Vernal Pool Tadpole Shrimp
(Lepidurus packardi)

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
Sacramento Fish and Wildlife Office
Sacramento, California

September 2007

5-YEAR REVIEW
Vernal pool tadpole shrimp (*Lepidurus packardi*)

I. GENERAL INFORMATION

I.A. Methodology used to complete the review:

This review was prepared by the Sacramento Fish and Wildlife Office (SFWO) of the U.S. Fish and Wildlife Service (Service) using information from the 2005 *Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon* (Recovery Plan) (Service 2005a), species survey and monitoring reports, peer-reviewed journal articles, documents generated as part of Endangered Species Act (Act) section 7 consultations and section 10 coordination, Federal Register notices, the California Natural Diversity Database (CNDDB) maintained by the California Department of Fish and Game (CDFG), and species experts who have been monitoring various occurrences of this species. We also considered information from a Service-contracted report. The Recovery Plan and personal communications with experts were our primary sources of information used to update the "species status" and "threats" sections of this review.

I.B. Contacts

Lead Regional or Headquarters Office – Diane Elam, Deputy Division Chief for Listing, Recovery, and Habitat Conservation Planning, and Jenness McBride, Fish and Wildlife Biologist, California/Nevada Operations Office, 916-414-6464

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I.C. Background

I.C.1. FR Notice citation announcing initiation of this review: 71 FR 14538, March 22, 2006. This notice requested information from the public; we received no information in response to the notice.

I.C.2. Listing history

Original Listing
FR notice: 59 FR 48136
Date listed: September 19, 1994
Entity listed: Species *(Lepidurus packardi)*
Classification: Endangered

I.C.3. Associated rulemakings:

Critical habitat for this species was proposed on September 24, 2002 (67 FR 60033). The final rule to designate critical habitat for the vernal pool tadpole shrimp was published on August 6,

2003 (68 FR 46684). A re-evaluation of non-economic exclusions from the August 2003 final designation was published on March 8, 2005 (70 FR 11140). An evaluation of economic exclusions from the August 2003 final designation was published on August 11, 2005 (70 FR 46924). Administrative revisions were published on February 10, 2006 (71 FR 7117).

I.C.4. Review History:

We have not conducted any previous status reviews.

I.C.5. Species' Recovery Priority Number at start of review:

The recovery priority is 2C (based on a 1-18 ranking system where 1 is the highest recovery priority and 18 is the lowest), reflecting a high degree of threat, a high potential for recovery, a taxonomic rank of full species, and conflict with construction or other development projects or other forms of economic activity.

I.C.6. Recovery Plan or Outline

Name of plan: Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon
Date issued: December 15, 2005

II. REVIEW ANALYSIS

Species Overview

The vernal pool tadpole shrimp is found only in ephemeral freshwater habitats, including alkaline pools, clay flats, vernal lakes, vernal pools, vernal swales, and other seasonal wetlands in California (Helm 1998). Vernal pools are an ephemeral type of wetland that is found in California and southern Oregon. Vernal pools are generally small, shallow wetlands, located on a clay or hardpan layer, that fill with water during the winter and spring, then dry up until the next rainy season. Vernal pools form where a soil layer (hardpan, duripan, or claypan) exists below or at the surface that is impermeable or nearly impermeable to water (Smith and Verrill 1998). 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). Duripan is a horizon in a mineral soil that is characterized by cementation by silica. 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. Crustaceans, such as the vernal pool tadpole shrimp, produce cysts or eggs that lie buried in the soil until the next winter rains trigger the eggs to hatch. The cysts may hatch in as little as 4 days (Ahl 1991, Rogers *in litt*. 2001).

