, or the Northern Pike Program conducted by California Department of Fish and Game, funds for NIS are provided after the problems become widespread. Generally these funds provide resources for limited control efforts and do very little to prevent further spread to uninfested areas.

Costs associated with this management plan and associated implementation plans must be identified. Once costs are determined, sources of revenue should be investigated and pursued. Traditional sources include but are not limited to the US Fish and Wildlife Service, ANS Task Force, US Army Corps of Engineers, US Environmental Protection Agency, Natural Resource Conservation Service and the National Fish and Wildlife Foundation. For federal agencies, allocations of discretionary funds may be necessary if dedicated funding by decision makers (Congress) can not be achieved. At the state level, one or more agencies may have to submit Budget Change Proposals to obtain long term funding in support of a statewide management program.

In addition to traditional funding sources, a working group within the NISAC, should develop a number of nontraditional funding options for NISAC consideration and recommendation. These funding options should recognize that management of NIS benefits all Californians and will actually prove cost-effective over the long term. It should not tax or levy fees in a manner that unfairly impacts one, two or three user groups. In other words, a balance between general fund revenue and user group revenue should be achieved.

Other nontraditional source of revenue and resources involve cooperative agreements and partnerships. Federal, state, local agencies and private organizations with NIS management responsibilities will be encouraged to coordinate, share or pool resources. This can include shared purchase of supplies and use of equipment, use of staff and other human resources, sharing of mapping and monitoring data and expertise and to achieve potential purchase savings for bulk purchases of chemical supplies, biological control and educational materials.

MONITORING, MAPPING AND ASSESSMENT

Ecosystems infested with NIS are not consistently identified and delineated. Complete up to date maps, displaying the distribution and severity of NIS infestation are available only in a few areas. Knowledge of which species are located where is paramount for: 1) increasing public awareness and concern, 2) obtaining support and funding for developing a strategic program, 3) accurately predicting where new infestation may occur from already infested areas and, 4) developing effective integrated management and prevention plans with specific actions to mitigate or prevent impacts caused by NIS, 5) Establishing the costs of eradication/control efforts.

As part of the CALFED program, a Comprehensive Assessment, Monitoring and Research Program (CMARP) is under development to address the needs of CALFED's common programs and related agency programs. The CALFED NIS Program will communicate and coordinate with CMARP programs and activities.

An ecosystem inventory, mapping and monitoring system should be based on standards which allow for easy exchange of information among federal, state and local agencies as well as private organizations. Compatible systems and software will be utilized and GIS will be integrated into this process.

Research and Technology Transfer

A strong commitment to research and information/technology transfer is critical towards achieving the goals presented in this management plan. A working group with NISAC should review research needs already developed by various entities, identify new areas of research relative to the various actions and tasks presented in the plan, prioritize areas of research and opportunities for funding and submit a report to NISAC. This should be done on at least an annual basis. This commitment also extends to the transfer of information developed to a wide audience through many venues to assure coordination and cooperation with others involved in the same type of endeavors.

Enforcement and Compliance

In those areas where enforcement and compliance are identified as an issue, this program will develop the information base to illustrate and define the issue and possible approaches and make recommendations to appropriate agencies to enhance the adherence to regulations.

Program Evaluation

To be effective and responsive this management program and associated implementation plans must include an evaluation component to identify progress, evaluate implementation problem/needs and make necessary corrections at anytime. The adaptive management strategy will be highlighted. The evaluation process will include:

1. Establishment of an evaluation subcommittee within NISAC responsible for reviewing performance measures, conducting the evaluation efforts, reporting the results to NISAC and others if required, and identifying program or plan adjustments that address projected outcomes.

2. The three program goals, as previously presented, provide the focal point for evaluation. Ways to assign measurable objectives to these goals should be developed to provide meaningful evaluation.

3. The evaluation process should be inclusive, involving those with implementation responsibility, resource user groups and others affected by the program and/or plan implementation.

4. An annual report highlighting progress and achievements will be prepared and distributed. The annual report will include evaluation of the efficacy of the programs strategies and tasks and identify revisions as needed. The annual report will be readily available on the Internet and distributed to local and federal agency and legislative decision makers.

5. Work with CALFED program managers to evaluate the NIS component/impact to their program actions and how NIS may affect the overall goal of the program.

6. Work with CALFED management through CMARP to provide NIS information as it applies to management decisions.

Implementation Objectives and Actions

The three goals of the CALFED Nonnative Invasive Species Program are:

Goal I: Preventing new introductions and establishment of NIS into the ecosystems of the San Francisco Bay-Delta, the Sacramento/San Joaquin Rivers and their watersheds.

GOAL II: LIMITING THE SPREAD OR, WHEN POSSIBLE AND APPROPRIATE, ELIMINATING POPULATIONS OF NIS THROUGH MANAGEMENT ACTIONS.

GOAL III: REDUCING THE HARMFUL ECOLOGICAL, ECONOMICAL, SOCIAL AND PUBLIC HEALTH IMPACTS RESULTING FROM INFESTATION OF NIS THROUGH APPROPRIATE MITIGATION.

The Objectives that follow are identified beginning on page 8 of this document and within the draft NIS Strategic Plan as Major Issues of concern for the NIS Program. Under each Objective, specific Actions and Tasks have been identified which are considered essential elements of the implementation of this program.

OBJECTIVE 1: LEADERSHIP, AUTHORITY AND ORGANIZATION:

DEVELOP AND IDENTIFY THE LEADERSHIP, AUTHORITY AND ORGANIZATION NECESSARY TO PREDICT, PREVENT AND REDUCE THE IMPACTS OF NIS INTRODUCTIONS IN THE ECOSYSTEMS OF THE SAN FRANCISCO BAY-DELTA, THE SACRAMENTO/SAN JOAQUIN RIVERS AND THEIR WATERSHEDS.

ACTION 1A: Form an Interagency Nonnative Invasive Species Advisory Council (NISAC) to develop the leadership, authority and organization necessary to effectively promote the NIS goals.

1. NISAC will coordinate and streamline the authorities to regulate NIS between state and federal agencies. Specific problems will be identified and pathways evaluated.

2. NISAC will develop and analyze information and recommendations to go to CALFED and program elements specific to areas of CALFED concern.

    A. NIS Technical Review Team assist with preparation of requests for proposals and coordinate peer review of proposal solicitation responses and evaluate the potential of the action in encouraging the establishment of NIS.

    B. Provide information for CALFED management decisions on the prevention NIS introductions.

    C. Develop interface with CMARP for information exchange and coordination aimed at the prevention of the introduction of NIS.

3. Develop Rapid Response Plan to address early infestations of NIS.

4. Develop and implement standard reporting procedures for NIS.

5. NISAC will develop the resources necessary to carry on the council activities beyond FY 2000.

ACTION 1B: Identify existing authorities, leadership and areas which could benefit from further support and leadership and link this information to CALFED actions and management decisions. In particular, identify those with the authority to prevent the introduction of species through:

- Ballast Water releases
- Bait use (marine and freshwater).
- Deliberate introductions
- Aquaculture releases
- Aquarium and pet trades
- Water features industry
- Landscape and nursery industry
- Urban forestry
- Urban entomology
- Road/Highway construction/repair/mitigation
- Animal feeds
- Off-road vehicles
- Boating practices

1. Identify existing species specific workgroups and authorities of NIS not yet present in the CALFED area and work with those groups to determine if that species presents a threat to reaching CALFED areas of concern. Work with those groups to determine measures which can prevent the introduction of the species into the CALFED study area.

ACTION 1C: Identify gaps in existing authorities that would affect CALFED interests and coordinate with appropriate bodies to meet CALFED needs.

ACTION 1D: Develop and implement a program to systematically apply available resources to the support of viable regulations and authorities to prevent introductions of NIS.

1. Support improvements to exclusionary activities (ballast management, clean lists and border station programs).

2. Support efforts to designate ballast water as a pollutant to be regulated under existing state law (regarding the release of point source pollution and the uptake of ballast in infested waters.)

3. Recommend and provide protocols for improved detention and quarantine procedures (Cargo, packing materials, dredge spoils).

4. Review and make recommendations to improve routine inspections programs and processes of entities that may transfer NIS such as:
   - Retail outlets
   - Commodity transfers
   - Commercial activities
   - Public Venues
   - Irrigation districts

ACTION 1E: Utilize a technical working group within NISAC to review and recommend statutory and regulatory changes for state legislation to limit spread, prioritize control strategies and evaluate approaches that may limit spread of NIS.

ACTION 1F: Identify the organization(s) with the expertise and experience necessary to implement control strategies for NIS.

ACTION 1G: Develop a process through NISAC to review, recommend and coordinate control and management plans.

ACTION 1H: Provide a forum for CMARP, CALFED program managers, and stakeholders to discuss CALFED actions and the possibility of these actions encouraging the establishment or spread of NIS. Facilitated discussions of project or action modification to avoid encouraging NIS establishment will be part of the forum. Relate the impacts of NIS on CALFED actions and facilitate discussions of methods of reducing or eliminating the NIS impacts.

ACTION 1I: Establish interjurisdictional approaches to facilitate legislative, regulatory and other actions to prevent NIS introductions.

1. Pacific States Fisheries Legislative Task Force

2. Pacific States Marine Fisheries Commission

OBJECTIVE 2: COORDINATION, COOPERATION AND PARTNERSHIP.

ESTABLISH AND SUPPORT COALITIONS AND INTERJURISDICTIONAL APPROACHES TO FACILITATE PARTNERSHIP, COORDINATION AND COOPERATION IN THE EFFORTS TO PREVENT NIS INTRODUCTIONS, CONTROL NIS POPULATIONS AND REDUCE THEIR NEGATIVE IMPACTS.

ACTION 2A: NISAC will monitor NIS management efforts and assure effective coordination between CALFED and other NIS programs.

ACTION 2B: Develop partnerships with regional and national programs to facilitate the recognition of NIS threatening to spread to CALFED solution area such as:

1. Western Regional Panel
2. Aquatic Nuisance Species ask Force
3. National and California Sea Grant
4. Pacific States Marine Fisheries Commission
5. Invasive Species Council
6. Water agencies, including NAQA, etc.
7. California Interagency Noxious Weed Coordinating Committee
8. California Exotic Pest Plant Council
9. Grassroots organizations
10. Irrigation districts
11. University of California Cooperative Extension
12. Pacific Ballast Water Group
13. Weed Management Areas

ACTION 2C: Initiate and maintain a communication network of NIS scientists and resource managers via NISAC and the work teams to encourage information exchange and coordination of effort.

ACTION 2D: Establish and support interjurisdictional process to ensure compatibility and consistency between western states and between states, public, private and semi-public agencies and federal agencies. (Federal consistency, a tool implemented by coastal management programs to ensure that federal activities/projects are compatible with enforceable policies of the state, is recommended to facilitate interjurisdictional endeavors.)

Action 2E: Establish and support coalitions among the western states including agricultural, natural resource agencies, state universities, the Coastal State Organization, coastal managers, tribal groups, recreational boaters, nurserymen, pet industry, angler groups and other concerned resource users. Assist coalitions in promoting state and federal legislation and programmatic support for the prevention of new NIS introductions or the spread of existing populations that could impact CALFED objectives.

Action 2F: Implement a watershed approach as a basic organizational structure limiting the spread of NIS but with the understanding that current water transport facilities and modes of transportation transcends traditional watershed patterns of distribution.

1. Establish cooperative policies with counties (and other entities) sharing watersheds and water transport facilities to limit the spread of NIS.

2. Establish a network of coastal counties and regional interests sharing coastal access to limit the spread of NIS.

Action 2G: Establish and maintain cooperative relationships with groups working to limit spread of NIS and work to coordinate and complement those efforts.

1. Team Arundo

2. Spartina Technical Control Committee

3. Department of Food and Ag (Hydrilla program and others)

4. Boating and Waterways (Egeria, Hyacinth and others)

5. ANS Task Force European Green Crab Workgroup

6. IEP Chinese mitten crab Project Work Team

7. Pacific Ballast Water Group

Action 2H: Support and enhance the operations and projects of the organizations responsible for ongoing programs to prevent, mitigate, control, or eradicate NIS populations.

