U.S. Fish & Wildlife Service

Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon

Vernal pools at Phoenix Park / Dwight Harvey, U.S. Fish & Wildlife Service

Recovery Plan for Vernal Pool Ecosystems

of California and Southern Oregon

Region 1
U.S. Fish and Wildlife Service
Portland, Oregon

Approved: Steve Thompson

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U.S. Fish and Wildlife Service

Date: DEC 15 2005

U.S. FISH AND WILDLIFE SERVICE'S MISSION IN RECOVERY PLANNING

Section 4(f) of the Endangered Species Act of 1973, as amended, directs the Secretary of the Interior and the Secretary of Commerce to develop and implement recovery plans for species of animals and plants listed as endangered or threatened unless such plans will not promote the conservation of the species. The U.S. Fish and Wildlife Service and the National Marine Fisheries Service have been delegated the responsibility of administering the Endangered Species Act. Recovery is the process by which the decline of an endangered or threatened species is arrested or reversed, and threats to its survival are neutralized, so that its long-term survival in nature can be ensured. The goal of this process is the maintenance of secure, self-sustaining wild populations of species with the minimum necessary investment of resources. A recovery plan delineates, justifies, and schedules the research and management actions necessary to support recovery of a species. Recovery plans do not, of themselves, commit staffing or funds, but are used in setting regional and national funding priorities and providing direction to local, regional, and State planning efforts. Means within the Endangered Species Act to achieve recovery goals include the responsibility of all Federal agencies to seek to conserve endangered and threatened species, and the Secretary's ability to designate critical habitat, to enter into cooperative agreements with the states, to provide financial assistance to the respective State agencies, to acquire land, and to develop Habitat Conservation Plans with applicants.

The U.S. Fish and Wildlife Service is committed to applying an ecosystem approach to conservation to allow for efficient and effective conservation of our Nation's biological diversity. In terms of recovery plans, ecosystem considerations are incorporated through the development and implementation of recovery plans for communities or ecosystems where multiple listed species and species of concern occur, in a manner that restores, reconstructs, or rehabilitates the structure, distribution, connectivity, and function upon which those listed species depend. In particular, these recovery plans shall be developed and implemented in a manner that conserves the biotic diversity of the ecosystems upon which the listed species depend.

The Endangered Species Act mandates the preparation of recovery plans for listed species unless such a plan would not contribute to their conservation. Recovery plans detail the actions necessary to achieve self-sustaining, wild populations of listed species so they will no longer require protection under the Endangered Species Act. Species of concern are not required to have recovery plans, however, they are included in this recovery plan because a community-level strategy provides opportunities for pre-listing conservation of species with needs similar to those of listed species.

DISCLAIMER

Recovery plans delineate reasonable actions that are believed to be required to recover and/or protect listed species. We, the U.S. Fish and Wildlife Service, publish recovery plans, sometimes preparing them with the assistance of recovery teams, contractors, State agencies, and others. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not necessarily represent the views, official positions, or approval of any individuals or agencies involved in the plan formulation, other than our own. They represent our official position ***only*** after they have been signed by the Director, Regional Director, or Manager as ***approved***. Approved recovery plans are subject to modification as dictated by new findings, changes in species statuses, and the completion of recovery actions.

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An electronic copy of this recovery plan will be made available at http://www.fws.gov/pacific/ecoservices/endangered/recovery/plans.html and http://www.fws.gov/endangered/recovery/index.html#plans.

PLAN PREPARATION

Numerous individuals have contributed to the authorship of the Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon over a period of several years. The individuals primarily responsible for finalizing this recovery plan are listed in alphabetical order below. We sincerely apologize to anyone whose name was omitted inadvertently from this list.

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The Geographic Information System (GIS) mapping analysis was conducted by: Cheryl Hickam, Joni Mitchell, and Brian Cordone, U. S. Fish and Wildlife Service.

GUIDE TO RECOVERY PLAN ORGANIZATION

This recovery plan provides individual species accounts for all of the 33 species covered. Because of the length and complexity of this recovery plan, an appendix is provided listing the common name and scientific name of all plants and animals mentioned in the document (Appendix A). A glossary of technical terms has been provided in Appendix B.

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We wish to sincerely thank and gratefully acknowledge the Vernal Pool Ecosystem Recovery Team. We sincerely apologize to anyone whose name was omitted inadvertently from this list.

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EXECUTIVE SUMMARY

Introduction: This recovery plan features 33 species of plants and animals that occur exclusively or primarily within a vernal pool ecosystem in California and southern Oregon. The 20 federally listed species include 10 endangered plants, 5 threatened plants, 3 endangered animals, and 2 threatened animals. The federally endangered plants are *Eryngium constancei* (Loch Lomond button-celery), *Lasthenia conjugens* (Contra Costa goldfields), *Limnanthes floccosa* ssp. *californica* (Butte County meadowfoam), *Navarretia leucocephala* ssp. *pauciflora* (few-flowered navarretia), *Navarretia leucocephala* ssp. *plieantha* (many-flowered navarretia), *Orcuttia pilosa* (hairy Orcutt grass), *Orcuttia viscida* (Sacramento Orcutt grass), *Parvisedum leiocarpum* (Lake County stonecrop), *Tuctoria greenei* (Greene's tuctoria), and *Tuctoria mucronata* (Solano grass). The federally threatened plants are *Castilleja campestris* ssp. *succulenta* (fleshy owl's clover), *Chamaesyce hooveri* (Hoover's spurge), *Neostapfia colusana* (Colusa grass), *Orcuttia inaequalis* (San Joaquin Valley Orcutt grass), and *Orcuttia tenuis* (slender Orcutt grass). The three federally endangered animal species are the Conservancy fairy shrimp (*Branchinecta conservatio*), longhorn fairy shrimp (*Branchinecta longiantenna*), and vernal pool tadpole shrimp (*Lepidurus packardi*). The two federally threatened animal species are the vernal pool fairy shrimp (*Branchinecta lynchi*) and delta green ground beetle (*Elaphrus viridis*).

In addition, 13 species of concern are addressed. The plants include *Astragalus tener* var. *ferrisiae* (Ferris' milk vetch), *Astragalus tener* var. *tener* (alkali milk vetch), *Atriplex persistens* (vernal pool smallscale), *Eryngium spinosepalum* (spiny-sepaled button-celery), *Gratiola heterosepala* (Boggs Lake hedge-hyssop), *Juncus leiospermus* var. *ahartii* (Ahart's dwarf rush), *Legenere limosa* (legenere), *Myosurus minimus* var. *apus* (little mousetail), *Navarretia myersii* ssp. *deminuta* (small pincushion navarretia), and *Plagiobothrys hystriculus* (bearded popcorn flower); and the animals include the midvalley fairy shrimp (*Branchinecta mesovallensis*), California fairy shrimp *(Linderiella occidentalis)*, and western spadefoot toad (*Spea hammondii*).

These species occur primarily in vernal pool, swale, or ephemeral freshwater habitats and are largely confined to a limited area by topographic constraints, soil types, and climatic conditions. Surrounding (or associated) upland habitat is critical to the proper ecological function of these vernal pool habitats. The primary threats to the species are habitat loss and fragmentation due to urban development and associated infrastructure, agricultural conversion, altered hydrology, nonnative invasive species, inadequate regulatory mechanisms, exclusion of grazing in areas where grazing has been a historic land use, and inappropriate grazing regimes (overgrazing or undergrazing). Resulting small population sizes are subject to extinction due to random, naturally occurring events.

Recovery Priority: Recovery priority numbers for listed species addressed in this recovery plan are provided in Appendix C. Recovery priority numbers are determined per criteria published in the Federal Register (U.S. Fish and Wildlife Service 1983a) as described in Appendix D.

Recovery Goals, Objectives, Strategies, and Criteria: The overall goals of this recovery plan are to:

- Achieve and protect in perpetuity self-sustaining populations of each species.
- Delist the 20 federally listed plant and animal species.
- Ensure the long-term conservation of the 13 species of special concern.

Interim goals of this recovery plan are to:

- Stabilize and protect populations to prevent further decline of each species.
- Conduct research necessary to refine reclassification and recovery criteria.
- Reclassify to threatened status those species listed as endangered.

The overall objectives of this recovery plan are to:

- Ameliorate or eliminate the threats that caused the species to be listed as federally endangered or threatened, and to ameliorate any newly identified threats, in order to be able to delist or downlist these species.
- Ameliorate or eliminate the threats that affect the species of concern and ameliorate any newly identified threats in order to conserve these species.
- Confirm the status of *Plagiobothrys hystriculus*, a species of concern that is currently presumed extinct. If extant populations are discovered, the ultimate goal would be to ensure the long-term conservation of this species.
- Promote natural ecosystem processes and functions by protecting and conserving intact vernal pools and vernal pool complexes.

Ecosystem-level Strategy for Recovery and Conservation: This recovery plan presents an ecosystem-level strategy for recovery and conservation because all of the listed species and species of concern co-occur in the same natural ecosystem and are generally threatened by the same human activities. The likelihood of successful recovery for listed species and long-term conservation of species of concern is increased by protecting entire ecosystems. This task can be most effectively accomplished through the cooperation and collaboration of various stakeholders.

The over-arching recovery strategy for species in this recovery plan is habitat protection and management. The five key elements that compose this ecosystem-level recovery and conservation strategy are described below.

1. Habitat Protection

Considering that habitat loss and fragmentation due to human activities are the primary causes of endangerment for species in this recovery plan, a central component of species recovery and conservation is to establish conservation areas and reserves that represent all of the important vernal pool habitat within the recovery plan area. Habitat protection does not necessarily require land acquisition or easements; only that land uses maintain or enhance species habitat values. Another recommendation of the recovery plan is that, whenever possible, blocks of conservation lands should be situated so that species dispersal mechanisms remain functional.

2. Adaptive Habitat Management, Restoration, and Monitoring

In most cases, active management of the land is necessary to maintain and enhance habitat values for the species covered in this recovery plan. For most species, management strategies have not been investigated; therefore, few management plans with species-specific strategies have been developed. The current condition and status of special status species should be considered in light of past management practices before a new management regime is imposed. After specific threats or habitat goals are identified, the management regime can be adjusted. The response of the species, habitat, and threats should be monitored, the results evaluated, and management potentially adjusted again based on this information; hence an adaptive management approach. Many vernal pools and vernal pool complexes have been degraded by disturbance or alteration of hydrology, or lost completely. In addition to active management, habitat restoration may be necessary in many instances to achieve proper functioning of a vernal pool ecosystem prior to conducting routine habitat management and monitoring.