This species inhabits freshwater habitats containing clear to highly turbid water, with water temperatures ranging from 50 to 84 degrees Fahrenheit and pH ranging from 6.2 to 8.5 (King 1996; Syrdahl 1993). Vernal pool tadpole shrimp generally take between 3 and 4 weeks to mature (Ahl 1991, King *et al.*1996). Reproduction begins after individuals reach 0.4 inch or more in carapace length and fecundity increases with body size Ahl (1991). Large females,

greater than 0.8 inch carapace length, can deposit as many as 6 clutches, ranging from 32 to 61 eggs per clutch, in a single wet season Ahl (1991). Vernal pool tadpole shrimp may be hermaphroditic (individuals have both male and female reproductive organs) (Longhurst 1955, Lynch 1966, C. Rogers *in litt.* 2001). Multiple hatching within the same wet season allows vernal pool tadpole shrimp to persist within pools as long as these habitats remain inundated, sometimes for 6 months or more (Ahl 1991, Gallagher 1996, Helm 1998). Hatching of vernal pool tadpole shrimp eggs is temperature-dependent. Optimal hatching occurs between 50 to 59 degrees Fahrenheit, with hatching rates becoming significantly lower at temperatures above 68 degrees Fahrenheit (Ahl 1991). Vernal pool tadpole shrimp eggs and adults are carried from one wetland to another by a variety of methods, the most important likely being overland flooding from rainstorms, and by waterfowl and other migratory birds (on the bird's feet or in its gut).

Vernal pool tadpole shrimp feed on both living organisms such as fairy shrimp and on detritus (Service 2005a), and can be identified by the large, shield-like carapace that covers the anterior half of their bodies and the paddle-like supra-anal plate located between the paired cercopods (jointed antenna-like appendages). Vernal pool tadpole shrimp have from 30 to 35 pairs of phyllopods (swimming legs that also function as gills), a segmented abdomen, and fused eyes. Mature vernal pool tadpole shrimp range from 0.6 to 3.3 inches in length (Service 2005a).

The vernal pool tadpole shrimp has a patchy distribution across the Central Valley of California, from Shasta County southward to northwestern Tulare County, with isolated occurrences in Alameda and Contra Costa Counties (CNDDB 2007). Although vernal pool tadpole shrimp are spread over a wide geographic range, their habitat is highly fragmented and they are uncommon where they are found (Helm 1998; Service 2005a). The California Natural Diversity Database currently reports 226 occurrences of vernal pool tadpole shrimp in the following 19 counties: Alameda, Butte, Colusa, Contra Costa, Fresno, Glenn, Kings, Merced, Placer, Sacramento, San Joaquin, Shasta, Solano, Stanislaus, Sutter, Tehama, Tulare, Yolo, and Yuba. Sacramento County contains 28 percent, the greatest amount, of the known occurrences (CNDDB 2007).

II.A. Application of the 1996 Distinct Population Segment (DPS) policy

II.A.1. Is the species under review listed as a DPS?

____ ***Yes***.
_X_ ***No***

The Endangered Species Act defines species as including any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate wildlife. This definition limits listings as distinct population segments only to vertebrate species of fish and wildlife. Because the species under review is an invertebrate and the DPS policy is not applicable, the application of the DPS policy to the species listing is not addressed further in this review.

II.B. Recovery Criteria

II.B.1. Does the species have a final, approved recovery plan containing objective, measurable criteria?

_X_ ***Yes***
___ ***No***

II.B.2. Adequacy of recovery criteria.

II.B.2.a. Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat?

__X_ ***Yes***
____ ***No***

II.B.2.b. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)?

__X_ ***Yes***
____ ***No***

II.B.3. List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information. For threats-related recovery criteria, please note which of the 5 listing factors are addressed by that criterion. If any of the 5-listing factors are not relevant to this species, please note that here.