Objective 3: Education and Outreach:

DEVELOP AND IMPLEMENT A COORDINATED AND COMPREHENSIVE INFORMATION AND EDUCATION PROGRAM TO EXPAND THE UNDERSTANDING OF THE BENEFITS OF PREVENTION, THE RISKS AND IMPACTS ASSOCIATED WITH INTRODUCTIONAND SPREAD OF NIS, CONTROL STRATEGIES, ASSOCIATED ENVIRONMENTAL IMPACTS AND THE POSSIBLE MODIFICATION OF HUMAN BEHAVIOR AND ACTIVITIES THAT MAY REDUCE HARMFUL IMPACTS.

Action 3A: Provide the most up to date information in a format useful in CALFED management and program decisions:

1. Develop for CALFED managerial use, fact sheets on life history, environmental, economic impacts and preventative measures, etc for species that threaten to establish in the CALFED area of concern. The information on this sheet is more specific than those for general public distribution.

2. Provide a quarterly newsletter on potential NIS introductions, range distribution changes, unexpected beneficial and detrimental impacts of NIS, etc. The target audience will be CALFED managers and those making policy decisions for the CALFED program.

Action 3B: Acquire or develop and distribute appropriate information to educate and inform appropriate resource user groups about NIS and their harmful impacts in cooperation with existing resources.

1. Develop a CALFED NIS web page to educate the resource users and the public about introductions.

2. Create NIS exhibits and supply materials to public facilities interpretive displays such as state parks, boat launches, the DWR State Water Project visitors centers, and public libraries.

3. Include information in boater registration mailer.

4. Utilize existing environmental and resource newsletters and other educational materials to publish and publicize appropriate NIS information.

ACTION 3C: Acquire or develop and distribute appropriate information to educate and inform appropriate businesses and other entities that may contribute to the introduction, establishment and spread of NIS.

1. Work with business and industry involved in the development of new technologies to reduce the transfer and movement of NIS.

2. Identify methods to prevent inadvertent "hitchhiking" of NIS during transport of commercial products.

3. Promote the use and inspection of packaging materials to reduce transport of NIS.

4. Acquire or develop and distribute Best Management Practices and regulation and compliance information to reduce the risk of activities which contribute to the introduction, establishment or spread of NIS. Such businesses and entities include:
   - Fishing (sport and commercial)
   - Live Seafood Dealers/ Sellers
   - Pet Stores
   - Nursery industry
   - Bait Dealers/Sellers
   - Aquatic Plant Distributors
   - Aquascape/Landscape Designers
   - Public venues (aquariums, zoos, botanical gardens)
   - Aquaculture operations.

5. Distribute information on regulations and enforcement that may apply to activities that contribute to introduction of NIS.
   - Immigration
   - Customs
   - Military

ACTION 3D: Acquire from partners or develop and distribute appropriate information to educate and inform the public about NIS and their harmful impacts.

1. Participate in and support the 100th Meridian Initiative to prevent the westward spread of zebra mussels.

2. Promote and utilize existing public education materials such as the zebra mussel traveling trunk.

3. Support development of materials specifically designed to educate the public about the hazards of intentional/accidental introduction in cooperation with other outreach efforts and organizations like UC Cooperative Extension.
   - Aquaria/Pet stores
   - Aquatic plant/nursery
   - Fishermen
   - Boaters.

4. Support development of a K-12 curricula in conjunction with the State Department of Education in cooperation with other interested parties such as county advisors of UC Cooperative Extension, Sea Grant.

5. Support the development and distribution of appropriate information to educate and inform the public about public health risks identified by public health agencies as associated with NIS.

ACTION 3E: In cooperation with other groups, develop identification materials to facilitate participation by the public and others in recognizing and reporting spread of NIS.

ACTION 3F: Inform and educate user groups and the public about the management strategies that are necessary to limit spread of NIS.

ACTION 3G: Coordinate community volunteer groups, fishermen, sport divers. Shell collectors, school groups and others in and around the Bay-Delta habitats to act as an early warning system and to communicate "sightings" of NIS to NISAC.

ACTION 3H: Develop and distribute appropriate information to educate and inform the public and appropriate resource users groups about control strategies, associated environmental impacts and the rationale for implementing such programs.

1. Utilize existing groups/programs responsible for information dissemination when appropriate and feasible such as:
   - UC Cooperative Extension
   - National and California Sea Grant
   - Western Regional Panel
   - California Exotic Plant Pest Council

ACTION 3I: Establish monitoring, tracking, survey programs to evaluate the effectiveness of information/education efforts.

OBJECTIVE 4: FUNDING AND RESOURCES

INVESTIGATE, IDENTIFY AND DEVELOP SOURCES OF FUNDING TO SUPPORT PREVENTION ACTIVITIES, CONTROL EFFORTS AND ACTIONS TO REDUCE NEGATIVE IMPACTS.

ACTION 4A: As information is developed about potential species that may impact CALFED actions, identify public and private entities that may also be specifically impacted by the species for program support.

ACTION 4B: Submit the CALFED NIS Strategic and Implementation Plan and a request for support to the ANS Task Force as a regional management plan.

ACTION 4C: Identify sources of Rapid Response Funds to address emergency actions taken to attack a relatively new infestation of NIS that may possibly be eradicated with early intervention.

ACTION 4D: Create a matrix of funding programs vs. types of NIS prevention needs.

ACTION 4E: Develop support for NIS prevention programs by state and federal agencies, environmental groups, academic institutions, and others.

ACTION 4F: Develop criteria for identifying and prioritizing funding needs both for short term rapid response and long term for more sustained funding.

OBJECTIVE 5: MONITORING, MAPPING, AND ASSESSMENT

DEVELOP AND ENHANCE MONITORING AND EXCLUSION PROGRAMS TO PREVENT INTRODUCTIONS, PROVIDE FOR EARLY DETECTIONS, LIMIT SPREAD AND REDUCE IMPACTS IN COOPERATION WITH CMARP AND OTHER NIS PROGRAMS. THIS OBJECTIVE IS CLOSELY LINKED TO RESEARCH, OBJECTIVE 6.

ACTION 5A: Establish new and participate in and/or review existing monitoring programs to detect new introductions and detect the spread of existing populations.

1. Working with CMARP, determine how existing monitoring programs can be adjusted to detect the appearance of any new species susceptible to their sampling methods. Also determine a process of notification should a new species be detected.

2. Working with CMARP, develop species specific monitoring programs as needed to detect the appearance of a specific NIS in the CALFED area of concern. Also determine the process of notification should that species be detected.

ACTION 5B: Develop and recommend materials suitable to educate and train monitoring groups and field scientists in the detection and recognition of new NIS introductions.

1. Develop a list of experts for each taxonomic group.

2. Support development of appropriate keys to facilitate identifications of established and invading organisms.

ACTION 5C: Evaluate NIS data to develop information for CALFED Programs and managers to assist with directing CALFED actions.

ACTION 5D: Develop a comprehensive relational database with georeferenced data documenting habitat and landscape features as well as vector information for use with GIS to assess the distribution of likely sites for new invasions.

1. GIS system would be used in conjunction with GIS showing jurisdictional boundaries to establish authorities and permitting requirements.

2. GIS will be used to project the rate of future spread based on changing distribution patterns, habitat and landscape variables.

ACTION 5E: Participate with the Science Coordinating Committee of the California Biodiversity Council in cooperating on developing the links to other organizational resource databases.

OBJECTIVE 6: RESEARCH

SUPPORT AND COORDINATE SCIENTIFIC INVESTIGATION BY RESEARCHERS FROM STATE AND FEDERAL AGENCIES, ACADEMIC INSTITUTIONS, NONPROFITS AND OTHER ORGANIZATIONS THAT ADDRESS POTENTIAL MANAGEMENT STRATEGIES TO PREVENT THE INTRODUCTIONS, LIMIT SPREAD AND REDUCE THE HARMFUL IMPACTS OF NIS INTO THE SAN FRANCISCO BAY-DELTA, SACRAMENTO-SAN JOAQUIN RIVERS AND THEIR WATERSHEDS.

ACTION 6A: In partnership with other states and federal agencies, academic institutions and environmental groups develop specific and regional listings of NIS, that have the potential to infest or spread and negatively impact the ecosystems of the CALFED solution area.

1. Utilize existing knowledge base to develop lists of NIS that represent a potential threat to invade CALFED areas of concern.
2. Utilize the above list to develop a decision-making matrix which includes the pathways, vectors, impacts, control feasibility and options of specific organisms.
3. Evaluate the matrix to determine the species most likely to arrive, least likely to be managed or controlled successfully and very likely to create a high level of negative impacts.
4. Develop a process to prioritize research needs encompassing CALFED objectives and program elements that would provide information necessary to make informed judgements about targeting species.

ACTION 6B: Promote support of appropriate biosystematic infrastructure, including alpha-taxonomy, genetics, maintaining collections and enhancing expertise through the combined efforts of public agencies, universities, NGOs and other groups. Define alpha-taxonomy: species determination based on existing published morphology and anatomical characteristic and taxonomic keys.

ACTION 6C: Conduct or promote research on selected species that threaten to invade via state or federal research initiatives, academia, or the private sector.

1. Evaluate the potential interaction between NIS, if it were to establish, and native biota of the CALFED area of concern. (found in the CALFED Habitat Conservation Strategy). (examples *Spartina alterniflora* and *S. foliosa*, green crab and *Cancer magister*)
2. Investigate the interactions between NIS, habitat restoration efforts and CALFED activities including conveyance, etc.
3. Support research to develop information that may translate into management actions to prevent, control, limit spread or eradicate NIS. Work cooperatively with industry and stakeholders whenever possible. Such topics may include:
   - Reproductive and dispersal mechanisms
   - Viability
   - Life history
   - Suitable habitats
   - Biocontrol
   - Ecological interactions with native flora and fauna
   - Integrated pest management
   - Genetic diversity
   - Geographic origin
   - Hybridizing ability
   - Early detection technologies
   - Invasibility of Ecosystems
4. For organisms determined to be especially harmful and difficult to control, support early detection efforts and rapid response activities.
5. Whenever possible, support the development and documentation of information about NIS impacts to the food web and how those impacts may relate to efforts to revive specific populations of concern.

ACTION 6D: Coordinate with CMARP to support the conduct of research to investigate the establishment of beneficial, native organisms as part or restoration or rehabilitation actions. Recommend that CALFED policy include the proactive use of native species during restoration activities whenever possible.

ACTION 6E: Incorporate the information obtained through monitoring and research to ensure that CALFED actions do not contribute to the spread of NIS.

ACTION 6F: Develop/implement mitigation/control activities to reduce/eradicate populations of targeted NIS.

1. Assess physical, chemical and biological mechanisms with respect to economy, efficiency, species-specificity, efficacy, timeliness, and all associated risks/impacts.

2. Create work group with expertise on the biology of the species and with knowledge of the habitats and economic systems being impacted.

3. The work group will develop a list of control activities ranging from Rapid Response (in coordination with other Rapid Response efforts) to long term site/facility specific activities to mitigate impacts.

4. Develop list of criteria to be used to evaluate the success of the control activity as well as criteria to evaluate any negative impacts from control efforts.

ACTION 6G: Evaluate the economic significance of the overall impacts for NIS with respect to impacts on industrial facilities, water diversions, transportation and commerce activities, fisheries and agricultural activities, navigational needs and recreational activities, etc.

1. Develop a means of valuation of economic impacts in collaboration with economic professionals.

2. Develop a database that includes measurable economic impacts and estimated values of NIS on above activities and facilities.

3. Include this information in the matrix of Goal II, Action 6A1.

4. Based on these estimates, develop a priority ranking of economic impacts associated with different NIS.

ACTION 6H: Support the evaluation of the public health risks of NIS.

1. Determine the identity of species of public health interest (e.g. Cholera bacteria) likely to be coming into SF Bay or Delta.

2. Identify the vectors associated with NIS species of public health interest.

3. Develop a priority list of the most likely and the most dangerous species of public health interest based on information and recommendations developed by public health agencies.

ACTION 6I: Develop human behavior and activity modification recommendations wherever feasible to reduce the negative impacts of NIS.

OBJECTIVE 7: TECHNOLOGY AND INFORMATION TRANSFER

ENSURE THE AVAILABILITY OF ALL INFORMATION AND TECHNOLOGY DEVELOPED THROUGH THIS PROGRAM TO CALFED PROGRAM MANAGERS FOR MANAGEMENT AND POLICY DECISIONS AND TO OTHER INTERESTED PARTIES.