3. Status Surveys

Declines in species populations must be halted and/or reversed and threats to the populations ameliorated or eliminated if populations are to be self-sustaining and ultimately warrant delisting. Rangewide species monitoring through use of standardized status surveys will be necessary to determine whether recovery criteria regarding population sustainability and habitat protections are being met. Additionally, standardized status surveys will assist in eliminating data shortfalls regarding whether occurrences are actually extant. "Occurrence" is defined by the California Natural Diversity Database as a location occupied by a species separated from other locations by at least 0.4 kilometer (0.25 mile), and may contain one or more populations. A "population" is defined as a group of organisms of one species, occupying a defined area small enough to permit interbreeding among all members of the group, and isolated to some degree from other members of the same species (Barbour *et al.* 1987, Lincoln 1993). The surveys will include the current status of threats, the historical management regimes associated with the species, and may identify additional species occurrences that will contribute to recovery.

4. Research

Many important aspects of species biology and management have not yet been studied. Thus, continued research, in conjunction with adaptive management is a crucial component of this recovery plan. Results of research will be used to refine habitat protection, habitat management, and species and ecosystem monitoring to more effectively meet recovery criteria. Recovery criteria and actions may be reevaluated for each species as research is completed.

Primary information needs for the species covered in this recovery plan are:

- surveys to determine species distributions;
- population censusing and monitoring;
- reproductive and demographic studies;
- habitat management technique research;
- restoration technique research;
- biosystematic and population genetics studies;
- studies of pesticide and herbicide effects; and
- habitat and species restoration trials.

5. Participation and Outreach

Participation of many groups, including other Federal, State, and local agencies, conservation organizations, private groups, interested stakeholders, and private landowners, will be essential to achieving the recovery goals for the covered species. This recovery plan includes establishing regional recovery implementation working groups representing a diversity of partners from stakeholder groups and Federal, State, and local agencies. These working groups will guide implementation of recovery actions within their regions necessary to achieve recovery goals. In addition to establishing participation of a broad range of partners in recovery implementation, outreach and education will be necessary to inform landowners and partners of recovery opportunities and to garner public support and participation in the recovery process.

Recovery Criteria: The ecosystem-level approach facilitates species recovery and conservation but does not negate the need to consider the requirements of each species. Thus, individual downlisting and/or delisting criteria are presented for each listed species covered in this recovery plan to track their progress towards recovery or conservation. Elements common to the downlisting/delisting criteria of most listed species include:

- protection from further habitat loss, fragmentation, and incompatible uses of the habitat to protect and maintain the full range of genetic and geographic variation in each species;

- development and implementation of appropriate habitat management plans for each species and area identified for protection;

- achievement of self-sustaining populations as determined through species monitoring and status surveys;

- completion of research necessary to refine measures to ameliorate or eliminate threats, and incorporation of results into habitat protection, management, and species monitoring efforts; and

- establishment of regional recovery implementation working groups and development of outreach and education programs to ensure public support and participation in recovery efforts.

Actions Needed: The actions needed to meet the recovery criteria are: 1) protect habitat within core areas, vernal pool regions, and all other areas that contribute to recovery, as appropriate; 2) refine areas for vernal pool conservation by conducting Geographic Information Systems, Remote Sensing, and other analyses; 3) restore habitat where needed and adaptively manage vernal pool conservation areas; 4) develop and implement standardized survey and monitoring protocols to determine success in meeting recovery criteria; 5) conduct research necessary to refine management techniques and recovery criteria; 6) develop and implement cooperative programs and partnerships by establishing regional recovery implementation working groups; and 7) develop and implement participation programs in the form of outreach and education.

Implementation Participation: Although we (the U.S. Fish and Wildlife Service) have the statutory responsibility for implementing this recovery plan, and only Federal agencies are mandated to take part in the effort, the participation of various stakeholders is the key to successful recovery of these species. This recovery plan recommends the establishment of regional recovery implementation working groups comprising all stakeholders and interested parties to develop participation plans, coordinate education and outreach efforts, assist in developing economic incentives for conservation and recovery, ensure that adaptive management is practiced, and oversee the recovery of the species covered in this recovery plan.

Total Estimated Cost of Recovery: The total estimated cost of downlisting/delisting the 20 federally listed species, and ensuring the long-term conservation of the 13 species of concern is broken down by priority of actions. Certain costs, such as securing and protecting specific areas of vernal pool habitat, are dependent on local economics, therefore they may vary from the estimates shown.

Priority 1 actions: $774,193,730

Those actions that must be taken to prevent extinction or prevent the species from declining irreversibly in the foreseeable future.

Priority 2 actions: $1,107,421,800

Those actions that must be taken to prevent a significant decline in the species population or habitat quality, or some other significant negative impact short of extinction.

Priority 3 actions: $202,926,340

All other actions necessary to meet the recovery and conservation objectives outlined in this recovery plan.

Date of Recovery: Recovery is defined in relation to a climatological cycle for most species covered in this recovery plan. If recovery criteria are met, we estimate most listed species covered in this recovery plan could be recovered by 2064 (58 years), based on the interval between the last two droughts of 5 years or longer. Some species, such as those with narrow distributions, could be recovered in less time.

Vernal Pool Recovery Plan Implementation: This recovery plan is designed to be implemented in a logical, progressive manner. Core areas are ranked as Zone 1, 2, or 3 in order of their overall priority for recovery. We anticipate that a number of the species covered by this recovery plan can be recovered primarily through the protection of Zone 1 core areas. In particular, the most narrowly endemic species (e.g., *Limnanthes floccosa* ssp. *californica*) occur only in Zone 1 and do not merit further protection of Zone 2 habitat. On the other hand, the most widely distributed species such as vernal pool fairy shrimp and *Orcuttia tenuis* occur broadly through Zones 1 and 2. Protection of Zone 2 core areas will significantly contribute to recovery of these species, and if sufficient might offset the need to protect some lands within the Zone 1 core areas. In general we consider recovery recommendations in Zones 2 and 3 to be more flexible than in Zone 1, and recovery criteria specific to Zone 2 and 3 core areas may be modified on a case by case basis based on future information. However, certain Zone 2 core areas are important for recovery of some species (*e.g.*, *Lasthenia conjugens*, longhorn fairy shrimp) that are rare and localized but have significant populations within Zone 2. Further implementation of recovery actions in vernal pool habitat outside core areas and outside vernal pool regions could be recommended for a species if recovery actions have been implemented in Zones 1, 2, and 3 and recovery has not yet been achieved.

"Suitable habitat" is defined as habitat that contains the elements necessary for the continued existence of each individual species in this plan. The physical elements include at a minimum: vernal pool type, soil series, area (*i.e.* dimensions), slope, water quality, depth, duration and timing of inundation, and elevation from which each species has been reported to date. Not all information is currently known about all of the requirements for every species in this plan. Vernal pool habitat must be inundated sufficiently by rainfall at the appropriate time of year to allow the vernal pool crustaceans to reach maturity and reproduce and to allow the vernal pool plants to set viable seed. In addition to these elements, an essential, inseparable part of "suitable habitat" is the watershed surrounding the vernal pools which collects and contributes water to the pools. Each species in this plan has a different suite of habitat requirements, though similarities exist and some of the species co-occur..

This recovery plan cannot be implemented in a static manner (*i.e.*, following a recipe) if recovery of the species is to be achieved. The threats and environmental conditions existing today may be vastly different from those that will be present in 5, 20, or 50 years. The plan is structured to enable the user to implement the plan based on the dynamics occurring on the land at that particular point in time when a new recovery action is implemented. Those responsible for implementing this plan must be able to determine, in coordination with us, what is the most appropriate course of action to benefit these species under changing circumstances, while still adhering to the basic structure of this recovery plan for reaching the goals of habitat protection and stable or increasing numbers of individuals.

The total costs of implementation of this recovery plan will depend on what level of effort is needed to achieve recovery for all species. For example, if recovery is achieved for species at the Zone 1 core area level, the cost would be approximately $773 million if fee title acquisitions, the most expensive manner to achieve habitat protection, were used exclusively for all recommended habitat protection actions. If, however, conservation easements are used as an option to protect land, rather than fee title acquisition, the recovery costs could be substantially reduced (*e.g.*, 40 percent or more in some cases).

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PREFACE

Critical habitat designation and recovery planning are two separate processes under the Endangered Species Act. While some of the same information regarding species biology and threats is used in each process, the ultimate outcomes are distinct and independent.

The designation of critical habitat is a regulatory process. A critical habitat designation focuses on areas that contain physical and biological features that meet two criteria: they (a) are essential to the conservation of the species, and (b) may require special management considerations. Additionally, critical habitat does not have to be designated if it is deemed not prudent to do so, either because it is a species that is threatened by certain human activities (*e.g*, vandalism or overcollecting), or the designation would not be considered beneficial to the species. Critical habitat must take into consideration the economic impact of the designation, and an area may be excluded if it is determined that the benefits of such exclusion outweigh the benefits of specifying such areas as critical habitat.

A critical habitat designation may include a subset of areas that may be identified within a recovery plan as important for recovery of a species, but the regulatory standard of adverse modification is measured in terms of effects on the primary constituent elements and essential functions provided by the critical habitat, as identified in the critical habitat designation, and not against recovery plan thresholds.

Recovery plans, on the other hand are voluntary guidance documents, not regulatory documents, that broadly address conservation needs of the species by identifying research, habitat protection and restoration, and management, and all other actions that must be taken to bring a species to a state in which it may be delisted or downlisted. Recovery planning documents are necessarily expansive, identifying as many options and strategies that may contribute to recovery as possible. None of the actions or maps associated with this recovery plan carry any regulatory authority.

The Endangered Species Act clearly envisions recovery plans as the central organizing tool for guiding each species' recovery process. They should also guide Federal agencies in fulfilling their obligations under section 7(a)(1) of the Endangered Species Act which call on all Federal agencies to "utilize their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species and threatened species..." In addition to outlining proactive measures to achieve the species' recovery, recovery plans provide context and guidance for the implementation of other provisions of the Endangered Species Act, such as section 7(a)(2) consultations with other Federal Agencies and the development of Habitat Conservation Plans.