General recovery criteria for vernal pool tadpole shrimp and 19 other listed plants and animals are described in the Recovery Plan (Service 2005a). This Recovery Plan uses an ecosystem-level approach because many of the listed species and species of concern co-occur in the same natural ecosystem and share the same threats. The over-arching recovery strategy for vernal pool tadpole shrimp is habitat protection and management. The five key elements that comprise this ecosystem-level recovery and conservation strategy are: (1) habitat protection; (2) adaptive management, restoration, and monitoring; (3) status surveys; (4) research; and (5) public participation and outreach. The recovery criteria address four listing factors noted in the 1994 rule to list the species (59 FR 48136): destruction, modification, or curtailment of habitat or range (factor A); disease or predation (factor C); inadequacy of existing regulatory mechanisms (factor D); and other man-made or natural factors affecting its continued existence (factor E). Factor B, overutilization for commercial recreational, scientific, or education purposes, was not included as a threat in the listing rule and is not addressed in the Recovery Plan. Since the Recovery Plan has only recently begun to be implemented, species surveys and monitoring efforts that will provide data to evaluate progress towards recovery have yet to be established.

Downlisting /delisting criteria for vernal pool tadpole shrimp include:

1. <u>Habitat protection</u>: Accomplish habitat protection that promotes vernal pool ecosystem function sufficient to contribute to population viability of the covered species.

The Recovery Plan recommends protection of suitable habitat within core areas. Core areas are the specific sites that are necessary to recover the endangered or threatened species addressed in

the Recovery Plan, or to conserve sites that are necessary to recover these listed species and/or the species of concern addressed in the Recovery Plan. Core areas are not species-specific and may contain multiple listed species and species of concern. Higher recovery priority is assigned to: (1) species with low numbers of populations or limited geographical distributions, (2) the largest blocks of habitat, (3) the largest populations of each taxon, and (4) populations or species representing unique ecological conditions and genotypes. Core areas may be modified in the future based upon the results of status surveys and research.

Core areas are ranked as zone 1, 2, or 3 in order of their overall priority for recovery. Core areas containing vernal pool tadpole shrimp are included as both zones 1 and 2 in the Recovery Plan. Further implementation of recovery actions in vernal pool habitat outside of the zone 1 and 2 core areas described in the Recovery Plan could be recommended for vernal pool tadpole shrimp if additional populations are found outside of zone 1 and zone 2 core areas. Protection of zone 1 and 2 core areas and protection of 80 percent of natural populations will significantly contribute to recovery of vernal pool tadpole shrimp. This criterion addresses Factor A.

1A. Suitable vernal pool habitat within each prioritized core area for the species is protected.

The Recovery Plan recommends that, for downlisting, 80 percent of the occurrences known at the time the Recovery Plan was signed be protected. In addition, the Recovery Plan specifies criteria for protection of suitable vernal pool tadpole shrimp habitat within 24 core areas found within seven vernal pool regions; suitable habitat may be occupied or unoccupied by vernal pool tadpole shrimp. These criteria recommend that 95 percent of suitable habitat in zone 1 and 85 percent of suitable habitat in zone 2 core areas be protected range-wide. The Recovery Plan recommends that, for delisting, 100 percent of reintroduced populations be protected. None of these criteria has been met.

The Service does not yet have sufficient information to quantify either the acreage of suitable habitat within each core area or the acreage of protected habitat that is suitable for vernal pool tadpole shrimp. The amount of suitable habitat that exists range-wide has not yet been estimated; therefore, the percentage that has been protected range-wide is still unknown. The core areas, including the protected habitat that is suitable for vernal pool tadpole shrimp within each core area, are described below in section II.C.2.a.

1B. Species occurrences distributed across the species geographic range and genetic range are protected. Protection of extreme edges of populations protects the genetic differences that occur there.

This criterion has been partially met. Each of the seven vernal pool regions in which vernal pool tadpole shrimp is found contain some occurrences of the species that are located on lands receiving some level of protection. These lands are owned and managed variously by the California Department of Fish and Game (Ecological Reserves), U.S. Fish and Wildlife Service (National Wildlife Refuges), California Department of Parks and Recreation (State Parks), and privately-owned conservation banks. The boundaries of the range of the tadpole shrimp have been protected within the Stillwater Plains Conservation Bank in Shasta County (north), Stone

Corral Ecological Reserve in Tulare County (south and east), and San Francisco Bay National Wildlife Refuge (NWR) in Alameda County (west). Portions of the central part of the range within the San Joaquin Valley, however, are not known to contain any protected occurrences of the species. The Service does not have sufficient information to determine whether the habitat protection completed to date is promoting vernal pool ecosystem function sufficient to contribute to vernal pool tadpole shrimp population viability.