ACTION 7A: Encourage and support the publication and distribution of NIS information directly relevant to CALFED restoration activities in readily available and user friendly formats to promote informed decisions and actions.

ACTION 7B: Establish NIS LIST SERVE and NIS web pages on the CALFED website to facilitate information transfer with links to CMARP.

ACTION 7C: Encourage and support the publication of information developed through this program in appropriate and accessible media.

ACTION 7D: Provide regular updates of information developed through this program to organizations such as: the ANS Task Force, WRP, industries (i.e., aquaculture, bait), water agencies, irrigation districts, the Western Weed Coordinating committee and other interested parties.

ACTION 7E: In cooperation with CMARP, provide education and training for personnel responsible for monitoring to acquaint them with NIS infestations and spread potential.

ACTION 7F: Utilize existing technology transfer programs (such as IEP, ICE_NRPI) and when necessary, work through CMARP to develop new programs to distribute research findings and technology advances.

OBJECTIVE 8: ENFORCEMENT AND COMPLIANCE

DEVELOP AND SUPPORT EFFECTIVE ENFORCEMENT AND COMPLIANCE MEASURES WHICH ADDRESS PREVENTION, CONTROL/ERADICATION AND REDUCTION OF NEGATIVE IMPACTS.

ACTION 8A: Through NISAC, establish and encourage improved enforcement and compliance with regulations and authorities which will contribute to the prevention, control, or eradication of NIS.

ACTION 8B: NISAC will review existing enforcement programs and recommend improvements, changes or additional programs as needed.

ACTION 8C: Encourage the expansion and enhancement of the operations, responsibilities and funding of such prevention activities as the CDFA border inspection stations.

ACTION 8D: Inform public health agencies of NIS infestations which may have public health implications.

ACTION 8E: Support and enhance the operations and projects of the organizations responsible for ongoing enforcement and compliance programs to limit spread of NIS.

ACTION 9A: Evaluation program will be specified for each Action and/or Task undertaken as part of this plan.

1. The evaluation will address CALFED goals and objectives, as well as the NIS Program goals and objectives.

2. The evaluation will be inclusive, involving those with implementation responsibility, resource user groups and other affected by the program or plan implementation.

ACTION 9B: Convene annual workshop which includes some presentations, facilitated discussion about NIS research, management advances, and problems to evaluate current progress and future needs.

ACTION 9C: An annual report highlighting progress, achievements and revisions will be prepared, distributed and made available on the web site.

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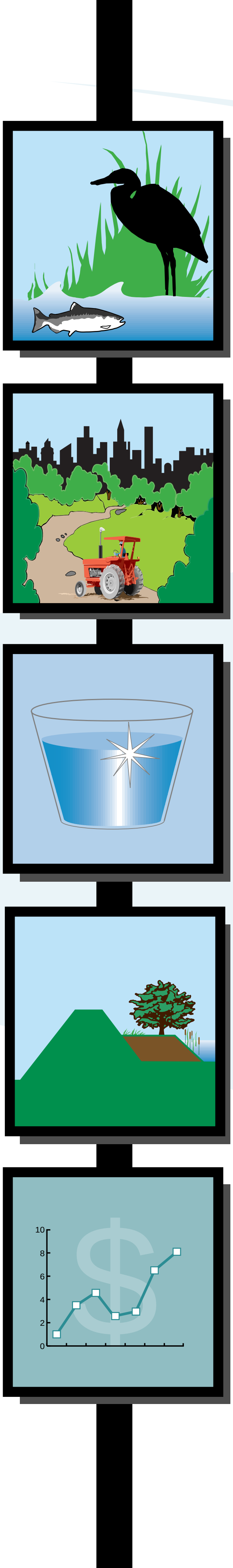