I. INTRODUCTION

Wetlands are among America's most endangered ecosystems, with more than 50 percent of them having been lost in the lower 48 states since pre-colonial times (Dahl 1990). In California, aerial photo studies indicate that as much as 80 to 90 percent of historic habitat has been lost and that the loss continues unabated (Holland 1978, 1998). The few wetlands that remain, or that have been re-created, in the Central Valley are among the most valuable and biologically productive ecosystems in the state, fulfilling a variety of beneficial needs that include protecting and improving water quality by absorbing and storing floodwaters, filtering pollutants, and maintaining surface water flows during dry periods; providing fish and wildlife habitats; and offering recreational opportunities to millions of Americans annually. Because of their productivity, wetlands support a great diversity of plants and animals, both aquatic and terrestrial, including both federally and State listed threatened and endangered species.

Vernal pools are a unique kind of wetland ecosystem. Central to their distinctive ecology is their ephemeral nature. Vernal pools fill with water temporarily, typically during the winter and spring, and then disappear until the next rainy season. In California, where extensive areas of vernal pool habitat developed over a long geological timeframe, unique suites of plants and animals have evolved that are specially adapted to the unusual conditions of vernal pools. Fish and other predators are among species that have been excluded evolutionarily by the annual filling and drying cycles of vernal pools. The prolonged annual dry phase of the vernal pool ecosystem also has prevented the establishment of plant species typical of more permanent wetland ecosystems.

California and southern Oregon vernal pools are also renowned for their showy displays of spring wildflowers, blooming in concentric rings around the pools. Native bees pollinate these vernal pool wildflowers while crustaceans and other insects produce cysts and eggs that lie buried in the mud awaiting the next rainy season alongside seeds of plants produced in past years. In essence, vernal pools constitute a "bank" of life waiting to emerge at the onset of the next rainy season.

A. OVERVIEW

1. Species Represented

This recovery plan covers 33 plant and animal species associated with vernal pools, 20 of which are federally listed as endangered or threatened (**Table I-1**). Covered plants include 10 that are endangered, 5 that are threatened, and 10 species of special concern. Covered animals include three that are endangered, two that are threatened, and three species of special concern.

Of the 20 federally listed species included in this recovery plan, 2 have a previously approved final recovery plan. A combined recovery plan for the delta green ground beetle (*Elaphrus viridis*) and *Tuctoria mucronata* (Solano grass) was approved in 1985 (U.S. Fish and Wildlife Service 1985*a*). Thus, this recovery plan represents a revision of the final recovery plan for those species.

Thirteen plant and animal species of concern that occur within vernal pools are fully considered in this recovery plan (**Table I-1**). Species of concern are sensitive species that have not been listed, proposed for listing nor placed in candidate status. "Species of special concern" is an informal term used by some but not all of our offices. Species of concern receive no legal protection and the use of the term does not necessarily mean that the species will eventually be proposed for listing as a threatened or endangered species. One species of concern addressed in this plan, *Plagiobothrys hystriculus* (bearded popcorn flower) is presumed extinct.

Critical Habitat

Of the 20 federally listed species included in this recovery plan, critical habitat has been designated for 11 plants and 4 animals within the *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon; Evaluation of Economic Exclusions From August 2003 Final Designation; Final Rule* (U.S. Fish and Wildlife Service 2005). Additionally, critical habitat has been designated for the delta green ground beetle (U.S. Fish and Wildlife Service 1980a).

Section 4 of the Endangered Species Act requires that we designate critical habitat on the basis of what we know at the time of designation. Habitat is often dynamic, and species may move from one area to another over time. Furthermore, we recognize that designation of critical habitat may not include all of the habitat areas that may eventually be determined to be necessary for the recovery of the species. For these reasons, critical habitat designations do not signal that habitat outside the designation is unimportant or may not be required for recovery. Some areas within Zone 1 and Zone 2 core areas were excluded from critical habitat for economic reasons (U.S. Fish and Wildlife Service 2005), creating a discrepancy between the core area boundaries and critical habitat. We anticipate that some lands in recovery core areas outside of the areas designated as critical habitat will be necessary for recovery. Additionally, this recovery plan covers a total of 33 species, 20 of which are listed under the Act. Of those listed species covered in this plan, critical habitat has been designated for 16 species. As critical habitat has not been designated for the remaining four listed species (see Table I-1), it is not possible to state whether or not the boundaries of the critical habitat designation would match those of the recovery core areas, if in fact critical habitat had been designated for those four species.

Similarly, critical habitat designations made on the basis of the best available information at the time of designation will not control the direction and substance of future plans, or other species conservation planning efforts if new information available to these planning efforts calls for a different outcome.

Critical habitat affects Federal agencies by requiring them to evaluate the effects that any activities they fund, authorize, or carry out may have on listed species. Agencies are required to ensure that such activities are not likely to jeopardize the survival of a listed species or adversely modify (*e.g.*, damage or destroy) its critical habitat. By consulting with us, Federal agencies can usually minimize or avoid any potential conflicts and, thus, activities usually proceed in some form. It should be noted that critical habitat designation does not create a wilderness area, preserve, or wildlife refuge. It applies only to activities sponsored at least in part by Federal agencies. Such federally-permitted land uses as grazing and recreation may take place if they do not adversely modify critical habitat. Designation of critical habitat does not constitute a land management plan nor does it signal any intent of the government to acquire or control the land. Therefore, if there is no Federal involvement (*e.g.*, Federal permit, funding, or license), activities of a private landowner, such as farming, grazing or constructing a home, generally are not affected by a critical habitat designation, even if the landowners' property is within the geographical boundaries of critical habitat. Without a Federal nexus to a proposed action, designation of critical habitat does not require that landowners of State or other non-Federal lands do anything more than they would otherwise do to avoid take under provisions of section 9 and 10 of the Endangered Species Act. Although core areas were developed in part using critical habitat boundaries, the two areas differ in that core areas not included in critical habitat have no legal mandate for protection under the Endangered Species Act and solely rely upon voluntary implementation. Additionally, recovery planning documents are necessarily expansive, identifying as many options and strategies that may

Table I-1. Species addressed in the Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon.

Scientific name	Common name(s)	Status [1]	Critical Habitat Designated?	Vernal Pool Region [2]	Recovery Priority [3]
Listed Plant Species					
Castilleja campestris ssp. *succulenta*	fleshy owl's clover	FT, SE	Yes	So. Sierra Foothills	9
Chamaesyce hooveri	Hoover's spurge	FT	Yes	NE Sac, So. Sierra Foothills, Solano-Colusa	2c
Eryngium constancei	Loch Lomond button-celery	FE, SE	No	Lake-Napa	14
Lasthenia conjugens	Contra Costa goldfields	FE	Yes	Central Coast, Lake-Napa, Livermore, Mendocino, Solano-Colusa	5c
Limnanthes floccosa ssp. *californica*	Butte County meadowfoam	FE, SE	Yes	NE Sac	2c
Navarretia leucocephala ssp. *pauciflora*	few-flowered navarretia	FE, ST	No	Lake-Napa	3
Navarretia leucocephala ssp. *plieantha*[4]	many-flowered navarretia	FE, SE	No	Lake-Napa	3
Neostapfia colusana	Colusa grass	FT, SE	Yes	Solano- Colusa, So. Sierra Foothills, San Joaquin	2c
Orcuttia inaequalis	San Joaquin Valley Orcutt grass	FT, SE	Yes	So. Sierra Foothills	8
Orcuttia pilosa	hairy Orcutt grass	FE, SE	Yes	NE Sac, So. Sierra Foothills, Solano-Colusa	2c

Scientific name	Common name(s)	Status [1]	Critical Habitat Designated?	Vernal Pool Region[2]	Recovery Priority[3]
Orcuttia tenuis	slender Orcutt grass	FT, SE	Yes	Lake-Napa, Modoc Plateau, NE Sac, NW Sac, SE Sac	8
Orcuttia viscida	Sacramento Orcutt grass	FE, SE	Yes	SE Sac	5c
Parvisedum leiocarpum	Lake County stonecrop	FE, SE	No	Lake-Napa	2c
Tuctoria greenei	Greene's tuctoria	FE, SR	Yes	Modoc Plateau, NE Sac, NW Sac, So. Sierra Foothills, Solano-Colusa	2c
Tuctoria mucronata	Solano grass; Crampton's tuctoria	FE, SE	Yes	Solano-Colusa	2
Listed Animal Species					
Branchinecta conservatio	Conservancy fairy shrimp	FE	Yes	NE Sac, NW Sac, San Joaquin, Solano-Colusa,, SE Sac, So. Sierra Foothills	8
Branchinecta longiantenna	longhorn fairy shrimp	FE	Yes	Carrizo, Livermore, San Joaquin	8
Branchinecta lynchi	vernal pool fairy shrimp	FT	Yes	Carrizo, Central Coast, Klamath Mtn.[5], Livermore, NE Sac, NW Sac, San Joaquin, Solano-Colusa, SE Sac, So. Sierra Foothills, W. Riverside	2c
Elaphrus viridis	delta green ground beetle	FT	Yes	Solano-Colusa	8

I-5

Scientific name	Common name(s)	Status[1]	Critical Habitat Designated?	Vernal Pool Region[2]	Recovery Priority[3]
Lepidurus packardi	vernal pool tadpole shrimp	FE	Yes	NE Sac, NW Sac, San Joaquin, Solano-Colusa, SE Sac, So. Sierra Foothills	2c
Plant Species of Concern					
Astragalus tener var. *ferrisiae*	Ferris' milk vetch	none	-	NE Sac, Solano-Colusa	-
Astragalus tener var. *tener*[4]	alkali milk vetch	none	-	Central Coast, Lake-Napa, Livermore, San Joaquin, Solano-Colusa	-
Atriplex persistens	vernal pool smallscale	none	-	San Joaquin, Solano-Colusa	-
Eryngium spinosepalum	spiny-sepaled button-celery	none	-	So. Sierra Foothills	-
Gratiola heterosepala	Boggs Lake hedge-hyssop	SE	-	Lake-Napa, Modoc Plateau, NE Sac, NW Sac, Solano-Colusa, SE Sac, So. Sierra Foothills	-
Juncus leiospermus var. *ahartii*	Ahart's dwarf rush	none	-	NE Sac, SE Sac	-
Legenere limosa[4]	legenere	none	-	Lake-Napa, NE Sac, NW Sac, Solano-Colusa, SE Sac, So. Sierra Foothills	-
Myosurus minimus var. *apus*	little mousetail	none	-	San Diego, San Joaquin, So. Sierra Foothills, W. Riverside	-
Navarretia myersii ssp. *deminuta*	small pincushion navarretia	none	-	Lake-Napa	-

Scientific name	Common name(s)	Status [1]	Critical Habitat Designated?	Vernal Pool Region[2]	Recovery Priority[3]
Plagiobothrys hystriculus	bearded popcorn flower	none	-	Solano-Colusa	-
Animal Species of Concern					
Branchinecta mesovallensis	midvalley fairy shrimp	none	-	San Joaquin, SE Sac, So. Sierra Foothills	-
Linderiella occidentalis[4]	California fairy shrimp; California linderiella	none	-	Central Coast, NE Sac, Santa Barbara, San Joaquin, SE Sac, So. Sierra Foothills	-
Spea hammondii	western spadefoot toad	none	-	Central Coast, NW Sac, NE Sac, SE Sac, Solano-Colusa, So. Sierra Foothills, San Joaquin, Carrizo, W. Riverside, Santa Barbara, San Diego	-

[1] Status: FE = federally endangered, FT = federally threatened, SE = State endangered, ST = State threatened, SR = State rare

[2] Vernal Pool Regions based on Keeler-Wolf (1998).