1C. Reintroduction and introductions must be carried out and meet success criteria.

The 2005 Recovery Plan recommends the reintroduction of vernal pool tadpole shrimp to all the vernal pool regions and soil types from which status surveys indicate the species has been extirpated. The vernal pool tadpole shrimp is currently found in seven of the sixteen vernal pool regions. We do not have information to indicate whether this species currently exists or historically existed in the other nine vernal pool regions. This recovery criterion has not been met.

This species has been intentionally introduced into numerous created and restored vernal pools within its existing range. Monitoring of vernal pool tadpole shrimp at some of these sites indicates that the species is persisting, for example at Clay Station Mitigation Bank (S. Egan, ECORP Consulting, Inc. (ECORP), *in litt.*, 2007) and Laguna Terrace Vernal Pool Preserve (B. Roper, Wildlands, Inc. (Wildlands), pers. comm., 2007) in the Southeastern Sacramento Vernal Pool Recovery Region. While Rogers (1998) found that constructed vernal pools approximated the same invertebrate fauna as the natural habitat within two years, there are currently no success criteria with which to evaluate introductions or reintroductions of this species, and long-term population trends have not been studied. There is a concern that introductions conducted without systematic guidelines or supported by research may contribute to the genetic degradation of this species. For example, inoculants (donor soil containing shrimp cysts or eggs) from one soil type or geological formation sometimes are introduced to another soil type or geological formation during vernal pool construction or restoration, thereby possibly mixing genetic attributes from occurrences that may be genetically distinct (see King 1996 and discussion in II.C.1.c.) (C. Witham, California Native Plant Society (CNPS), pers. comm., 2007).

1D. Additional occurrences identified through future site assessments, GIS and other analyses, and status surveys that are determined essential to recovery goals are protected. Any newly found occurrences may count towards recovery goals if the occurrences are permanently protected.

Future surveys may locate additional occurrences of this species, particularly on private lands that support suitable habitat and soil types but that have not yet been surveyed. At this time, the Service is aware of additional vernal pool tadpole shrimp occurrences that have been discovered since the species was listed in 1994 (see discussion on current abundance in section II.C.1.a. below). No GIS or other analyses to identify areas of potential occurrences are known. This recovery criterion has not been met because status surveys are not consistently conducted throughout the species' known range.

1E. Habitat protection results in protection of hydrology essential to vernal pool ecosystem function, and monitoring indicates that hydrology that contributes to population viability has been maintained through at least one multi-year period that includes above average, average, and below average local rainfall, a multi-year drought, and a minimum of 5 years of post-drought monitoring.

To our knowledge, monitoring of hydrology has not occurred at any of the known extant occurrences; therefore, we have no data to evaluate ecosystem function of protected areas.

2. <u>Adaptive Habitat Management and Monitoring</u>

This criterion implicitly addresses Factors A, D, and E.

2A. Habitat management and monitoring plans that facilitate maintenance of vernal pool ecosystem function and population viability have been developed and implemented for all habitat protected, as previously discussed in sections 1A-E.

This criterion has been partially met. Although several vernal pool tadpole shrimp occurrences are protected within conservation banks, preserves, or sites that have management and monitoring plans in place, in most cases the plans are too new to determine whether they adequately facilitate maintenance of vernal pool ecosystem function, such as controlling invasive plant species or managing site hydrology. It has been estimated that, of the sites with presumably extant occurrences, only 16 percent are preserved and managed for biodiversity (CNDDB 2007; Jones & Stokes 2007). Many other occurrences do not benefit from the existence and implementation of habitat management and monitoring plans.

2B. Mechanisms are in place to provide for management in perpetuity and long-term monitoring of 1A-E, as previously discussed (funding, personnel, etc).