CALFED
BAY-DELTA
PROGRAM

Ecosystem Restoration Program Plan
Maps

Final Programmatic EIS/EIR Technical Appendix

July 2000

Figure 1
ERP Study Area and Ecological Management Zones

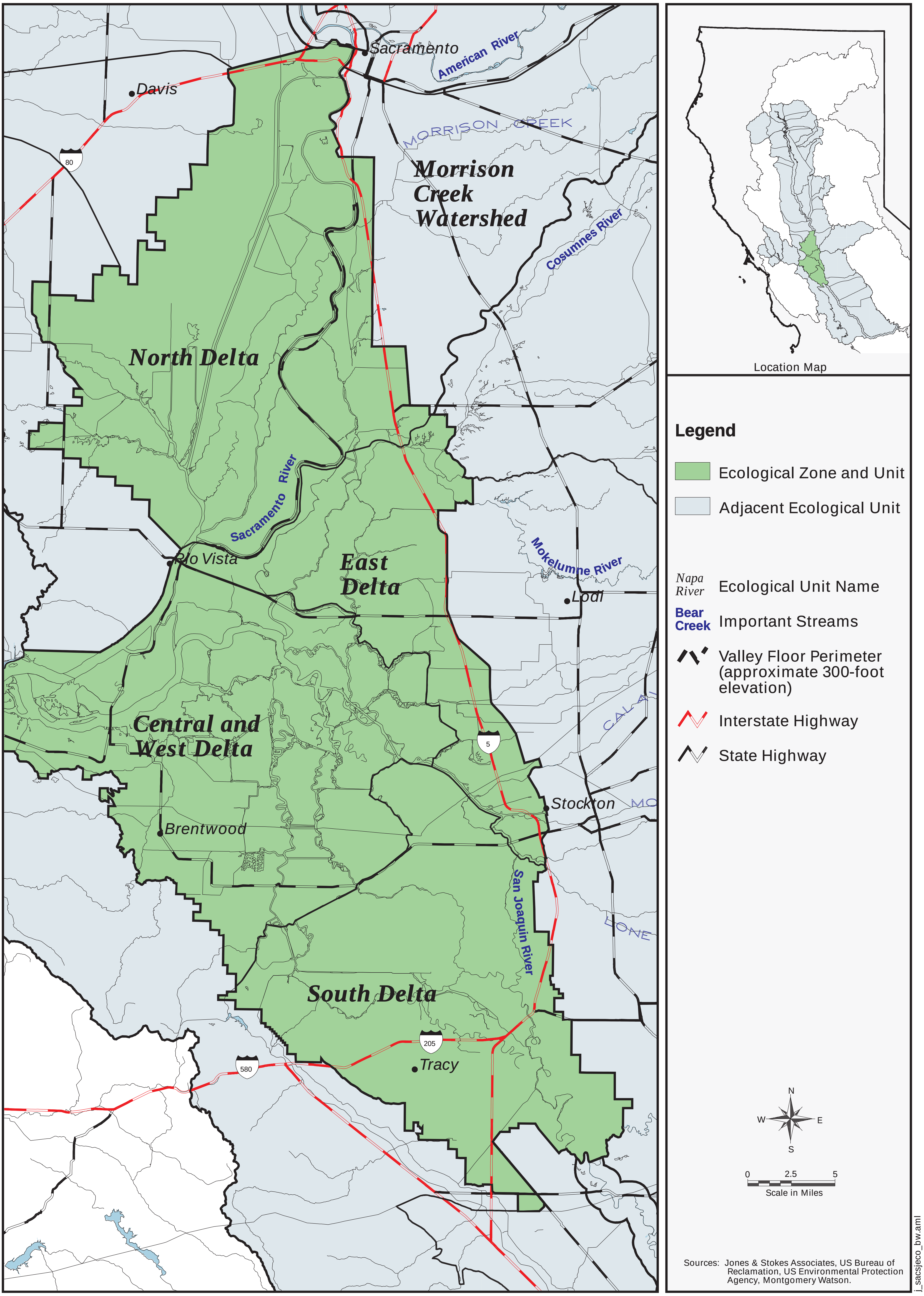

Figure 2
Sacramento-San Joaquin Delta Ecological Management Zone

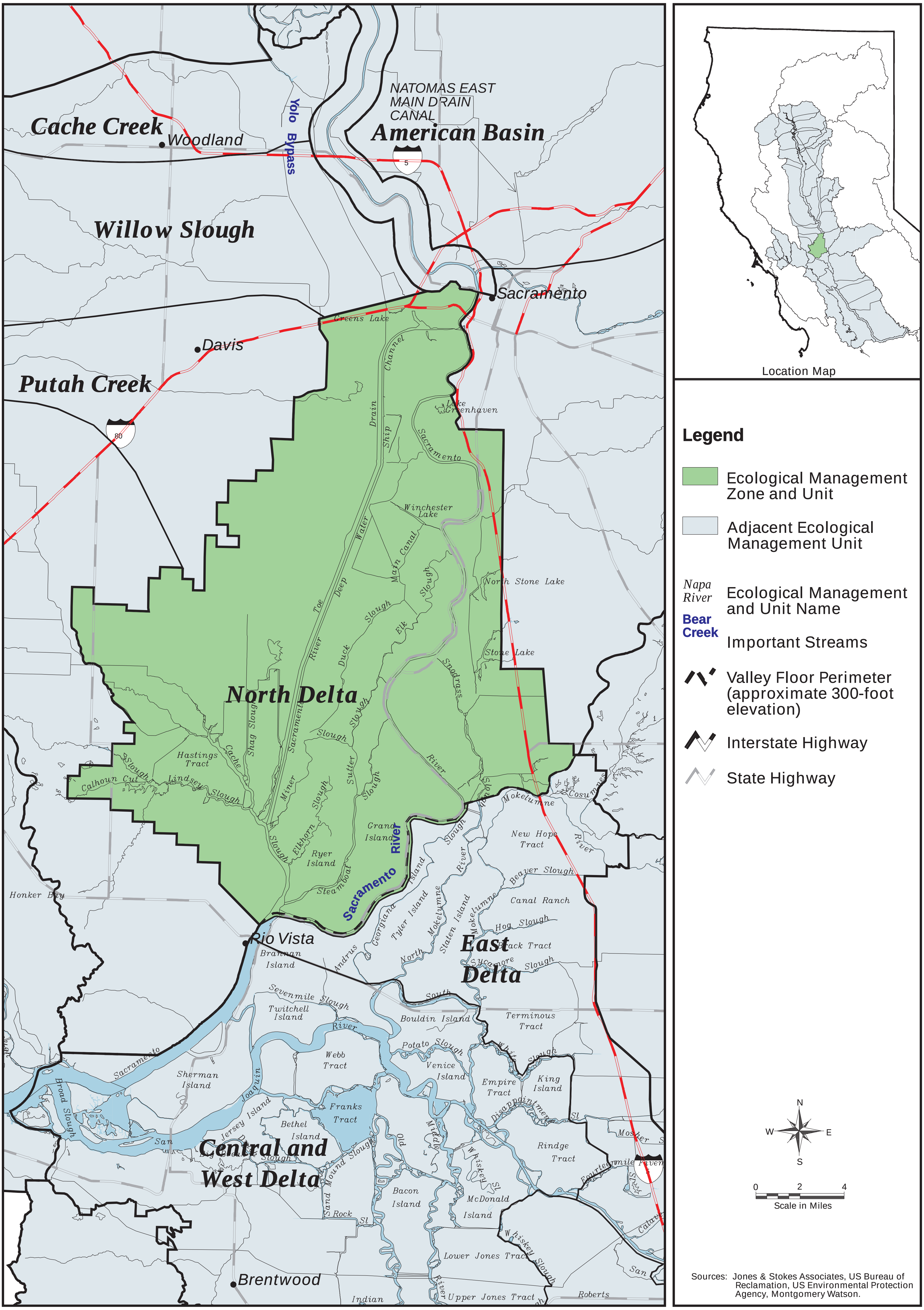

Figure 3
North Delta Ecological Unit

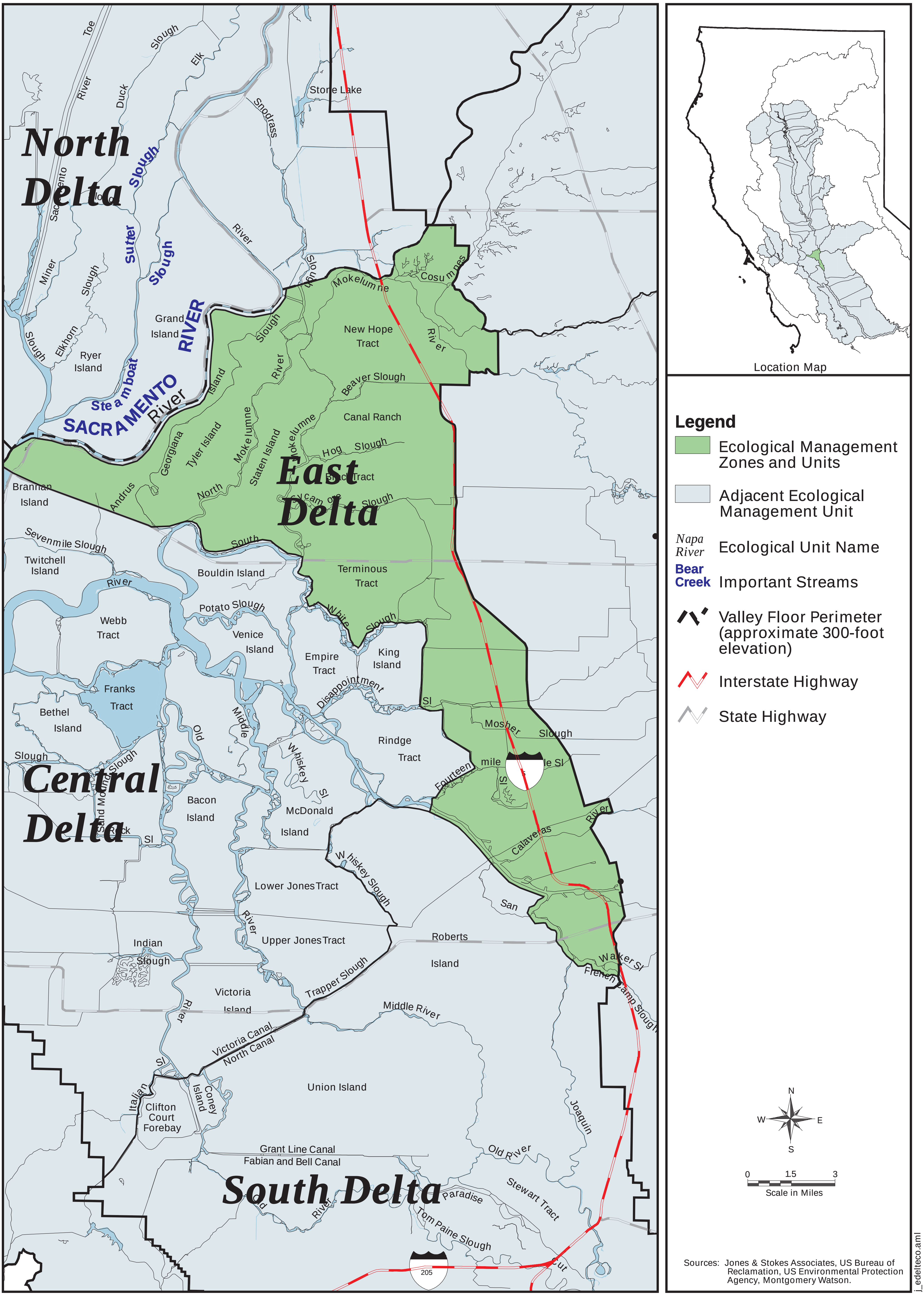