NE Sac= northeastern Sacramento Valley
SE Sac= southeastern Sacramento Valley
NW Sac= northwestern Sacramento Valley
So.= southern
W.= western

[3] Recovery Priority: See Appendix D for description of how recovery priority numbers are assigned for listed species.

[4] Species has also been reported to occur in the Santa Rosa vernal pool region described by Keeler-Wolf *et.al*. (1998); however, these populations will be covered in the Draft Santa Rosa Plains Recovery Plan (in development).

[5] Klamath Mtn. Vernal Pool Region not based on Vernal Pool Regions from Keeler-Wolf (1998).

contribute to recovery as possible. As a result, a suite of the actions identified in this recovery plan must occur to achieve recovery. However, while failure to take any particular action in this plan will not in itself preclude recovery of any of the plan's species, the specific importance of one area or action will be dependent on which other activities in the plan are occurring or are likely to occur. Generally speaking, the more activities identified in this plan that are actually achieved, the more likely it is that recovery will take place. Conversely, the fewer actions implemented or areas protected identified in this plan, the less likely it is that recovery will be achieved.

2. Classification of Vernal Pools

a. Vernal Pool Types

The variability of vernal pool types has led many researchers to try to classify these ephemeral habitats (Holland 1986; Sawyer and Keeler-Wolf 1995; Ferren *et al.* 1996; Smith and Verrill 1998). Most of these efforts have focused on classifying vernal pools based on the factors that influence variation in their physical features. Primary physical features that influence vernal pool size, depth, and soil and water chemistry include soil type, geologic formation, and landform. Landforms are physical attributes of the landscape resulting from geomorphological processes such as erosion and deposition, and include features such as alluvial terraces and basins, volcanic mudflows, and lava flows. The types and kinds of species that are found in vernal pools are largely determined by these physical factors (Holland and Griggs 1976; Zedler 1987; Eng et al. 1990; Holland and Dains 1990; Simovich 1998).

Sawyer and Keeler-Wolf (1995) classified vernal pools according to a number of physical, geographic, and biological characteristics. They identified several general vernal pool types, each of which corresponds to the nature of the impermeable layer that underlies a particular vernal pool and influenced the formation of that pool. The vernal pool types were identified as Northern Hardpan, Northern Claypan, Northern Basalt Flow, Northern Volcanic Mudflow, and Northern Ashflow vernal pools.

Northern Hardpan vernal pools are formed on alluvial terraces with silicate-cement soil layers. These pool types are on acidic soils and exhibit well-developed mima mound topography found on the eastern margins of the Central Valley. Northern Claypan vernal pools are formed on impermeable surfaces created by an accumulation of clay particles. These pool types are often found on basin and basin rim landforms and tend to occur in the central portion of the Central Valley and tend to be alkaline. Vernal pools identified as Northern Volcanic Mudflow, Northern Basalt Flow, and Northern Volcanic Ashflow are formed by an impervious bedrock layer of volcanic origin. These pool types are found on the eastern and coastal portions of the Central Valley, and tend to be small and restricted in distribution. Northern Basalt Flow vernal pools occur at greater elevations than other vernal pool types.

The vernal pools in Southern California are associated with several soil series types including but not limited to Huerheuero, Olivenhain, Placentia, Redding, and Stockpen (Bauder and McMillan 1998). These soil types and other vernal pool bearing soils and geologic formations have a nearly impermeable surface or subsurface soil layer with a flat or gently sloping topography (Service 1998). Due to local topography and geology, the pools are usually clustered into pool complexes (Bauder 1986; Holland and Jain 1988). Pools within a complex are typically separated by distances on the order of meters, and may form dense, interconnected mosaics of small pools or a more sparse scattering of larger pools. The pools within the Santa Rosa Plateau in Riverside County, California are the only known locality for the Southern Basalt Flow Vernal Pools.

Other vernal pools and pool complexes are not currently classified, but some of these pools converge on vernal lakes and others are associated with vernal alkali plains (Keeler-Wolf et al. 1998). The vernal pools in the Agate Desert in Southern Oregon are located on alluvial fans capped with a shallow layer of clay loam over cemented hardpan. Other vernal pools within the area include those formed on older basaltic andesite formations such as those found on Table Rock. Vernal pool complexes are characterized by patterned ground with mounds and vernal pools. These pools vary in size from 1 to 30 meters (3 to 100 feet) across, and attain a maximum depth of about 30 centimeters (12 inches) (Oregon Natural Heritage Program 1997). This landform is not true desert as it receives 48 centimeters (19 inches) of precipitation annually. The pools within the area support the vernal pool fairy shrimp and other listed vernal pool species such as the endangered Cook's lomatium (*Lomatium cookii*) and large-flowered woolly meadowfoam (*Limnanthes floccosa* ssp. *grandiflora*) (U.S. Fish and Wildlife Service 2002a).

b. Vernal Pool Regions

At this time, the geographic distribution of the endangered, threatened, and rare vernal pool taxa in this recovery plan can best be represented by the vernal pool regions defined in the California Department of Fish and Game, *California Vernal Pool Assessment Preliminary Report* (Keeler-Wolf *et al.* 1998). Keeler-Wolf *et al.* (1998) defined the vernal pool regions as discrete geographic regions identified largely on the basis of endemic species, with soils and geomorphology as secondary elements, although there is some overlap of these features among vernal pool regions. Overall, these vernal pool regions are representative of the range of biotic and abiotic features for the ecosystem and species covered in this recovery plan.

The California Department of Fish and Game has identified 17 distinct vernal pool regions (Keeler-Wolf *et al.* 1998). These regions include 5 in the Central Valley (Northeastern Sacramento Valley, Northwestern Sacramento Valley, San Joaquin Valley, Solano-Colusa, and Southeastern Sacramento Valley), and 12 regions occurring throughout the remainder of California (Carrizo, Central Coast, Lake-Napa, Livermore, Mendocino, Modoc Plateau, San Diego, Santa Barbara, Santa Rosa, Sierra Valley, Southern Sierra Foothills, and Western Riverside Regions). The Sierra Valley region is not included in this recovery plan as no listed species covered in this document occur there. The Santa Rosa vernal pool region was excluded from this recovery plan because the populations of listed species and species of concern in this region will be covered in the Draft Santa Rosa Plains Recovery Plan, currently in development.

The vernal pool regions described and discussed in this recovery plan correspond closely to those regions defined by the California Department of Fish and Game (Keeler-Wolf *et al.* 1998). Deviation from the boundaries of the California Department of Fish and Game vernal pool regions was necessary in certain instances where recent data from the California Natural Diversity Database (2005) and other sources suggest the inclusion of additional areas based on species occurrences, vernal pool habitat, watershed boundary data, topographic features, Holland (1998) data, and the National Hydrography Dataset. Seven vernal pool regions discussed in this recovery plan have boundaries that differ slightly from the Keeler-Wolf *et al.* (1998) vernal pool region boundaries. Modified regions include Carrizo, Central Coastal, Lake-Napa, Modoc Plateau, Northeastern Sacramento Valley, Solano-Colusa, and Santa Barbara. Specific modifications are described in the discussion of individual vernal pool regions in the Recovery Chapter. Since the Keeler-Wolf *et al.* (1998) vernal pool regions did not include Oregon, one vernal pool region (Klamath Mountains) has been defined for species occurring in that state based on species occurrence data and watershed boundaries.

The species addressed in this recovery plan inhabit 15 of the original 17 vernal pool regions defined by the California Department of Fish and Game (Keeler-Wolf *et al.* 1998) (**Figure I-I**), as well as the Klamath Mountains Vernal Pool Region in Oregon.

3. Factors in the Development of Vernal Pools

The three most important physical factors in the development of vernal pools are climate, soil, and topography. The climate in California and southern Oregon, classified as Mediterranean due to its rainy winters and dry summers, results in the filling and drying of pools during the wet and dry seasons, respectively. Vernal pools form where precipitation and surface runoff become trapped or “perched” above an impermeable or nearly impermeable layer of soil (Smith and Verrill 1998). As previously discussed, Sawyer and Keeler-Wolf (1995) classified

California vernal pools as Northern Hardpan, Northern Claypan, Northern Basalt Flow, Northern Volcanic Mudflow, and Northern Volcanic Ashflow based on the various types of impermeable layers.

A second major factor in the development of vernal pools is soil. Vernal pools form where a soil layer exists below or at the surface that is impermeable or nearly impermeable to water (Smith and Verrill 1998). The northern hardpan layers are formed on alluvial terraces by leaching, redeposition, and cementing of silica minerals from high in the soil profile to a lower ("B") horizon (Smith and Verrill 1998). Northern hardpan vernal pools are on acidic soils and exhibit well-developed rounded soil mounds referred to as mima mound topography, found on the eastern margins of the Central Valley. Northern claypan layers are formed by a similar redeposition process of fine clay particles sometimes augmented by saline or alkaline compounds, being transported to the B horizon where they accumulate and eventually hold water. Northern claypan vernal pools are often found on basin and basin rim landforms and tend to occur in the central portion of the Central Valley. Vernal pools identified as Northern Basalt Flow, Northern Volcanic Mudflow, and Northern Volcanic Ashflow are underlain by an impervious bedrock layer of volcanic origin. These pool types are found on the eastern and coastal portions of the Central Valley, and tend to be small and restricted in distribution. Northern Basalt Flow vernal pools occur at greater elevations than other vernal pool types. Smith and Verrill (1998) list many of the soil series associated with vernal pools in the Central Valley.