This criterion has been partially met. All of the Service-approved conservation banks that support occurrences of vernal pool tadpole shrimp have endowment funds to ensure management and long-term monitoring in perpetuity. While a portion of the sites that have been protected to support occurrences of vernal pool tadpole shrimp have endowment funds to ensure management and monitoring of habitat in perpetuity, some protected sites have older and inadequate funding mechanisms that may hinder long-term management and monitoring (S. Egan, ECORP, pers. comm., 2007). Further, some non-bank preserves lack endowments and are managed through normal operating budgets and fundraising by the organization (e.g., Vina Plains Preserve, R. Reiner, TNC, pers. comm., 2006). While long-term funding mechanisms for management and monitoring in perpetuity exist for many non-bank preserves, the endowment amount may be not large enough for the size of the preserve (e.g., Jepson Prairie Preserve [B. Wallace, Solano Land Trust, pers. comm., 2006]), not adequate for long-term site monitoring (e.g., Vina Plains Preserve [R. Reiner, The Nature Conservancy (TNC), pers. comm., 2007]), or temporally limited (e.g., Davis Global Communications Facility site [J. Marr, CDFG, pers. comm., 2007]). Several sites with known occurrences of vernal pool tadpole shrimp do not have funding mechanisms to provide for management and long-term monitoring in perpetuity (e.g., Borden Ranch [C. Feldheim, Center for Natural Lands Management (CLNM), pers. comm., 2007] and some parcels

within the Sacramento Prairie Vernal Pool Complex [A. Rutledge, Sacramento Valley Conservancy, pers. comm., 2007]). Funding at Federal or State-owned sites depends on yearly allocations to Federal and State agencies.

2C. Monitoring indicates that ecosystem function has been maintained in the areas protected under 1A-D for at least one multi-year period that includes above average, average, and below average local rainfall, a multi-year drought, and a minimum of 5 years of post-drought monitoring.

To our knowledge, monitoring of ecosystem function has not occurred for any of the known occurrences of this species. Therefore, we have no data to evaluate ecosystem function of protected areas.

3. <u>Status Surveys</u>:

This criterion implicitly addresses Factors A, D, and E.

3A. Status surveys, 5-year status reviews, and population monitoring show populations within each vernal pool region where the species occur are viable (e.g., evidence of reproduction and recruitment) and have been maintained (stable or increasing) for at least one multi-year period that includes above average, average, and below average local rainfall, a multi-year drought, and a minimum of 5 years of post-drought monitoring.

To our knowledge, monitoring has not occurred during a time period that meets the requirements specified in the Recovery Plan at any of the sites with known occurrences. Therefore, this criterion has not been met.

Vernal pool region working groups will be important for tracking the progress of recovery efforts, including monitoring the status of occurrences of this species, particularly on private lands that are not currently monitored.

3B. Status surveys, status reviews, and habitat monitoring show that threats identified during and since the listing process have been ameliorated or eliminated. Site-specific threats identified through standardized site assessments and habitat management planning also must be ameliorated or eliminated.

This criterion has not been met. While casual observations of vernal pool tadpole shrimp have occurred at many sites throughout its range, formal status surveys and habitat monitoring have not occurred at any sites. Annual monitoring of some vernal pool tadpole shrimp populations has occurred at Service-approved conservation banks; however, many of these banks have been established only recently and long-term data are not yet available.

The primary threat identified in the listing rule (59 FR 48136) was loss of habitat due to urban development, water supply/flood control activities, and conversion to agricultural use. Although some occurrences have been protected throughout the species' range, proposed urban development and related projects such as road widening continue to threaten several occurrences,

particularly in southern Sacramento County. Surveys conducted for vernal pool tadpole shrimp since listing have been designed for the purpose of determining presence of the species within proposed development or road projects and have generally been limited in scope, focusing on a single parcel or occurrence rather than on threats to the occurrences.