Figure 4
East Delta
Ecological Management Unit

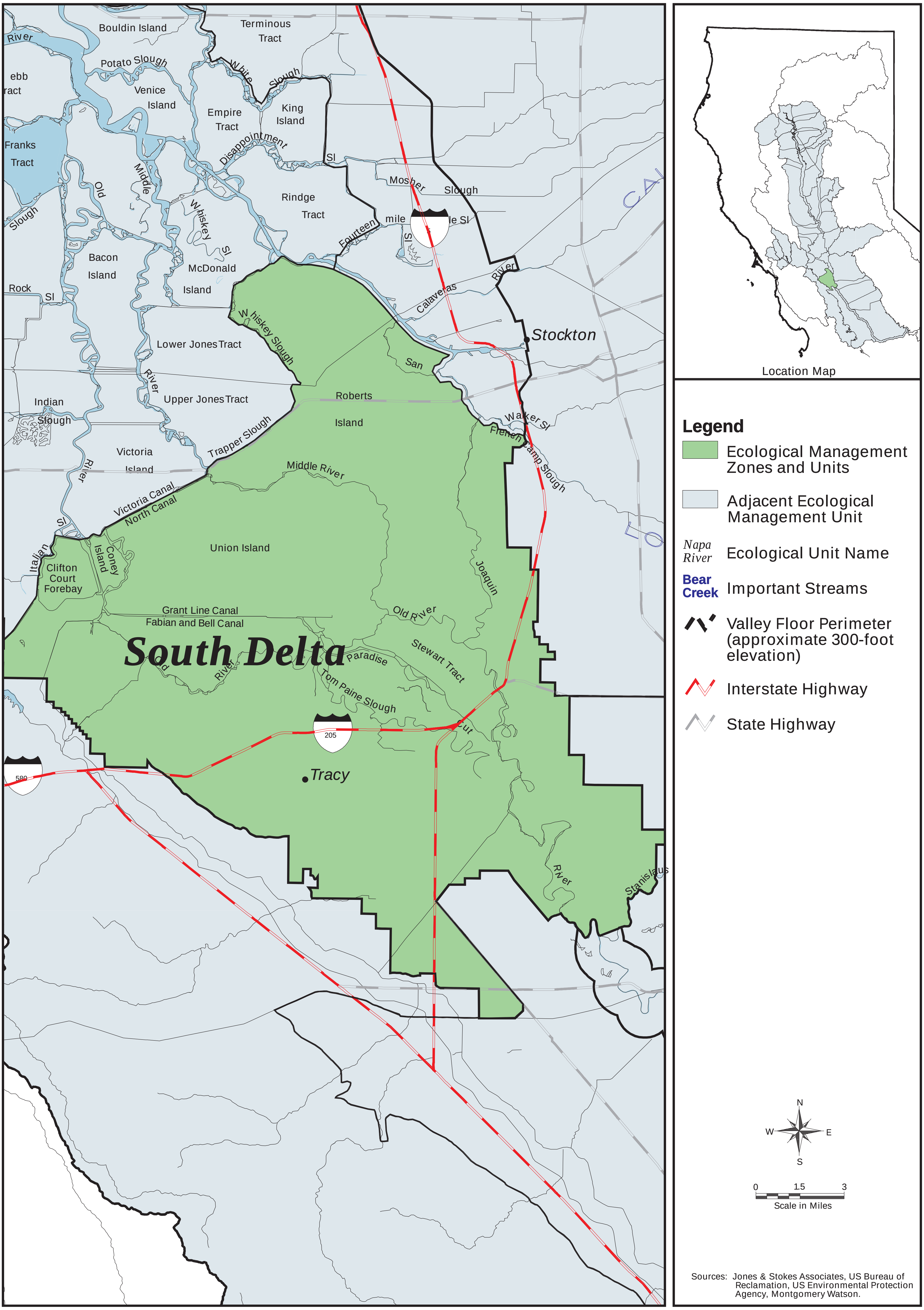

Figure 5
South Delta
Ecological Management Unit

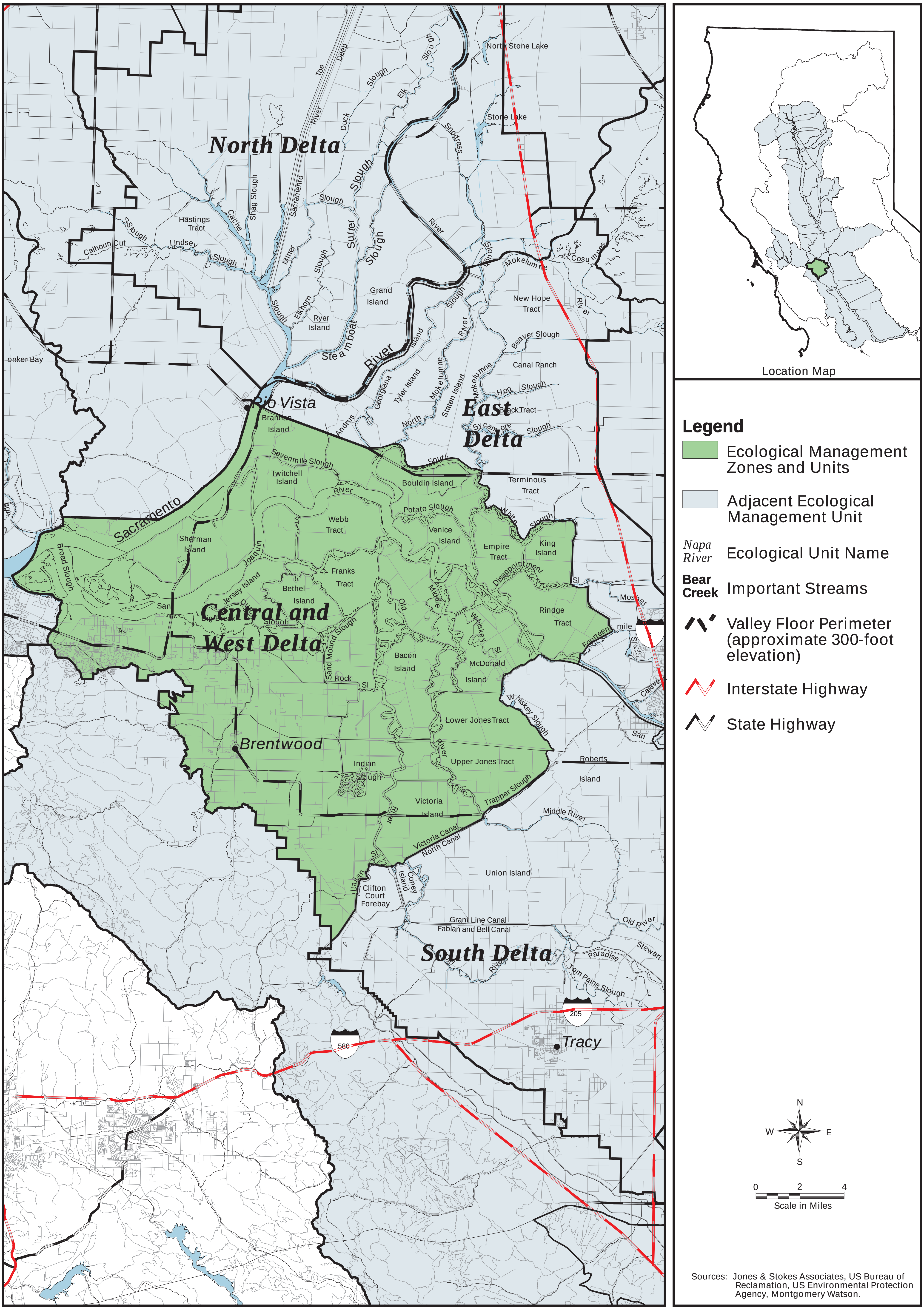

Figure 6
Central and West Delta Ecological Management Unit

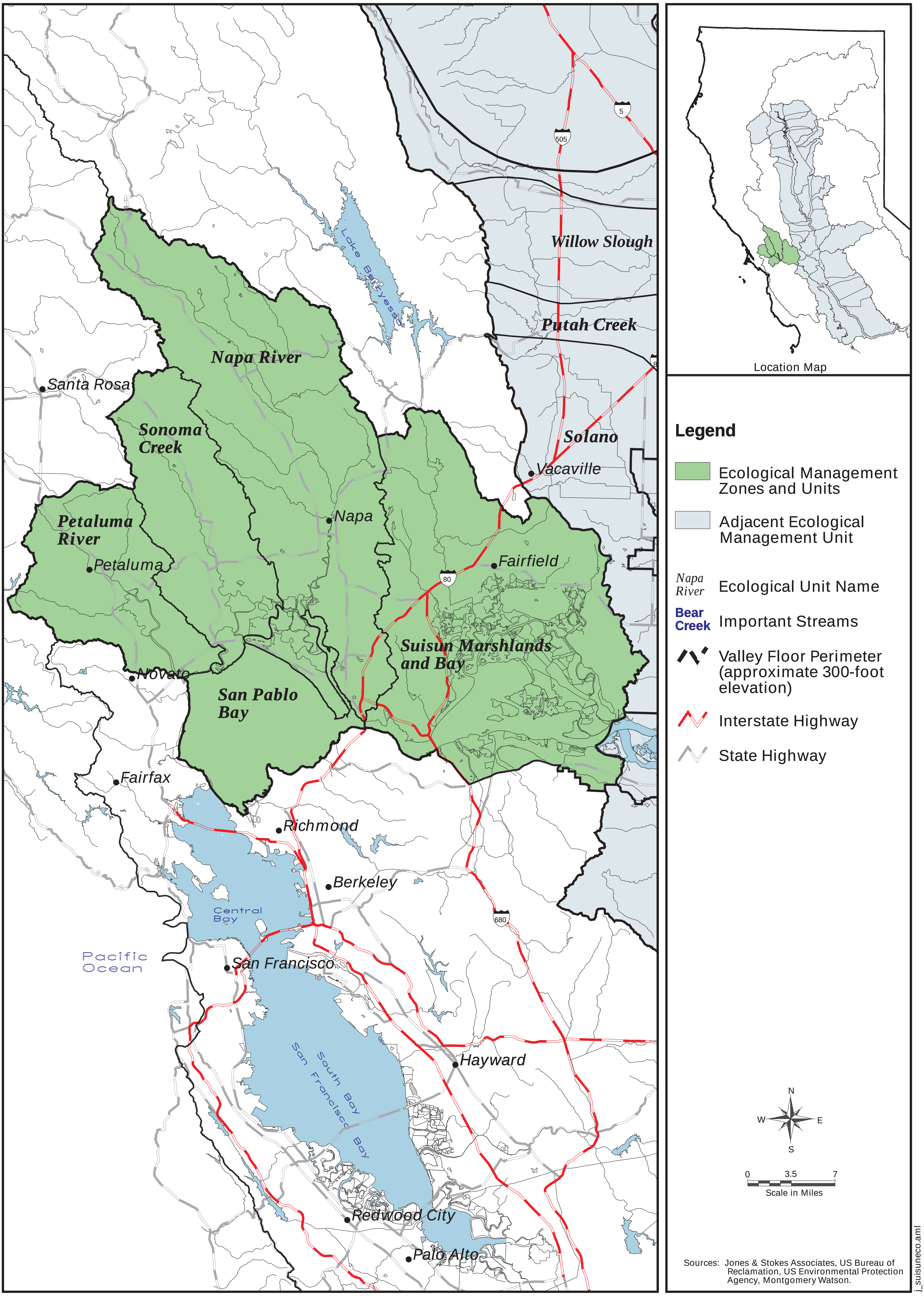

Figure 7
Suisun Marsh/North San Francisco Bay Ecological Management Zone