The third factor in the development of vernal pools is topography. Landforms, physical attributes of the landscape resulting from geomorphological processes such as erosion and deposition, influence the development of vernal pools. Landforms include such features as alluvial terraces and basin rims, and volcanic mudflows and lava flows. Vernal pools typically occur in landscapes that, at a broad scale, are shallowly sloping or nearly level, but on a fine scale may exhibit extreme topography. From the air, vernal pool landscapes often show characteristic patterning, produced by plant responses to mound and trough micro-relief, and such patterning has allowed detailed mapping of vernal pool habitats throughout California's Central Valley and adjacent areas (Holland 1998).

4. Physical Characteristics of Vernal Pools

Vernal pools vary from 1 square meter (approximately 1 square yard) to 1 hectare (2.5 acres) or more. Some larger vernal features, such as the 36-hectare (90-acre) Olcott Lake in the Jepson Prairie Preserve in Solano County, are also referred to as vernal lakes, playa pools, or lakes. Playa pools or lakes with high alkalinity are termed alkali sinks. These larger features share much of the flora and fauna of smaller pools, including many rare and endangered species included in this recovery plan.

Vernal Pool Regions

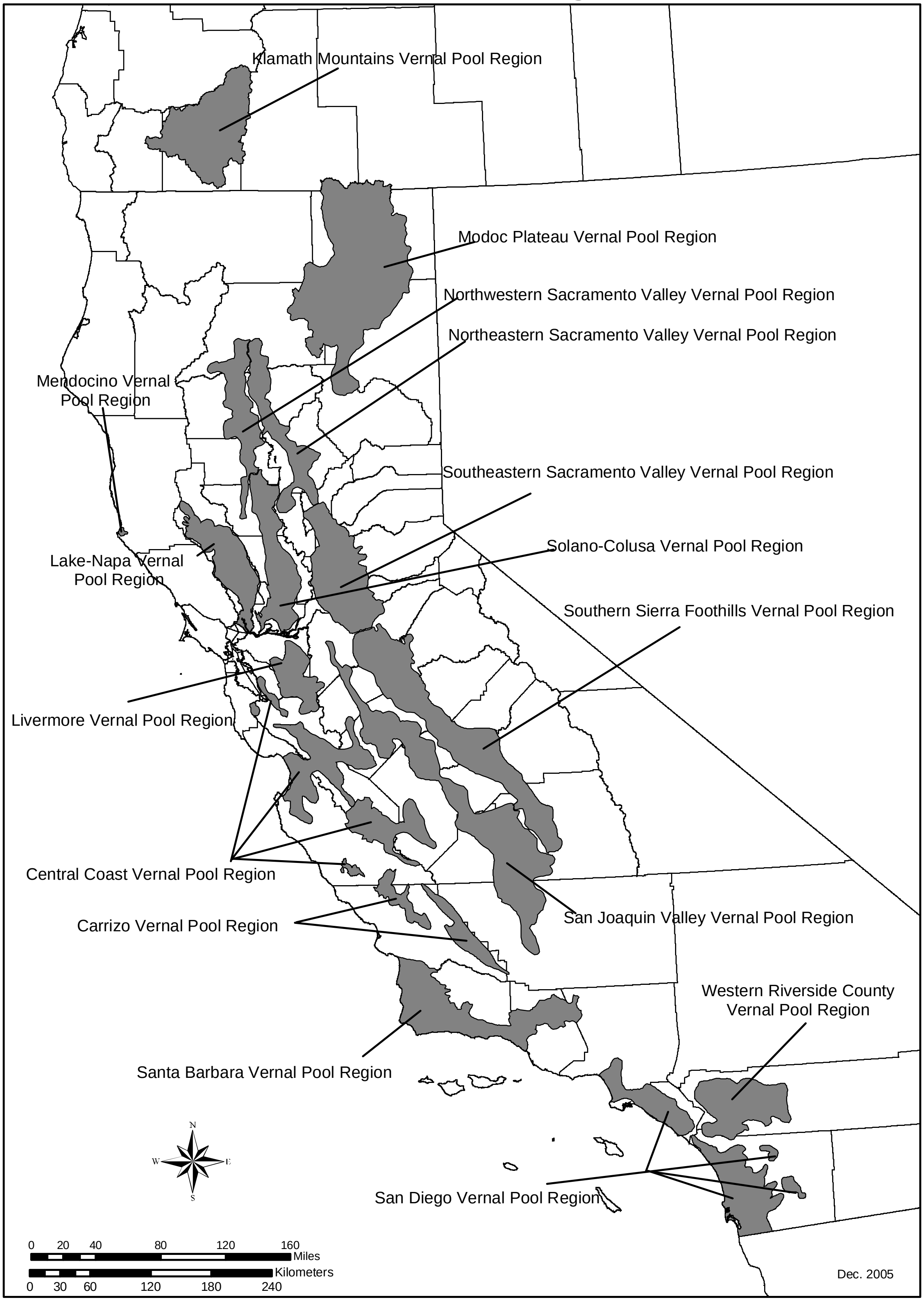

Figure I-1. Map of recovery plan area showing location of vernal pool regions.

Vernal pools in California tend to occur in clusters, called “complexes”, because appropriate combinations of climate, soil, and topography often occur over continuous areas rather than in isolated spots. Landscapes that support vernal pool complexes are typically grasslands with areas of obstructed drainage that form the pools. However, vernal pools also can be found in a variety of other habitats, including oak woodland, desert, and chaparral. The pools may be fed or connected by low drainage pathways called “swales.” Swales often remain saturated for much of the wet season, but are not inundated long enough to develop strong vernal pool characteristics. Trees are relatively rare in vernal pool complexes because of their shallow, seasonally saturated or inundated and sometimes alkaline soils, and their characteristic root-restricting subsurface layer. For the same reasons, vernal pool complexes have historically been considered poor farmland.

California’s vernal pools begin to fill with the winter rains. Before ponding occurs, there is a period during which the soil is wetted and the local water table may rise. Some pools are primarily fed by the surrounding watershed; others may fill almost entirely from rain falling directly into the pool (Hanes and Stromberg 1998). Although exceptions are not uncommon, the watershed generally contributes more to the filling of larger or deeper pools, especially playa pools. Even in pools filled primarily by direct precipitation, Hanes and Stromberg (1998) report that subsurface inflows from surrounding soils can help to damp water level fluctuations during late winter and early spring.

Both the amount and timing of winter and spring rainfall in California vary greatly from year to year. For this reason and others, pools may fill to different extents at different times. The duration of ponding of vernal pools also varies, and in some years certain pools may not fill at all. A recent study found evidence of droughts in California, as recently as medieval times, that far exceeded in duration and severity anything experienced since the arrival of Europeans (Stine 1994). Many characteristics of vernal pool plants and animals are dynamic adaptations to the highly variable and unpredictable nature of vernal pool environments.

The chemical characteristics of California vernal pools are diverse. The pH has been observed to vary between 6 and 10 in a southern California vernal pool (Keeley and Zedler 1998). Dissolved carbon dioxide can approach zero. Such conditions may limit photosynthetic production in the pools (Keeley 1990). Seasonal variation also is a factor in the diversity of vernal pool water chemistry (Helm 1998).

5. Vernal Pool Communities

The physical characteristics of vernal pools, as described above, influence the type of species found and their life history characteristics, such as the speed with which a species can mature and reproduce, the amount of soil moisture required for germination of plant seeds or hatching of invertebrate eggs or cysts, as well as tolerance to turbidity, total dissolved solids, and other aspects of vernal pool water chemistry (Holland and Griggs 1976, Zedler 1987, Eng *et al.* 1990, Holland and Dains 1990, Simovich 1998).

Many California vernal pool species are endemic, or found nowhere else in the world. In addition, while most of California's grasslands are now dominated by nonnative grasses and other introduced plants, accounting for a third of the species and more than 90 percent of the biomass in a California grassland, many vernal pools remain dominated primarily by native species. Seventy-five to 95 percent of plant species found in most undegraded vernal pools are native, and natives dominate in biomass as well as in number (Holland and Jain 1988, Jokerst 1990, Spencer and Rieseberg 1998). Vernal pool communities dominated by natives persist even while surrounded by grassland composed of nonnative vegetation. Vernal pool plant communities are able to resist invasion of nonnative plants in the portion of the pool that experiences prolonged inundation, where plants are severely constrained by environmental conditions with which nonnative plants have not evolved. However, when exotic grasses in the uplands are ungrazed for several years, vernal pool margin and swale natives experience microhabitat conversion due primarily to shading from the build-up of thatch. The grass thatch inhibits the germination of native annuals, but has little if any retarding effect on the germination and growth of exotic grasses. Results from an on-going California Department of Fish and Game study show that thatch depth is negatively correlated with frequency and percent cover of native forb species (M. McCrary, pers. comm. 2004).

Plants. Almost all California vernal pool plants are annuals, which means they grow, set seed, and die in a single growing season. The annual life cycle is an adaptation to the short growth period during the pool's drying phase and to extreme year-to-year variation in rainfall (Stone 1990, Zedler 1990). Many vernal pool plants germinate during the wetting phase or under water. Among some plants that can grow under water, many show underwater morphology distinct from parts of the same plant growing above water.

Many vernal pool plants exhibit unique adaptations to limit seed dispersal, as their seeds are unlikely to succeed in adjacent upland areas. Commonly, fruits and seeds are simply retained in the dried inflorescence (flowers). Some flowers are below the soil surface, with long styles (female organs) that reach above ground for fertilization, while the fruits and seeds remain below ground. In others, the peduncles (stems supporting the flowers and fruits) lengthen and push the fruit and seeds into the soil (Zedler 1990).