In some instances where monitored occurrences were deemed to be threatened, habitat planning or rapid response measures were implemented. This was the case with the Stone Corral Ecological Reserve in Tulare County and the Don Edwards San Francisco NWR in Alameda County, where grazing was implemented as a management tool to enhance vernal pool habitats (Service 2005a; Loredo 2007).

All of the threats to this species described in the 1994 listing rule are still present throughout the species' range (see II.C.2.a.).

4. <u>Research</u>:

Research implicitly addresses all five listing factors.

4A. Research actions necessary for recovery and conservation of the covered species have been identified (these are research actions that have not been specifically identified in the recovery actions but for which a process to develop them has been identified). Research actions (both specifically identified in the recovery actions and determined through the process) on species biology and ecology, habitat management and restoration, and methods to eliminate or ameliorate threats have been completed and incorporated into habitat protection, habitat management and monitoring, and species monitoring plans, and refinement of recovery criteria and actions.

The Recovery Plan discusses a variety of research that would help refine recovery actions and criteria, and guide overall recovery and long-term conservation efforts. The Recovery Plan recommends research on genetics, taxonomy, biology of vernal pool species, the effects of habitat management practices on vernal pool species and their habitat, and threats to vernal pool species and ecosystems (Service 2005a). This information is necessary to develop effective conservation strategies, indicate management needs (if any), and inform the effectiveness of conservation efforts. Although some research has been conducted, the majority of the information needs discussed in the Recovery Plan are still outstanding.

Recent research by Dr. Jaymee Marty on the effects of grazing on vernal pool species and inundation periods (Marty 2005; Pyke and Marty 2005) has been used to address grazing recommendations for preserves and private vernal pool habitats, although it is not yet incorporated into many management plans and may not be applicable range-wide. Virginia Meyer, a doctoral student with Dr. Michael Barbour of the University of California (U.C.) Davis, is currently comparing hydrology and vegetation of created and natural vernal pools at three vernal pool conservation sites within northern California (V. Meyer, U.C. Davis, *in litt.* 2007). Dr. Christopher Rogers is studying the mechanisms of dispersal among vernal pool crustaceans in order to more accurately detect and measure gene flow between populations (C. Rogers, Eco-Analysts, *in litt.*, 2007). The 1996 Conference on Ecology, Conservation, and Management of

Vernal Pool Ecosystems generated several papers relevant to vernal pool tadpole shrimp (Witham 1998). A study by Rains *et al.* (2006), which looked at hydrologic connectivity between perched aquifers, surface water, and vernal pools, provides information on how the habitat of the species functions.

4B. Research on genetic structure has been completed (for species where necessary – for reintroduction and introduction, seed banking) and results incorporated into habitat protection plans to ensure that within and among population genetic variation is fully representative by populations protected in the Habitat Protection section of the Recovery Plan sections 1A-E.

While a few studies have been conducted on the genetics of vernal pool tadpole shrimp (King 1996), to our knowledge, information on vernal pool tadpole shrimp genetics has not been specifically incorporated into habitat protection plans to date. No additional research on the genetics of the species has been published since the species was listed.

4C. Research necessary to determine appropriate parameters to measure population viability for each species have been completed.

No such research has been completed for this species.

5. <u>Participation and Outreach</u>:

Public participation and outreach implicitly address all five listing factors.

5A. Recovery Implementation Team is established and functioning to oversee range-wide recovery efforts.

The Recovery Plan discusses a variety of participation programs to achieve the goal of recovery of the listed species in the plan. An essential component of this collaborative approach is the formation of a single recovery implementation team overseeing the formation and function of multiple working groups formed at the vernal pool region level. The Service is currently in the preliminary stages of organizing both a recovery implementation team and multiple working groups. Service employees have met with various stakeholders to determine interest of stakeholders to be involved in working groups and/or the recovery implementation team. This criterion has not yet been met.

5B. Vernal pool regional working groups are established and functioning to oversee regional recovery efforts.

See 5A, above.

5C. Participation plans for each vernal pool region have been completed and implemented.

This action has not been initiated.