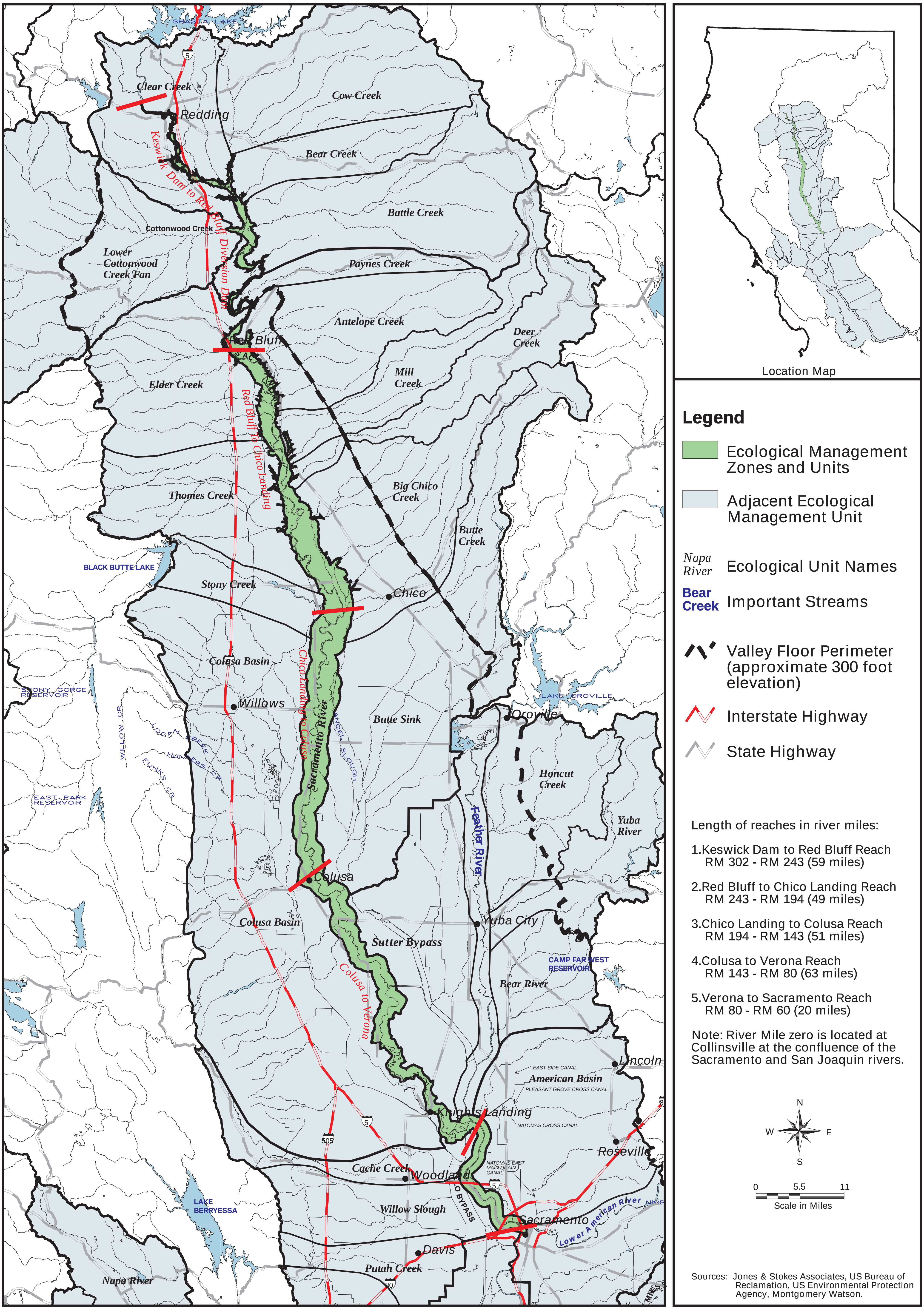

Figure 8
Sacramento River
Ecological Management Zone

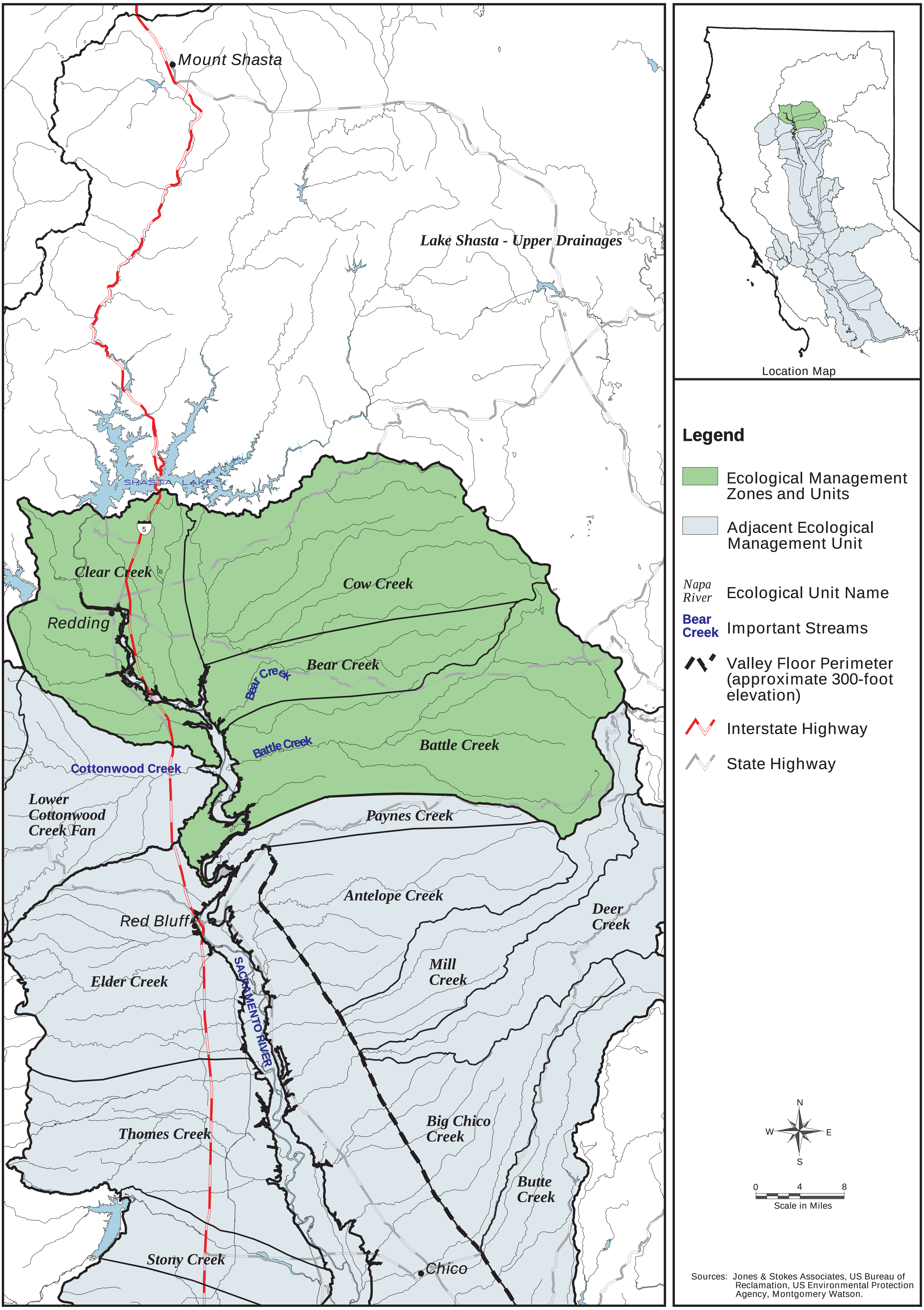

Figure 9
North Sacramento Valley Ecological Management Zone

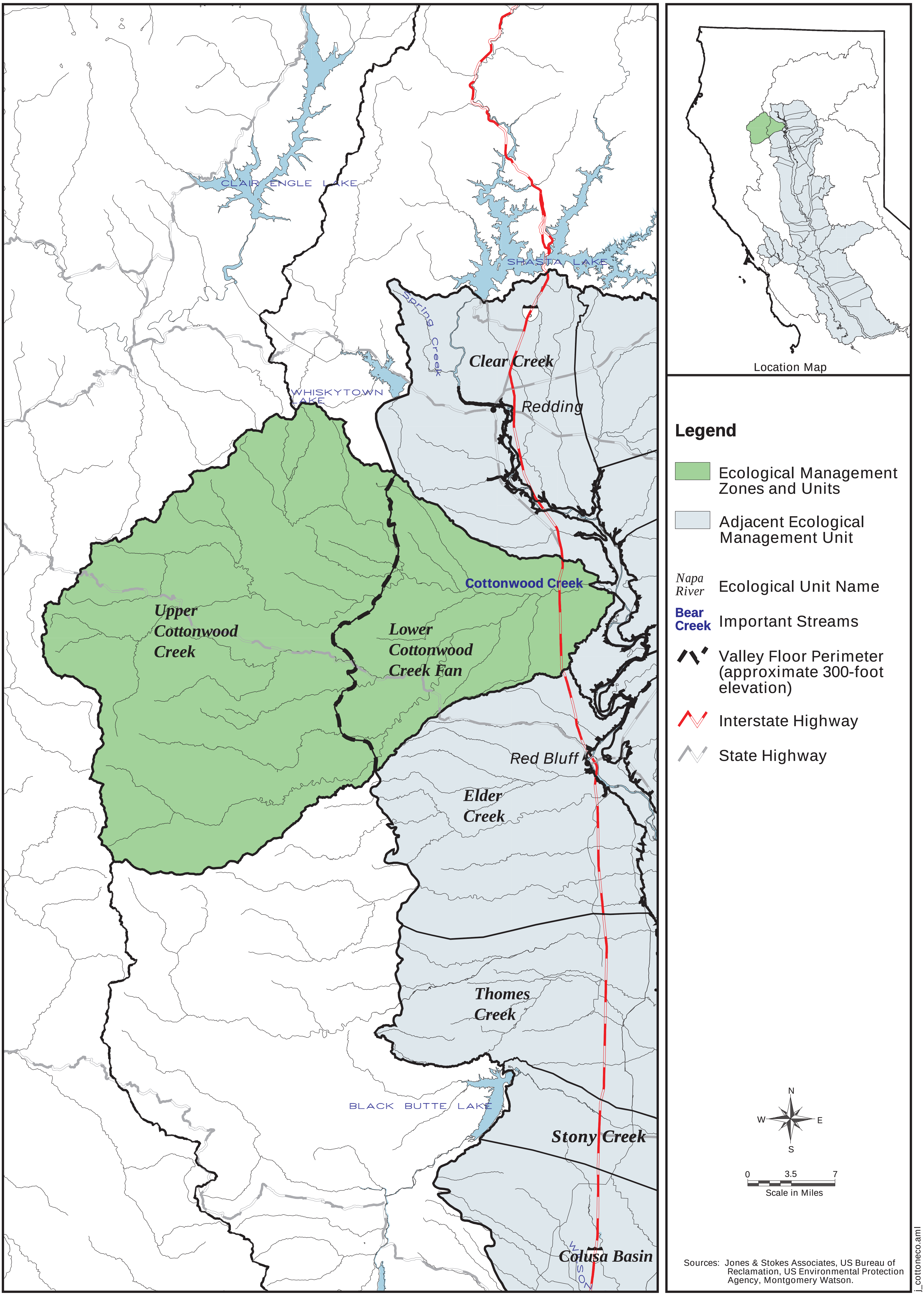

Figure 10
Cottonwood Creek Ecological Management Zone

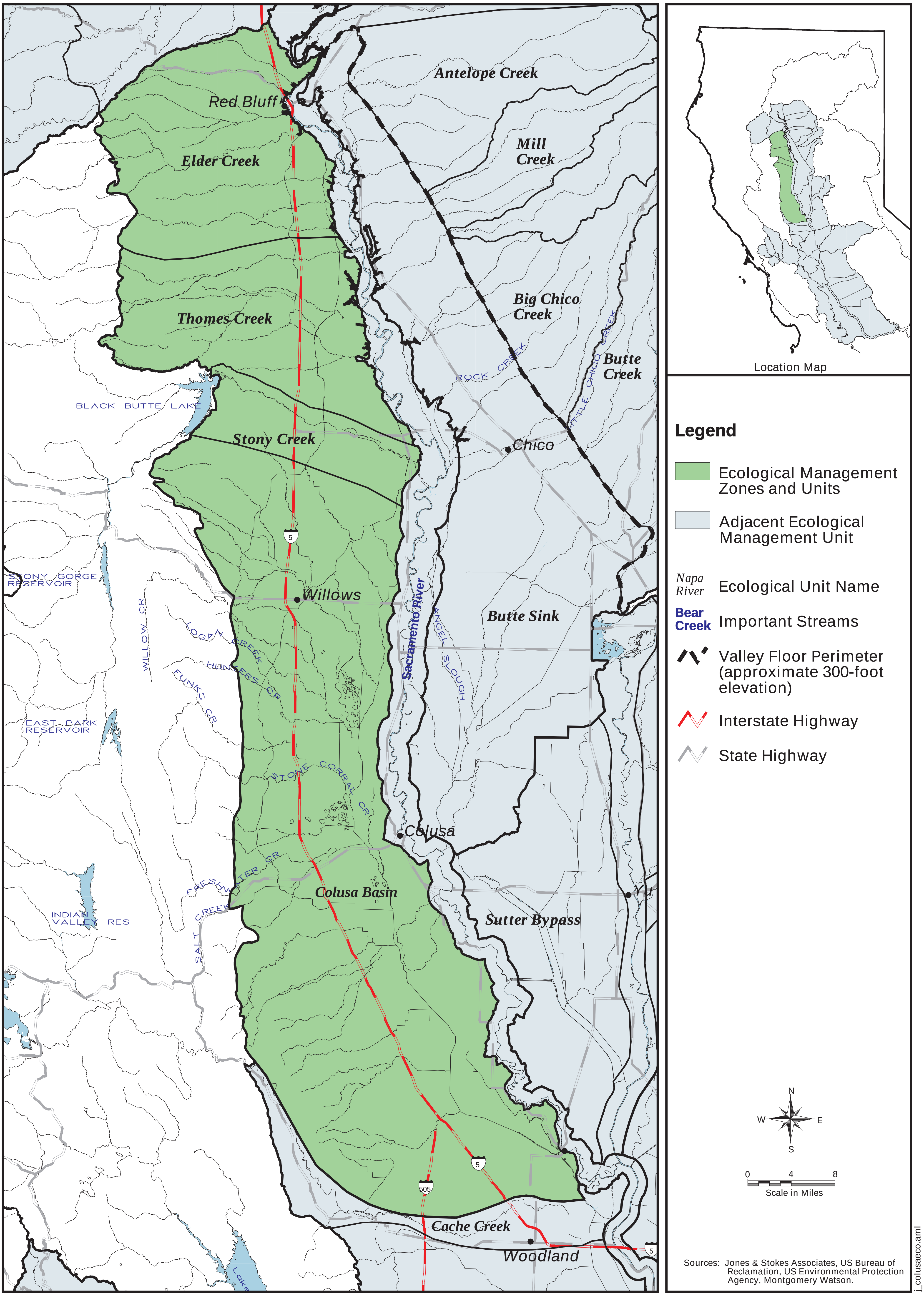

Figure 11
Colusa Basin
Ecological Management Zone