One of the most dramatic adaptations of vernal pool plants to their unique environment is their ability to remain dormant as a seed for years or even decades. While dormant, these tiny propagules must resist extreme heat and drought, repeated wetting and drying, and be able to re-activate their metabolism and life cycle when conditions are appropriate. The cues they use to emerge from dormancy are poorly understood. Studies and models of other seed banks in highly variable environments suggest that dormancy is a strategy to spread offspring across many years. In this way, not all seeds are lost in a climatically unfavorable year and at least some encounter more favorable conditions in future years.

Animals. Vernal pool animal communities also contain unique species. The most visible crustaceans in vernal pools are the large branchiopods (literally, "gill-foots"), comprising about 25 species in California of which approximately 8 species are endemic (King *et al*. 1996, Eriksen and Belk 1999) and 6 are federally listed as threatened or endangered. The federally-listed vernal pool shrimp found in southern California, Riverside fairy shrimp (*Streptocephalus woottoni*) and San Diego fairy shrimp (*Branchinecta sandiegonensis*), are covered in the Vernal Pools of Southern California Recovery Plan (U.S. Fish and Wildlife Service 1998a).

These branchiopod crustaceans all have life cycles adapted to the ephemeral and variable nature of vernal pools. Many are capable of producing cysts or eggs that can tolerate extreme and prolonged drying and high temperatures. Like the seeds of vernal pool plants, the cysts lie dormant in the soil, sometimes for many years (Belk 1998), until some poorly understood combination of environmental cues or an internal clock trigger them to hatch and begin the life cycle again. Some vernal pool crustacean species undergo more than one generation in a single wet season. Often eggs produced early in the season are of a different form, adapted to rapid development and hatching, and incapable of entering a resistant phase. Eggs produced later in the season may have the ability to lie dormant, if necessary. Species may reproduce sexually and/or parthenogenetically (when females reproduce clonally).

Amphibians and many insect species also live in vernal pools and the surrounding upland habitat, including two rarer amphibians native to vernal pools, the California tiger salamander (*Ambystoma californiense*) and the western spadefoot toad (*Spea hammondii*) (Morey 1998). The California tiger salamander, which co-occurs with some of the species in this plan, will be covered in the Draft Santa

Rosa Plains Recovery Plan (in development), and in the Draft Central Valley California Tiger Salamander Recovery Plan (to be developed).

The insect fauna of vernal pools is numerous, varied, and primarily native, including aquatic beetles (Coleoptera: Dytiscidae, Hydrophilidae, Gyrinidae, Halipidae, Hydraenidae), aquatic bugs, including backswimmers (Hemiptera: Notonectidae), water boatmen (Corixidae), and water striders (Gerridae), springtails (Collembola), mayflies (Ephemeroptera), dragonflies and damselflies (Odonata), and various flies with aquatic larvae, including midges (Diptera: Chironomidae), crane flies (Tipulidae) and mosquitoes (Culicidae), to name a few.

The plants and animals of vernal pools are important providers of food and habitat for waterfowl, shorebirds, and other species (Silveira 1998). Vernal pool complexes contribute to the continuity of wetland habitats along the Pacific Flyway. Ducks feed on vernal pool crustaceans and other invertebrates, which are sources of protein and calcium needed for migration and egg production. Cliff swallows (*Petrochelidon pyrrhonota*) glean mud from vernal pool beds for their nests, lesser nighthawks (*Chordeiles acutipennis*) nest in dry vernal pool beds, burrowing owl (*Athene cunicularia*) and pocket gopher (*Thomomys* spp.) burrows are found in mima mounds, and many species graze or hunt along vernal pool shorelines. Before their populations declined, elk (*Cervus elaphus*) and pronghorn antelope (*Antilocapra americana*) undoubtedly grazed vernal pool landscapes. Today, most grazing on vernal pools is done by domestic ungulates.

Certain species appearing to live outside the vernal pool community are nonetheless essential to it. For example, many vernal pool plants rely on insect pollinators, which do not reside in the pools themselves. Many native pollinators of vernal pool plants are solitary bees that make their individual nests in holes in the ground of the grasslands surrounding the pools (Thorp and Leong 1998). California ground squirrel (*Spermophilus beecheyi*) burrows provide summer refuges for adult and juvenile California tiger salamanders. Upland plant communities around vernal pools regulate runoff, remove nutrients, and filter out sediment. Grazers may have important and sometimes complex effects on vernal pool plant communities, as well as on thatch accumulation, nutrient levels, and physical disturbance.

6. Major Threats to Vernal Pool Species

Habitat loss and fragmentation is the largest threat to the survival and recovery of the listed species and species of concern addressed in this recovery plan. Habitat loss generally is a result of urbanization, agricultural conversion, and mining. Habitat loss also occurs in the form of habitat alteration and degradation as a result of changes to natural hydrology; invasive species; incompatible grazing regimes, including insufficient grazing for prolonged periods; infrastructure projects (*e.g*., roads, water storage and conveyance, utilities); recreational activities (*e.g.*, off-highway vehicles and hiking); erosion; climatic and environmental change; and contamination.

Habitat fragmentation generally is a result of activities associated with habitat loss (*e.g.*, roads and other infrastructure projects that contribute to the isolation and fragmentation of vernal pool habitats). The loss, fragmentation and isolation of functional vernal pool ecosystems has threatened the continued existence of the listed species and species of concern addressed in this recovery plan. Most species addressed in this recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These threats are discussed in greater detail below.

Historic habitat loss and fragmentation. Beginning around the mid-1800's, the primary threat to vernal pools was conversion to agriculture and water conveyance and storage projects (Frayer *et al.* 1989, Kreissman 1991). Holland (1998) estimated that almost three-quarters of vernal pool habitats in the Central Valley of California had been lost by 1997. Suitable habitat for vernal pool species occurring in the Central Valley has declined dramatically over the past century, and pressure to develop remaining lands in the Central Valley is increasing rapidly. Loss of habitat has been even more extensive in areas outside of the Central Valley. Along the Central California coast, at least 90 percent of historic vernal pools have been destroyed, and most remaining vernal pools have been degraded (Ferren and Pritchett 1988). In southern California, estimated loss of vernal pool habitat ranges from 95 to nearly 100 percent (Bauder 1987, Oberbauer 1990, Zedler 1990, Bauder and McMillan 1998). In the Agate Desert area of Oregon, 60 percent of vernal pool habitats have been destroyed, and only 18 percent of the remaining habitats are considered intact (Oregon Natural Heritage Program 1997; Borgias and Patterson 1999).

Current habitat loss and fragmentation. California has both the highest absolute and fastest relative human population growth in the United States. California's population is predicted to grow by almost 18 million by the year 2025, an increase of over 50 percent, the highest of any state in the nation (U.S. Census Bureau 1996). Approximately 73 percent of the land within the Central Valley is privately owned, and in areas containing vernal pool habitats, only 6 percent of the land area is in public ownership (California Department of Fish and Game 1998). According to the 1997 National Resources Inventory (U.S. Department of Agriculture 2000), California ranked sixth in the nation in amount of non-Federal land developed between 1992 and 1997, at over 221,200 hectares

(546,700 acres). This predicted population growth will continue to threaten vernal pool habitats, most of which are located on private land.

Conversion of vernal pool habitats to intensive agricultural uses continues to contribute to the decline of vernal pools. From 1992 to 1998, 50,825 hectares (125,591 acres) of grazing land were converted to other agricultural uses in the Central Valley of California. It is likely that much of this land supported vernal pools. Holland estimated that more than 12,950 hectares (32,000 acres) of vernal pool habitats had been lost in the San Joaquin Valley vernal pool region from the late 1980's until 1997, mostly as a result of agricultural conversion. Through section 7 of the Endangered Species Act, our Sacramento Fish and Wildlife Office has reviewed projects converting more than 6,070 hectares (15,000 acres) of vernal pool habitats to intensive agricultural uses since 1994.

In more recent years, vernal pool habitats have been lost primarily as a result of widespread urbanization. Since 1994, the Sacramento Fish and Wildlife Office has conducted section 7 consultation on impacts to almost 20,250 hectares (50,000 acres) of vernal pool habitats across California. Over half of this loss of habitat, 10,125 hectares (25,000 acres), was the result of residential, commercial, and industrial development projects. The construction of infrastructure associated with urbanization also has contributed greatly to the loss and fragmentation of vernal pool plant and crustacean populations, including the construction of highways, wastewater treatment plants, sewer lines, water supply projects, and other utility projects. Some of these impacts to vernal pool habitat have been offset, in part, by compensation which includes the preservation and long-term management of vernal pool habitat for the benefit of the listed species as terms and conditions of section 7 consultations.

Mining activities, particularly gravel and clay mining needed to support development of roads and other urban infrastructure, has destroyed vernal pools and degraded surrounding vernal pool complexes in many areas. It is currently unknown how much habitat loss is attributable to mining activities.

Effects of habitat fragmentation, alteration, and degradation. Direct losses of habitat, as discussed above, generally represent irreversible damage to vernal pools. Alteration and destruction of the habitat as a result of urbanization, agriculture, and mining often disrupts the physical processes conducive to functional vernal pool ecosystems. The more severe the alteration and destruction, the more difficult it is to recover such areas in the future due to disruption of soil formations, hydrology, seed banks, and other components of a functional vernal pool ecosystem.

Agricultural conversion and urbanization, as well as the construction of infrastructure including the construction of new highways, wastewater treatment plants, sewer lines, water supply projects, wind energy development projects, and other utility projects, have also contributed greatly to the destruction and fragmentation of vernal pool habitat. Habitat loss exacerbates the highly fragmented distribution of many of the listed species and species of concern addressed in this recovery plan, increases the vulnerability of adjacent populations of such species to random environmental events, and further disrupts gene flow patterns between populations of such species. Habitat fragmentation, alteration, and degradation may effectively serve as a barrier to dispersal for some species and may bisect the range of such species locally. Although genetic evidence suggests movement between historically disjunct vernal pool complexes was probably low (Hebert 1974, Havel *et al.* 1990, Boileau and Hebert 1991, Fugate 1992, King 1996, Davies *et al.* 1997), current fragmentation of originally intact vernal pool complexes could contribute significantly to the loss of genetic diversity among vernal pool plants and crustaceans, and reduce the likelihood of recolonization events following local population extinctions (Fugate 1998). Some additional effects of fragmentation on vernal pool crustaceans may be indirect, through their effect on an associated species. For example, the fragmentation of vernal pool habitats may decrease habitat suitability for avian species, resulting in decreased use of the smaller, isolated patches, especially those adjacent to incompatible land uses (J. Silveira, pers. comm. 2004). Such an effect on birds can have consequences on the genetic stability of populations of listed branchiopods because avian species are dispersal agents for the vernal pool crustaceans (Proctor 1964, Krapu 1974, Swanson *et al.* 1974, Driver 1981, Ahl 1991).