5D. Vernal pool region working groups have developed and implemented outreach and incentive programs that develop partnerships contributing to achieving recovery criteria 1-4.

This action has not been initiated.

II.C. Updated Information and Current Species Status

II. C.1. Biology and Habitat

II.C.1.a. Abundance, population trends (e.g., increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:

Annual surveys have not occurred at all sites with known vernal pool tadpole shrimp occurrences. Where surveys have been conducted for vernal pool tadpole shrimp, they were designed for the purpose of determining presence of species within proposed development or road projects and have generally been limited in scope, focusing on a single parcel or occurrence. Surveys are generally not conducted in a manner to facilitate determination of the population trends of this species. No trends either downward or upward have been reported at any of the monitored sites (S. Foreman, LSA Associates (LSA), pers. comm., 2007; C. Witham, CNPS, pers. comm., 2007); however, the accelerated loss and fragmentation of vernal pool tadpole shrimp habitat, particularly in the Southeastern Sacramento Valley Vernal Pool Region, is expected to result in markedly decreased long-term viability of this species (C. Witham, CNPS, pers. comm., 2007; J. Marty, TNC, pers. comm., 2007).

II.C.1.b. Spatial distribution, trends in spatial distribution (e.g., increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g., corrections to the historical range, change in distribution of the species' within its historic range, etc.):

The vernal pool tadpole shrimp continues to be found in each of the vernal pool regions from which it was known historically. At the time of listing in 1994, vernal pool tadpole shrimp were known from 18 populations, extending from east of Redding, Shasta County, southward to the San Luis NWR, Merced County, in the Central Valley, with a disjunct population at the San Francisco NWR, Alameda County (59 FR 48136). However, the precise location and extent of those populations and the number of counties occupied at that time are not known. The majority of the location information used in this review is from the California Natural Diversity Database (CNDDB), which reports species locations as "occurrences" rather than populations. "Occurrence", which may represent a documented collection, observation, or museum specimen of a species, is defined by the CNDDB as a location occupied by a species separated from other locations by at least 0.25 mile, and may contain multiple records. Currently, the number of occurrences reported by CNDDB is 226 within 19 counties; however, the number of populations represented by these occurrences has not been determined (CNDDB 2007).

Since 1994, vernal pool tadpole shrimp have been discovered in Contra Costa, Fresno, Kings, and Tulare Counties on private and state-owned lands (CNDDB 2007), resulting in an

approximately 100-mile extension of the southern boundary of the known range at the time of listing (59 FR 48136). Additional occurrences have been discovered within the range known at the time of listing, resulting in an increased known distribution of the vernal pool tadpole shrimp. This increase in known distribution is not likely attributed to a range shift or increase, but due to the fact that, since the time of listing, the number of people searching for and reporting occurrences of vernal pool tadpole shrimp has increased. The distribution of the vernal pool tadpole shrimp is patchy and sporadic throughout its range, with vernal pool tadpole shrimp often inhabiting only one or a few vernal pools in otherwise more widespread vernal pool complexes (Rogers 2001); this makes the species uncommon even where vernal pool habitats occur. NatureServe (2006) estimated that vernal pool tadpole shrimp were found in approximately 33 percent of all seasonal wetlands in the Central Valley of California; however, Helm (1998) found vernal pool tadpole shrimp in only 17 percent of vernal pools sampled across 27 counties. Sugnet and Associates (1993), using a non-random sampling methodology, found this species at only 11 percent of 3,092 locations across the state.

Because the CNDDB only includes information submitted to it (i.e., it is a "positive sighting" database), the CNDDB records are somewhat inconsistent, and an occurrence may represent individual pools, pool complexes, or groups of complexes. Moreover, the CNDDB may not be updated when a particular site or occurrence is extirpated unless that information is submitted to the CNDDB. For example, of the 226 current occurrences reported, only one historical occurrence reported as occurring one mile north of the City of Davis in Yolo County is noted as likely extirpated (CNDDB 2007). We know of only one other occurrence that likely has been extirpated, the Woodcreek Oaks Mitigation Site in Placer County (P. Balfour, ECORP, pers. comm., 2007). Because of the wide range of the species, it is likely that occurrences have been unknowingly extirpated during the course of agricultural and urban development in the Central Valley. Additionally, many occurrences recorded in the CNDDB have not been revisited or surveyed within the last 10 to 15 years; therefore, their current status is unknown although presumed to be extant.