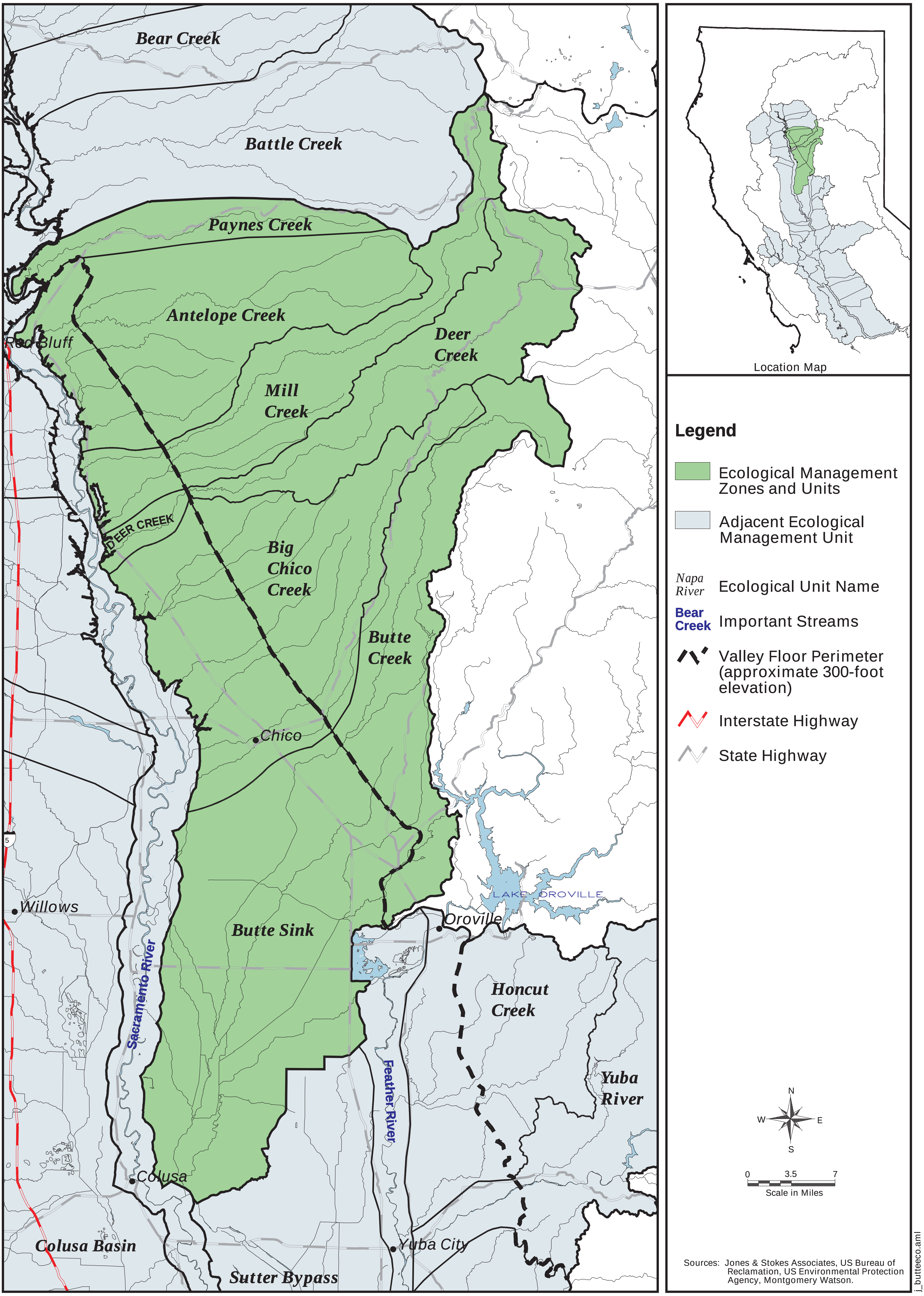

Figure 12
Butte Basin
Ecological Management Zone

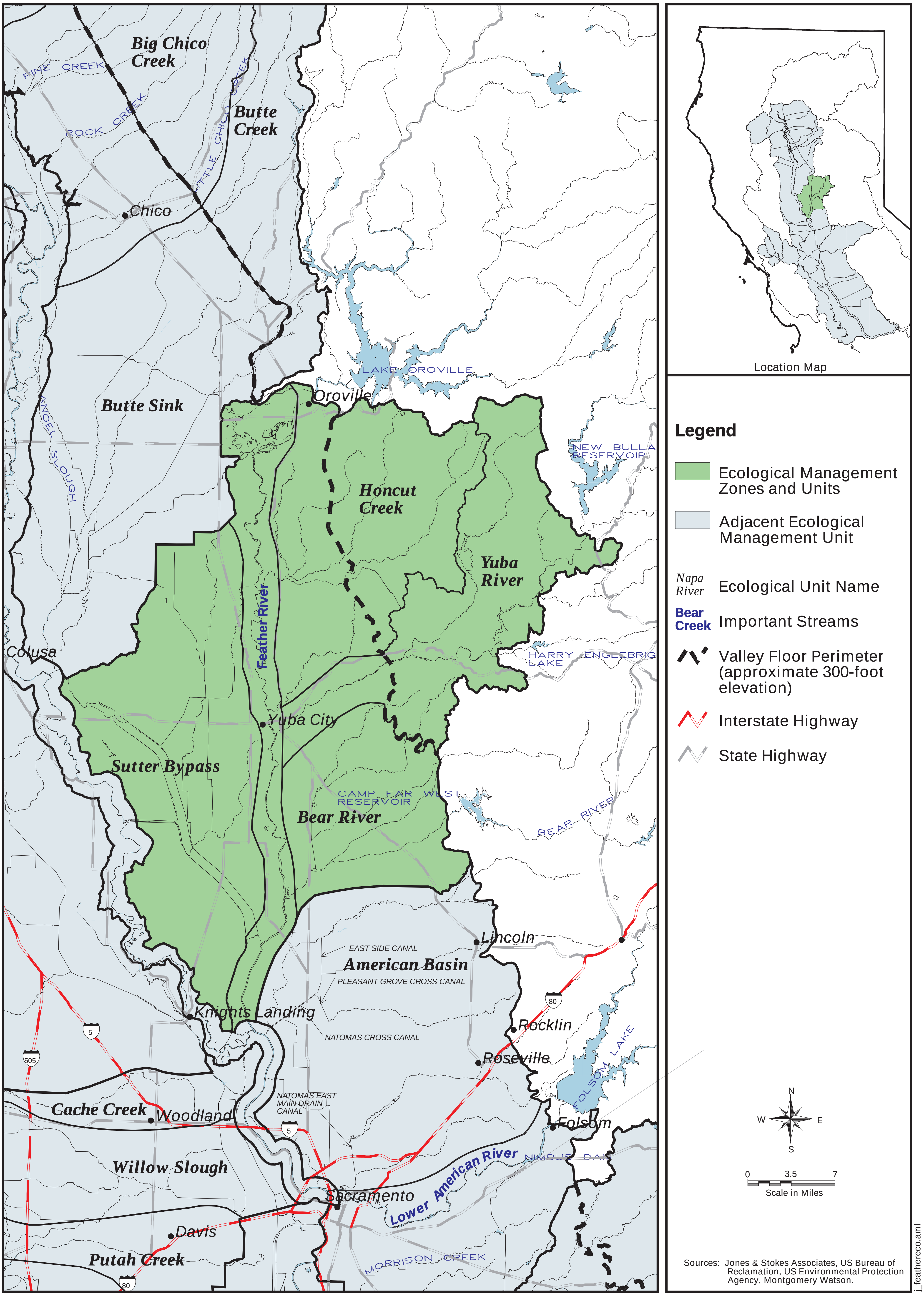

Figure 13
Feather River
Sutter Basin
Ecological Management Zone

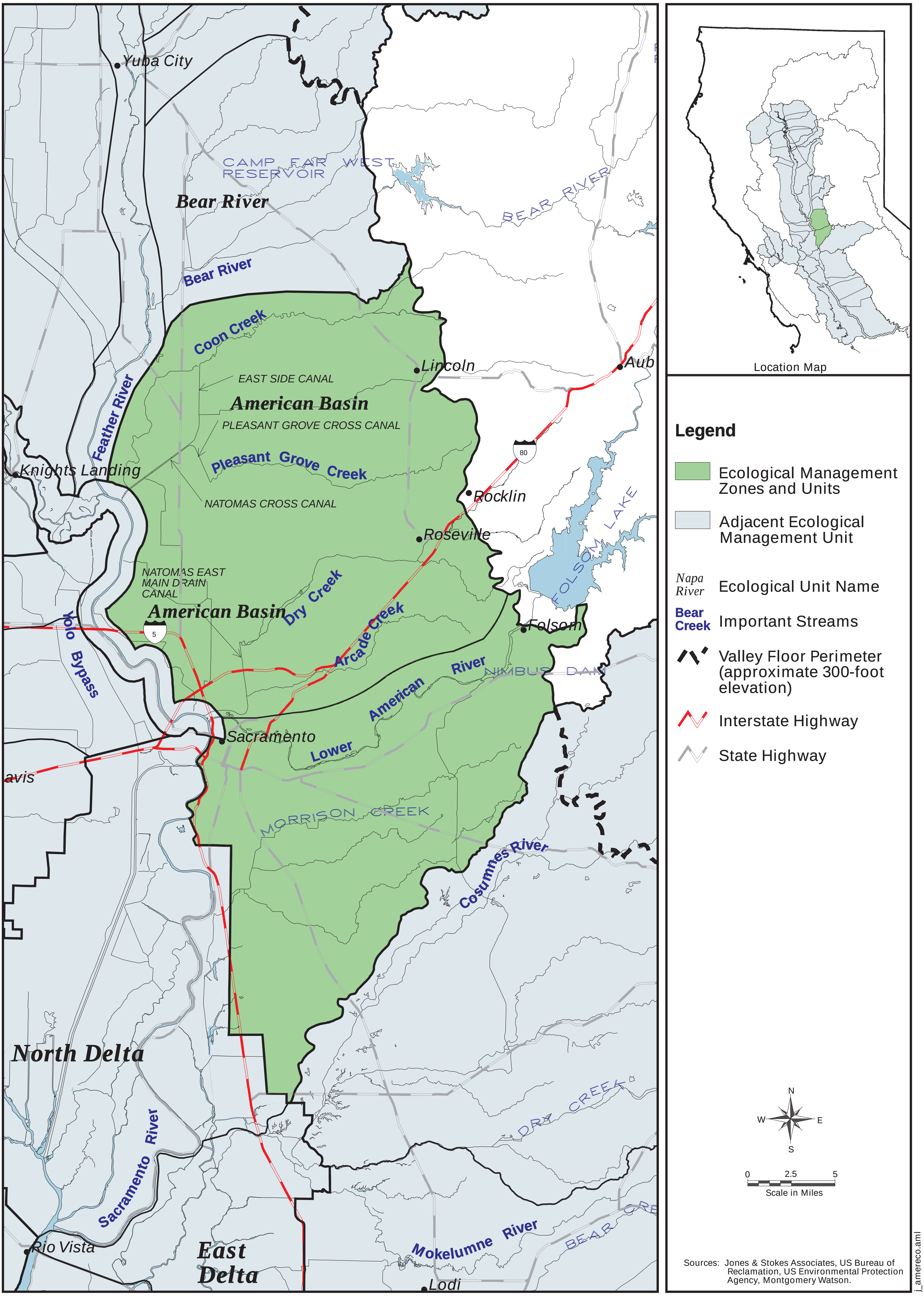

Figure 14
American River Basin
Ecological Management Zone

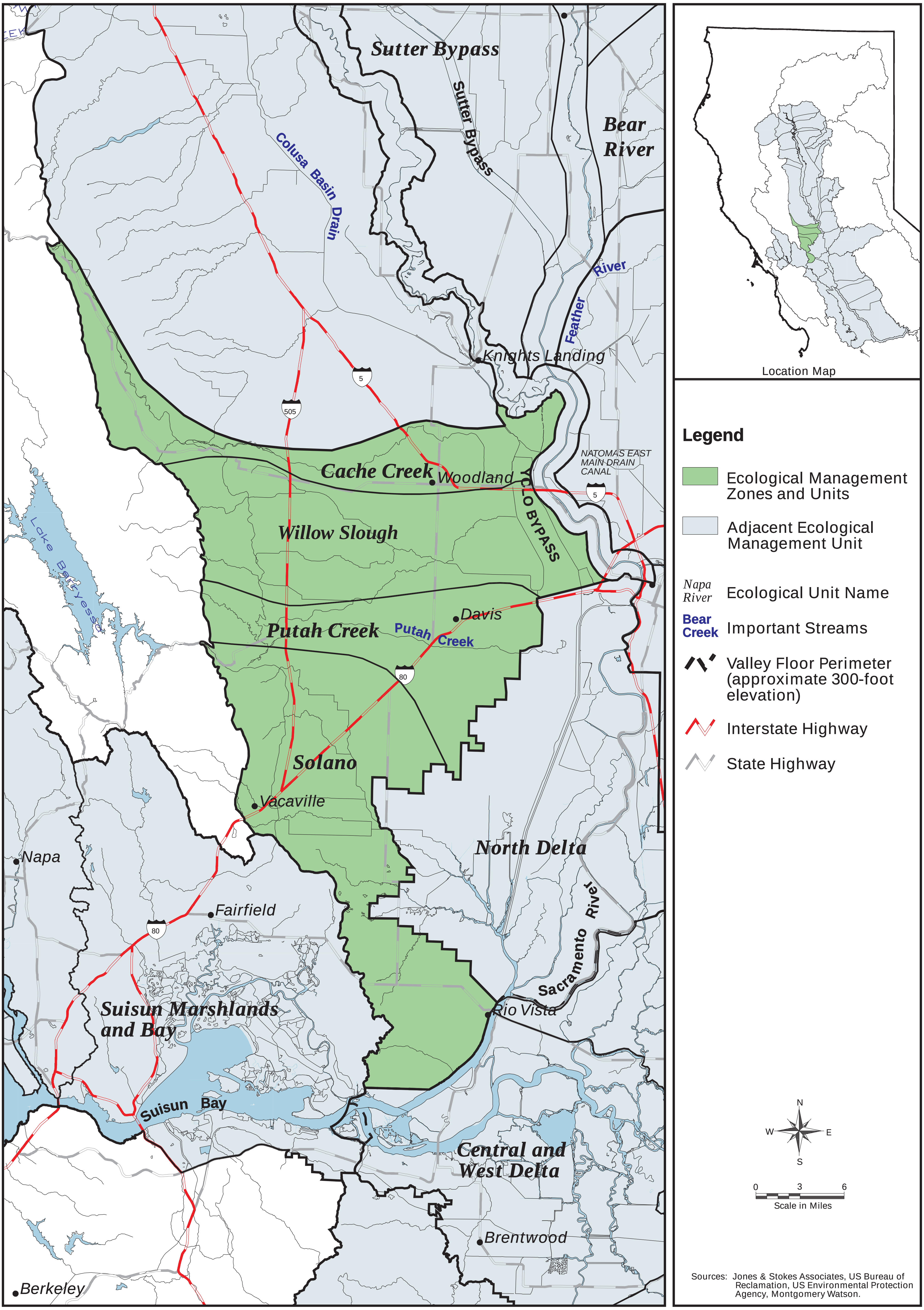

Figure 15
Yolo Basin
Ecological Management Zone