No information exists regarding the minimum area of land (wetlands and uplands) needed to sustain viable populations of the listed species or species of concern addressed in this recovery plan. Generally speaking, as populations become isolated and/or smaller such patches have a higher propensity towards localized extinction events. Effective management regimes also become difficult and expensive to implement on isolated and/or small patches. Limiting the size of a preserved area or preserving an area geographically isolated from other preserves could preclude the long-term conservation of the species. To alleviate threats from isolated or small populations, measures must be taken to ensure functions and processes occur that favor sustainable populations and associations of listed species and species of concern covered by this recovery plan, including pollinators for plants. Minor fragmentation of vernal pool habitats may effectively serve as a seed, pollen, and pollinator dispersal barrier between adjacent sites for many of the plants covered by this recovery plan. Habitat fragmentation will also lead to reduced gene flow between populations and a potential for loss of genetic variation within populations and greater susceptibility to disease and mortality due to stochastic events (G. Platenkamp *in litt*. 2005).

<u>Altered hydrology</u>. In addition to direct habitat loss, vernal pool crustacean and plant populations have declined because of a variety of activities that render existing vernal pools unsuitable for the species. Vernal pool hydrology can be altered directly when swale systems connected to vernal pools are dammed by physical barriers, such as roads and canals. These barriers can alter vernal pool hydrology both upstream and downstream of the barrier by truncating connectivity and flow. Vernal pool hydrology also may be altered by changes to patterns of surface and subsurface flow, depending on topography, precipitation, and soil types (Hanes *et al*. 1990, Hanes and Stromberg 1998). The increased runoff and nuisance flows associated with urban development and impervious surfaces may result in altered hydrology of seasonal wetlands on and off-site. For example, stormwater drains, or the coverage of land surfaces with concrete, asphalt, or irrigated lawns, can alter the duration, volume discharge and frequency of surface flows through increased flooding and runoff.

Vernal pool hydrology also may be altered by excluding livestock and/or changing the grazing intensity and/or season of use. Grazing animals may help to maintain appropriate inundation periods by limiting vegetation accumulation and by sustaining soil conditions that create favorable vernal pool habitat (Barry 1995). A significant amount of vegetation can grow around the edges of vernal pools on sites excluded from grazing. Standing dry or dead vegetation may reduce runoff by increasing net rain loss due to interception and direct evaporation. Accumulation of dry matter around a vernal pool can affect the length of inundation, especially in a low rainfall year (Barry 1998). The removal of cattle grazing from historically grazed grasslands has been found to dramatically decrease the inundation period of vernal pools (Marty 2004). The changes in vernal pool hydrology that occur from livestock exclusion are interrelated with the invasion of nonnative annual species. The percentage of nonnative vegetation in a vernal pool is closely tied to length of inundation (Bauder 1987).

The timing, frequency, and duration of inundation are critical to the survival of vernal pool species. Alterations of the hydrology can be particularly harmful to vernal pool crustaceans and the western spadefoot toad due to premature pool dry-down before the life cycles of the species are completed, preventing reproduction and disrupting gene flow. Flowing water that artificially removes plants and animals, including cysts, eggs or seeds, from the vernal pool complex also can prevent successful reproduction and disrupt gene flow. Water flow into vernal pools during the summer can significantly alter vernal pool species composition (Clark *et al.* 1998). Longer periods of inundation and/or changes in water depth could effectively change seasonal wetland functions (*e.g.*, change from vernal pool to perennial/permanent wetlands) and floral composition (*e.g.*, community changes from annual herbs to emergent macrophytes), which in turn may lead to the extirpation of some vernal pool plants. Longer periods of inundation may result in damage to the seed bank by facilitating seed rot, triggering unseasonable germination, or other effects. With respect to animals, a more permanent aquatic community may provide suitable habitat for introduced bullfrogs (*Rana catesbeiana*) and fish. These species are significant predators of vernal pool fairy shrimp and other vernal pool crustaceans (Bauder 1987).

Other causes of altered hydrology include impoundments such as reservoirs, stockponds, and other more permanent pools, which may decrease the period of inundation of a vernal pool complex. The construction of water conveyance systems (*e.g.*, canals) for irrigation, flood control, and other purposes through vernal pool habitats can dewater vernal pools via conduction of surface and subsurface flows into the canal. In addition to these causes of dewatering, encroachment of exotic grasses and the build-up of a thatch layer on pool margins and throughout vernal swales is an additional factor that decreases the hydroperiod (Marty 2004).

Runoff from irrigated agricultural lands also can alter the hydrology of adjacent vernal pools and also can contribute to erosion, siltation, and contaminant loads. In some areas, the alteration of hydrology, often in combination with specific land use practices, has caused downcutting of sloughs and swales, thus threatening the stability and functions of adjacent vernal pools. Any ground-disturbing activities, such as plowing, trenching, grading, deep-ripping, scraping, off-road vehicles, inappropriate management of livestock grazing, or other activities, adjacent to or within the watersheds of vernal pools can result in siltation when pools fill during the following wet season. Siltation is particularly likely in areas where high, disturbed slopes rise above the level of the vernal pools. Poorly designed trail and road systems near vernal pools may also cause erosion and result in siltation of vernal pools. Vernal pool crustaceans and larval amphibians may suffocate in pools with high degrees of siltation and turbidity due to their respiration through gills or gill-like organs. Siltation also may result in the burial and/or asphyxiation of eggs and cysts. Similarly, plants may not be able to germinate if too much siltation occurs.

Invasive Species. Although not all non-native species are harmful, those that outcompete native species or alter functioning of established ecosystems are usually considered invasive and undesirable. When invasive, nonnative species enter an ecosystem they can disrupt the natural balance resulting in reduction of biodiversity, degradation of habitats, alteration of native genetic diversity, and further threats to already endangered plants and animals (U.S. Environmental

Protection Agency 2005). The introduction of invasive species occurs through a variety of methods such as escape of plants used for ornamental gardening, agriculture, or erosion control, and dispersal via wind, water, animals, motor vehicles, cargo containers and dumping of ship ballasts.

Vernal pool plant species have declined due to the introduction of invasive, nonnative plant and animal species. Several factors contribute to the decline, including competition with invading plant species for nutrients, light, and water. Disturbance regimes that are not natural to the area may support invasive species distribution. Such disturbance includes urbanization, agricultural activities (Hannah *et al.* 1994 as cited in Stylinski and Allen 1999), as well as altered fire and grazing frequency (Stylinski and Allen 1999). The western states, California in particular, have been subject to these disturbances including aggregate mining and deep-ripping of the soil for vineyard development, which open the way for many exotic species to become established and reduce the species diversity within an area.

Invasive species are considered to be a threat to many of the vernal pool species covered by this plan. For example, two invasive species, *Lepidium latifolium* (perennial pepperweed) and *Crypsis schoenoides* (swamp grass), have invaded vernal pool habitat formerly occupied by *Tuctoria mucronata* and *Astragalus tener* var. *tener*, species that are addressed in this plan. These invasive plants have become a catalyst for an eradication plan in the Sacramento Valley region (Niall McCarten, Environmental Science Associates, CALFED report, August 2005).

Mosquitofish (*Gambusia affinis*), a small fish native to southeastern United States, are commonly stocked in permanent or temporary waters for mosquito control. Leyse *et al.* (2004) found that mosquitofish frequently prefer the California fairy shrimp (*Linderiella occidentalis*), one of the species addressed in this plan, to alternative prey including mosquito larvae. The listed fairy shrimp in this plan are similar in size to the California fairy shrimp, and occupy vernal pool habitat that may be stocked by mosquitofish. Therefore, mosquitofish may be a threat to the fairy shrimp species in this plan.

Contaminants. Vernal pool plant and crustacean populations also have declined as a result of water contamination. Vernal pool crustaceans are highly sensitive to the chemistry of their vernal pool habitats (Belk 1977, Eng *et al.* 1990, Gonzalez *et al.* 1996). Use of herbicides, fertilizers, and other chemicals are common in urban and agricultural settings. Although there is a general lack of specific studies to assess effects of herbicides, fertilizers, and other chemicals on vernal pool species, such chemicals could have detrimental impacts on these species if such chemicals reach seasonal wetlands via storm or nuisance sheet flow.

Specifically, herbicides may completely inhibit growth of listed plant species and plant species of concern. Contamination of vernal pools from adjacent areas may injure or kill vernal pool crustaceans and plants either directly or indirectly via pathways including the alteration of chemical properties of a pool (*e.g.*, pH) and inhibiting and/or disrupting biochemical processes creating less suitable conditions for reproduction or germination and growth. Toxic chemicals, such as petroleum products, pesticides, herbicides, fertilizers and detergents, may wash into vernal pools during the course of activities on adjacent areas. Certain chemicals are not registered to be used in or near aquatic settings due to their toxicities to aquatic organisms. Use of such chemicals in nearby areas may result in drift or runoff into vernal pools. The specific effects of such contamination are difficult to ascertain unless an accurate assessment can be made regarding the assimilation rate, or rate of decay, of such chemicals in route to the vernal pool. Vernal pools adjacent to existing developments may be contaminated from roadway contaminants in surface runoff (*e.g.*, grease, oil, and heavy metals). Pesticides used for mosquito abatement may also kill or injure fairy shrimp. Methoprene, a growth hormone contained in the pesticide Altocid, can result in delay of development of adult shrimp which may reduce the number of resting eggs (cysts) that are formed before the pools dry (Lawrenz 1984). Pesticide applications for combating West Nile virus, a disease transmitted by infected mosquitoes, may also affect fairy shrimp. In 2005, the Sacramento/Yolo Mosquito and Vector Control District conducted pesticide spraying (ground and aerial) throughout portions of Sacramento County to control and reduce the mosquito population. The ingredients in the pesticide included pyrethrins and piperonyl butoxide, which have high toxicity to fish, should not be applied directly to water, and may affect adjacent aquatic sites through drift. It is possible that this spraying may have had adverse effects on vernal pool species.

Contamination also may result from increased discharge of contaminants such as fertilizers, herbicides, and pesticides into surface waters from golf courses, irrigated agricultural lands, or landscaped residential areas (Petrovich 1990). Fertilizer contamination can lead to the eutrophication of vernal pools, which can kill vernal pool crustaceans by reducing the concentration of dissolved oxygen (Rogers 1998). Fertilizers may benefit the growth of invasive plants and could effectively lead to localized extirpation of listed plant and animal species and species of concern addressed in this recovery plan resulting from *competition*, thatch buildup, and effects of eutrophication.

Human waste, recreational use, and vandalism. As vernal pool habitats become increasingly rare and urban development expands, threats from disposal of waste, off-road vehicle use, and vandalism increase. People often dump unwanted items such as trash, tires, and appliances in vernal pool areas. Not only can these items release toxic substances into the environment and contaminate water and soil (Ripley *et al.* 2004), but they can directly affect species by crushing them (Hathaway *et al.* 1996) and restricting photosynthesis in plants by shielding the sun. Waste material also may disrupt the natural hydrologic flow.

Certain recreational activities threaten vernal pool ecosystems. Many of the vernal pool species in this recovery plan, particularly plants, are adversely affected by off-road vehicle use, hiking, and bicycling. When off-road vehicles and bicycles cut through vernal pool complexes, they may impair hydrological functions by displacing soil causing erosion or truncating swale connectivity, thus resulting in hydrological changes. Similarly, some off-road enthusiasts, bicyclists, *etc.* may create dirt jump ramps, which also could result in the aforementioned effects. Additionally these activities may result in burial of seeds and cysts of plants and animals so they have decreased viability. Plants and animals may be crushed and killed as a result of careless site users. Trampling also may reduce the reproductive output of vernal pool species. Recreational users also may introduce, or facilitate spread of, seeds of invasive plants that could be attached to vehicles, tires, or shoes and clothing. Germination of these seeds may result in competition with vernal pool plants and could further change the vegetative composition of the landscape. Vandals on off-road vehicles have cut down wire fences around vernal pool complexes to gain access to the land. Compaction of soils as a result of unregulated recreational use could reduce germination of seeds.

Loss of pollinator species. A potential threat to vernal pool plants is the decline of essential pollinators due to habitat fragmentation and the loss of upland habitat that supports pollinator species. Habitat loss and degradation interferes with reproduction and dispersal of pollinators. Pollinators for most vernal pool plant species have not been identified, so the status of their habitat cannot be assessed. It is likely that many of these pollinators require the uplands surrounding vernal pools for completion of their life cycle. For insect pollinated plants, the reduction of available habitat for pollinators could decrease pollinator populations, which could reduce reproductive success of the plants. Similarly, many of these pollinators (*e.g.*, andrenid bees) do not disperse great distances (Davis 1998, Leong 1994, Thorp and Leong 1995), so removal or modification of available vernal pool and upland habitat (*e.g.*, through urban development or the accretion of a dense thatch layer preventing access to burrowing sites) could minimize their ability to reproduce and disperse. If pollinators are unable to disperse, or habitat loss causes a reduction in pollinator populations, then it is likely genetic variability and reproductive success of insect pollinated plant species would be reduced, thus affecting the long-term viability of the taxon. Diminished reproductive success could lead to reduced numbers and susceptibility to extinction.

Inappropriate livestock grazing. Livestock grazing has three primary effects on vernal pools: consumption of vegetation, trampling, and nutrient input from urine and feces (Vollmar 2002). Inappropriate management of grazing, from overgrazing, undergrazing, or inappropriately-timed grazing, can result in significant adverse effects to vernal pool ecosystems. Physical trampling by livestock seriously can affect the viability of a species, especially if the species is restricted to a small area or if grazing occurs during sensitive parts of the growing season, such as during periods when the plants bloom or set seed. Research indicates that the perceived need for some amount of ecosystem disturbance should not be interpreted as an invitation to indiscriminately graze vernal pool landscapes. Because vernal pool species exhibit a variety of life history strategies, grazing regimes must take these needs into consideration. Grazing inappropriately for target species may result in problems comparable or greater than those encountered by exclusion of grazing (Vollmar 2002). Without grazing or fire to remove the competition of invasive annuals, the native species may set fewer seed, or add fewer seeds to the seedbanks than were removed through germination or other factors. Additionally, in areas that have been grazed for decades, grazing may be serving a role in controlling populations of nonnative annual plant species and maintaining appropriate inundation periods. Therefore a moderate grazing program (moderate in both stocking rates and length of grazing period) in areas which have been grazed historically, may be preferable to no grazing, especially where burning is impractical. Moderation in grazing lessens the potential to do damage while monitoring information is being gathered and the grazing regime is adapted and improved.

Climate and environmental change. Habitat alteration may result from global climate and environmental changes including nitrogen deposition, increase in atmospheric carbon dioxide, changes in precipitation patterns, and global warming. On a local scale, these changes may result in altering current vernal pool habitat to be more suitable to nonnative species and less suitable for native species. Thus native species could be out-competed resulting in changes to the species' ranges (Dukes and Mooney 1999). Climate and landscape ultimately define a species' range and conditions for growth and survival (Sutherst 2000). Species having larger ranges with individuals in the centers of those ranges will have the greatest chance for survival (Sutherst 2000). The vernal pool regions and core areas in this plan have been selected to include the current known habitat for these species; however, planning for such global changes is complex and beyond the scope of this plan. Should the California and Oregon climate become less hospitable to these species where they currently exist, it may be possible that new areas of suitable habitat would eventually evolve. It is also possible that protecting large blocks of vernal pool habitat, may help moderate the impacts of widespread changes by providing refugia and corridors to new habitat. Future management of preserves may also need to consider management options that respond to new moisture patterns (Peters 1988).

<u>Inappropriate management and monitoring</u>. Although many vernal pool habitats occur within protected areas, inappropriate management and monitoring of these areas poses a considerable threat to the recovery and conservation of vernal pool species and habitats. Examples of inappropriate management include complete elimination of grazing in areas where exotic grasses dominate the uplands and inappropriate timing or intensity of grazing. In addition, inappropriate management actions such as mowing and burning at an inappropriate season may result in deleterious effects to listed species and species of concern discussed in this recovery plan. Management and monitoring plans which do not include an adaptive management approach and do not facilitate natural processes and functions (*e.g.*, appropriate grazing and fire regimes) may not result in positive actions leading to the recovery and conservation of species discussed in this recovery plan. Inappropriate monitoring, although not a direct threat to the species, may limit the ability to determine population trends and recovery needs. Similarly, lack of funding to implement management and monitoring activities may contribute to a decline of habitat conditions and species baseline.

<u>Random, naturally occurring events</u>. Vernal pool plants and crustaceans existing in small habitat patches are vulnerable to random environmental fluctuations or variation (stochasticity) due to annual weather patterns and availability of food and other environmental factors superimposed on cumulative threats to the ecosystem. The populations of many vernal pool species are isolated from other populations and are distributed in discontinuous vernal pool systems. Such populations are vulnerable to stochastic extinction. The breeding of closely related individuals may cause genetic problems in small populations of crustaceans, particularly in the expression of deleterious genes (known as inbreeding depression). Individuals and populations possessing deleterious genetic material are less able to withstand environmental changes, even relatively minor ones.

<u>Overutilization</u>. For some species covered by this recovery plan overutilization represents a threat to their recovery and long-term conservation. Showy or unique species (*e.g.*, delta green ground beetle) are known to be popular with collectors. Although authorized collection of voucher specimens can be regulated, the illegal collection of organisms may surpass sustainable harvest with respect to recruitment.

<u>Disease</u>. Diseases and pathogens specific to vernal pool species are generally unknown. Vernal pool tadpole shrimp are known to be parasitized by flukes (Trematoda) of an undetermined species, which reduce the gonads of both sexes (Ahl 1991). It is likely that other diseases and pathogens are/or could be present in vernal pools. Chytrid fungus (*Batrachochytrium dendrobatidis*) is known to contribute to amphibian declines, and could be spread via infected organisms or contaminated equipment. Diseases and parasitic threats may range from benign to fatal. The vectors and biochemical pathways associated with spread and infection should be considered in order to adequately minimize the threats posed by diseases and pathogens.

<u>Inadequate regulatory mechanisms</u>. Current regulatory mechanisms are in place, however, they are not always fully implemented, enforced, or adequate to protect vernal pool habitats to the point that species addressed in the recovery plan can be fully recovered. The Endangered Species Act is the primary Federal law providing protection for the listed vernal pool species covered in the recovery plan. Since listing, many projects with the potential to destroy, degrade, or fragment vernal pool habitat have undergone consultation pursuant to section 7(a)(2) of the Endangered Species Act. Section 7(a)(2) requires Federal agencies to consult with us prior to authorizing, funding, or carrying out activities that may affect listed species (50 CFR part 402). The Endangered Species Act also provides additional protection for vernal pool species through section 7(a)(1) and section 10(a)(1)(B). Section 7(a)(1) mandates that Federal agencies use their authorities to further the purposes of the Endangered Species Act. Section 10(a)(1)(B) is a mechanism to permit the taking of listed species by persons without a nexus for section 7(a)(2).

Sections 401 and 404 of the Clean Water Act are additional regulatory mechanisms that provide some protection for vernal pool species covered in the recovery plan. Section 401 establishes procedures and requirements to ensure water quality. This section of the Clean Water Act is administered by the State Water Quality Control Board and applicants must have a section 401 permit before they can receive a section 404 permit.

Section 404 permits are issued by the U.S. Army Corps of Engineers. These permits are issued for the discharge of dredged or fill materials into navigable waters of the U.S. Not all vernal pools are subject to the U.S. Army Corps of Engineers; therefore, this regulatory mechanism is inadequate to protect all vernal pool habitat. State and local laws and regulations have not been passed to adequately protect these species. Additionally, inadequate regulatory mechanisms such as the California Environmental Quality Act and other sections of the Clean Water Act have failed to conserve suitable amounts of habitat for vernal pool species. This lost habitat includes the substantial amount of vernal pool habitat being converted for human uses in spite of Federal regulations implemented to protect wetlands. Considering the framework of existing regulatory mechanisms, government agencies must ensure their regulations and policies are being implemented appropriately in order to reduce threats from inconsistent application of regulations and policies.

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