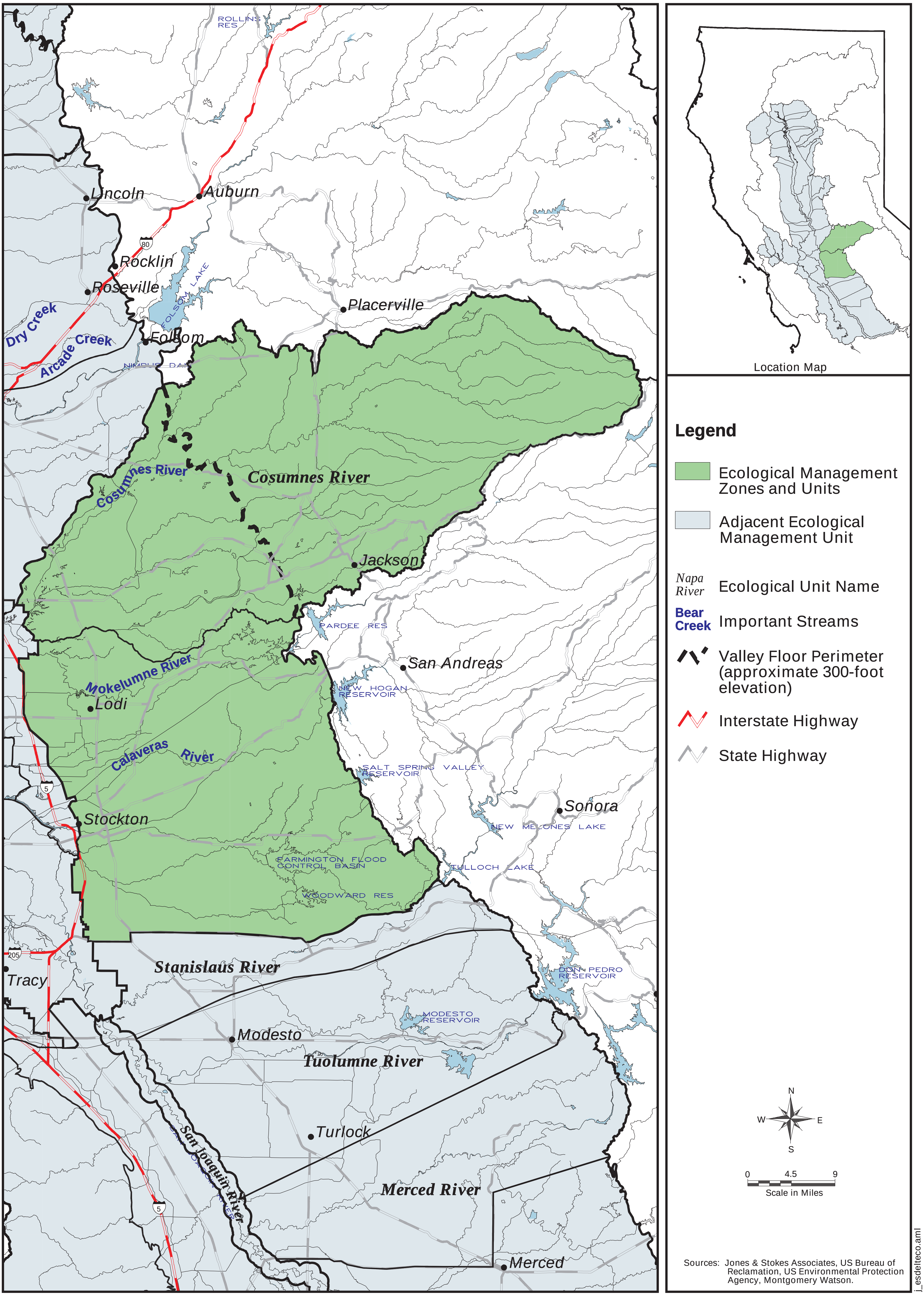

Figure 16
Eastside
Delta Tributaries
Ecological Management Zone

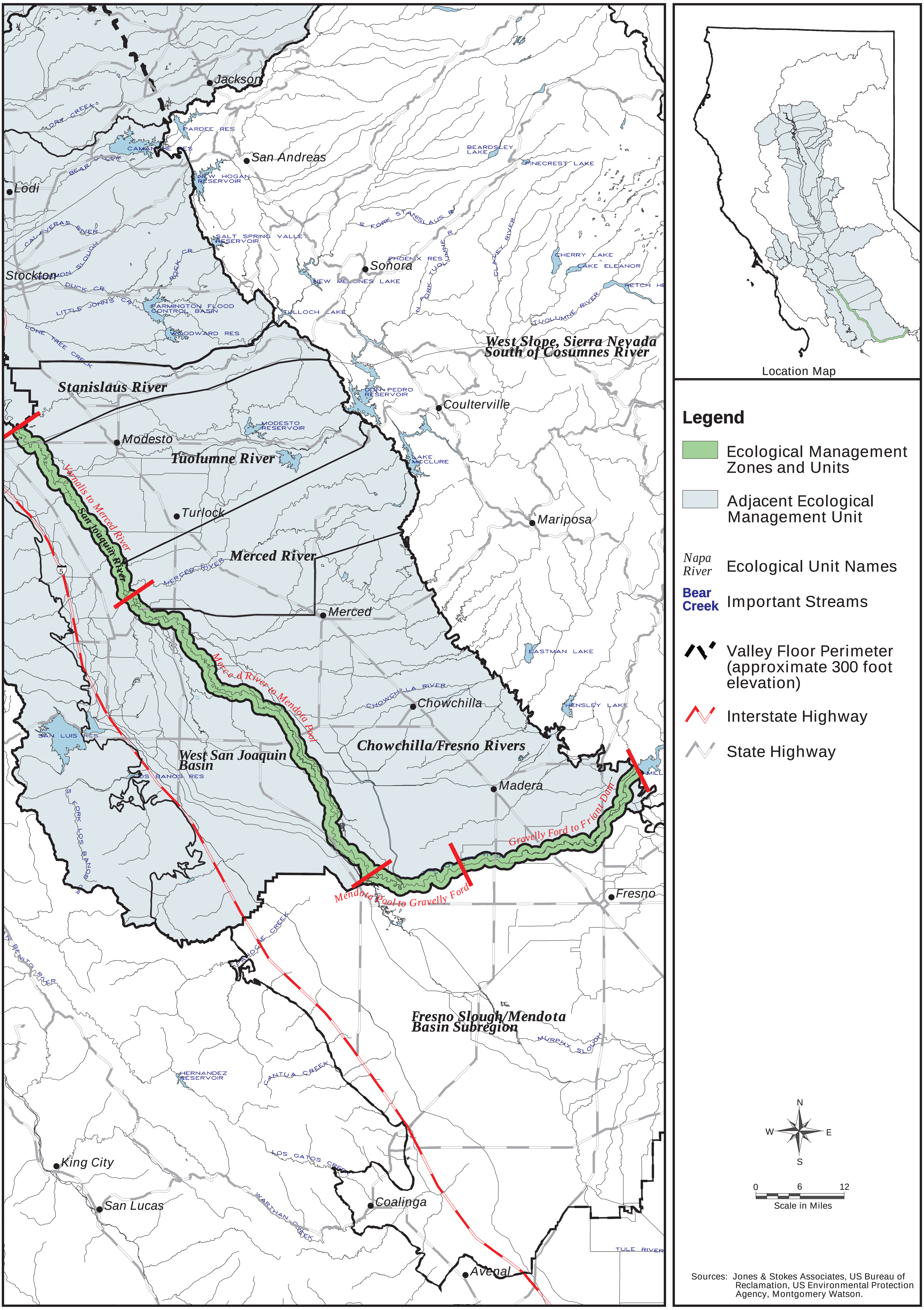

Figure 17
San Joaquin River Ecological Management Zone

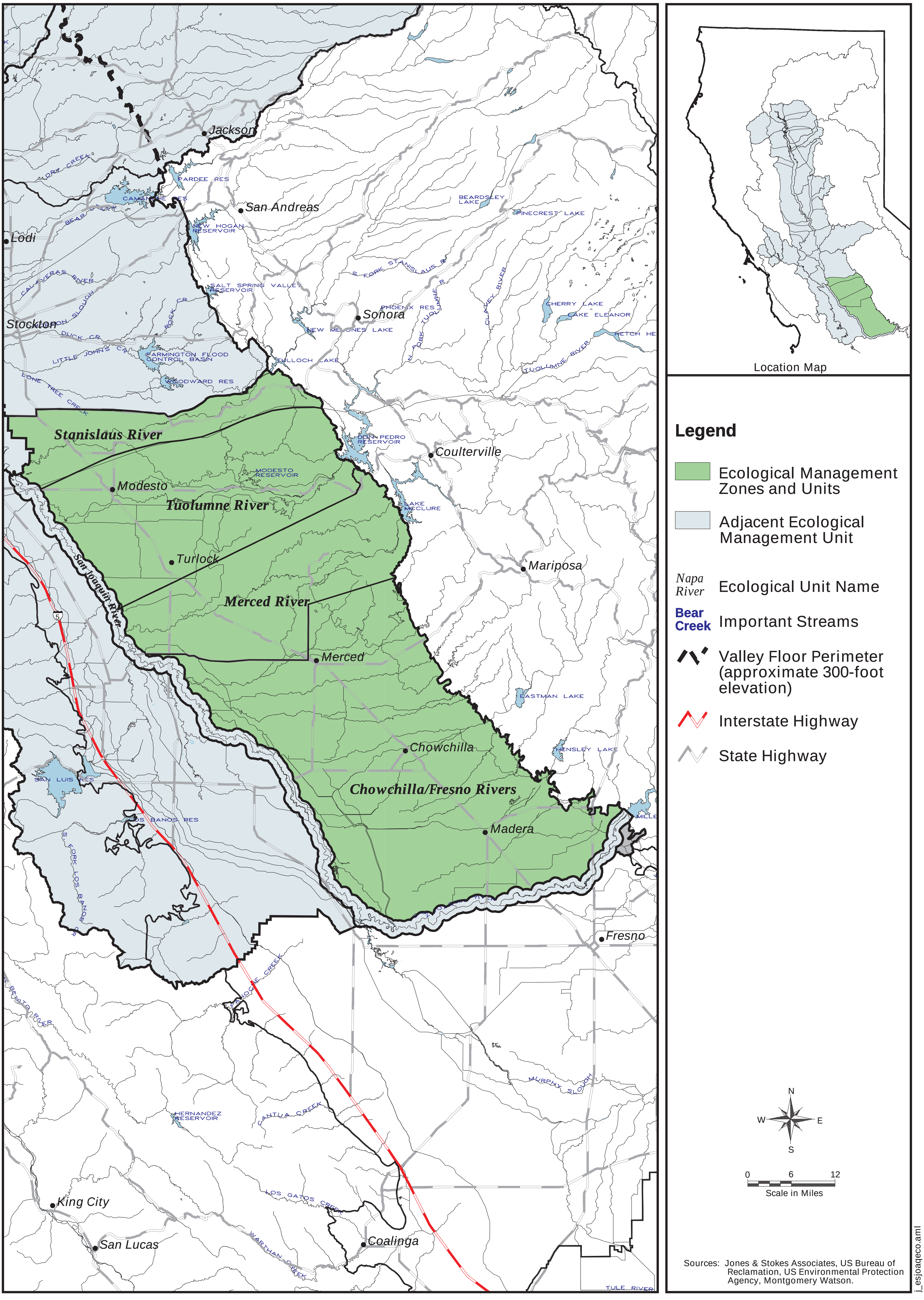

Figure 18
East San Joaquin Basin Ecological Management Zone

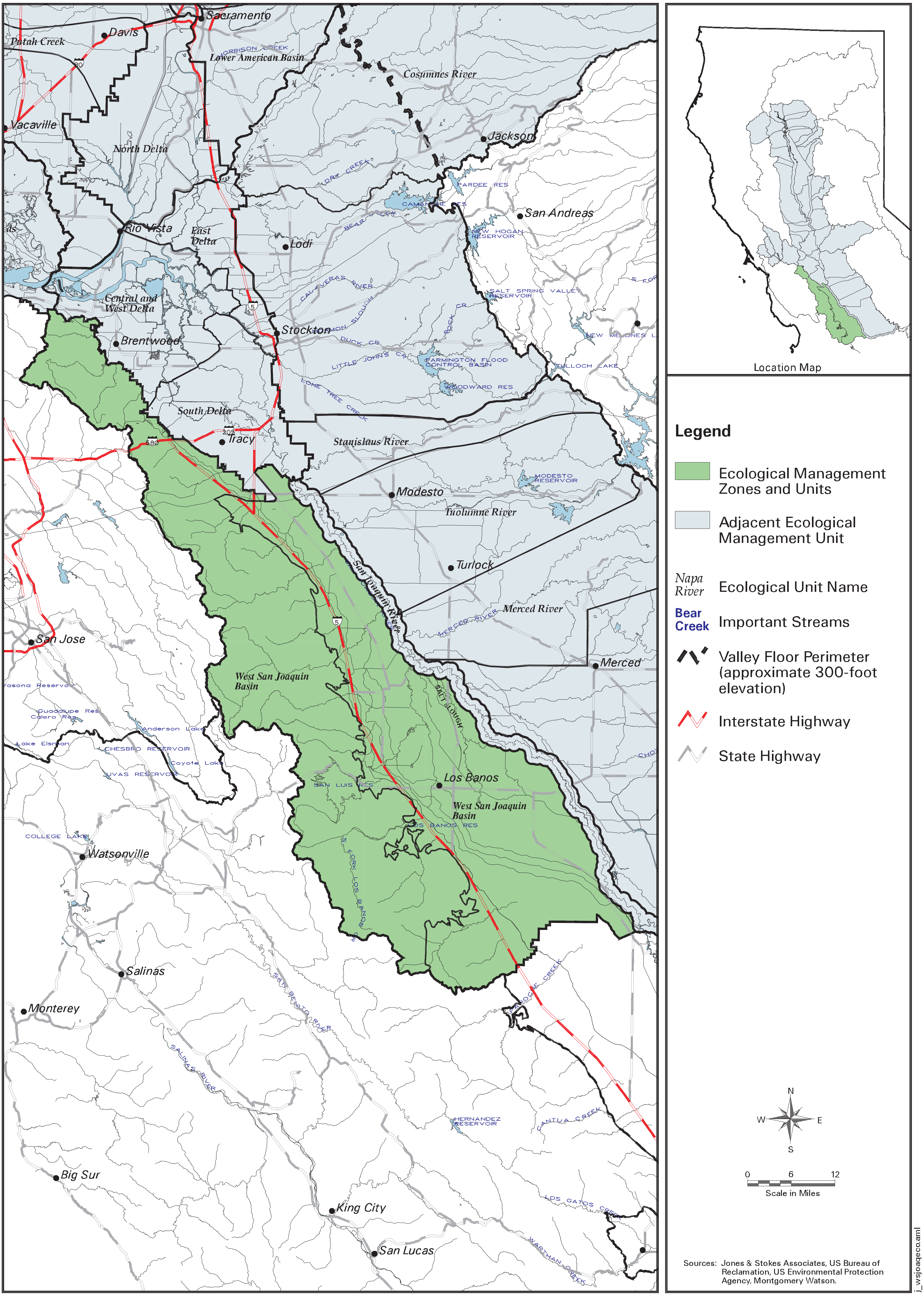

Figure 19
West San Joaquin Basin Ecological Management Zone