The extant occurrences of the vernal pool tadpole shrimp are distributed among seven vernal pool regions: Central Coast, Northeastern Sacramento Valley, Northwestern Sacramento Valley, San Joaquin Valley, Solano-Colusa, Southeastern Sacramento Valley, and Southern Sierra Foothills. The Southeastern Sacramento Valley Vernal Pool Region, which includes Sacramento County, contains almost 15 percent of the remaining vernal pool grasslands in California (Keeler-Wolf *et al.* 1998) and supports the largest concentration, or approximately 35 percent, of the known occurrences of the vernal pool tadpole shrimp documented in the CNDDB (Service 2005a). Sacramento County, which is part of the Southeastern Sacramento Valley Vernal Pool Region, contains the greatest number of vernal pool tadpole shrimp occurrences, or approximately 28 percent, of any single county (CNDDB 2007). Sugnet and Associates' (1993) found that of the pools that they surveyed in California, the majority of the pools (about 63 percent) occupied by vernal pool tadpole shrimp were located in Sacramento County. These occurrences are concentrated in Sacramento County southeast of the City of Sacramento, in and around the Mather core area (CNDDB 2007; Service 2005a). The Service has estimated that approximately 74 percent of all the vernal pool tadpole shrimp occurrences in the Southeastern Sacramento Valley occur in the Mather core area (Service 2007). The following is a discussion of the distribution of vernal pool tadpole shrimp by vernal pool region across its range.

Central Coast Vernal Pool Region: Three occurrences of vernal pool tadpole shrimp are documented on the Don Edwards San Francisco Bay NWR and private land in Alameda County (CNDDB 2007; WRA 2005).

Northeastern Sacramento Valley Vernal Pool Region: Thirty-eight occurrences have been documented on private land, including various preserves and conservation banks, in the vicinity of Chico in Butte County; and in Tehama County at the Vina Plains Preserve, the Dales Lake Ecological Preserve, and on California Department of Transportation (Caltrans) and Bureau of Land Management (BLM) lands (CNDDB 2007; North State Resources, Inc. 2003). Vernal pool tadpole shrimp are also likely to occur at the CDFG Table Mountain Ecological Reserve in Butte County (J. Marr, CDFG, pers. comm., 2007) and on The Nature Conservancy's (TNC) Lassen Foothills Project in Tehama County (R. Reiner, TNC, pers. comm., 2007), although their presence has not been confirmed.

Northwestern Sacramento Valley Vernal Pool Region: Nineteen occurrences have been documented in the Stillwater Plains and Millville Plains areas and in the vicinity of Redding in Shasta County, as well as in the vicinity of Red Bluff in Tehama County (CNDDB 2007). Additional occurrences are likely to be found on private lands in the vicinity of Redding (B. Bailey, Natural Resource Conservation Service (NRCS), pers. comm., 2007) and possibly on the CDFG Thomes Creek Ecological Preserve in Shasta County, which may support suitable habitat for vernal pool tadpole shrimp (J. Marr, CDFG, pers. comm., 2007).

San Joaquin Valley Vernal Pool Region: Eighteen occurrences have been documented on the Grasslands Ecological Area, which includes the Great Valley Grasslands State Park and the Merced and San Luis NWRs, and private land in Merced County; and from single locations in Tulare and Kings Counties (CNDDB 2007).

Solano-Colusa Vernal Pool Region: Forty occurrences have been documented on the Jepson Prairie (including numerous conservation banks and preserves), Travis Air Force Base (AFB), private land, and near Montezuma in Solano County; on the Davis Communications Annex site in Yolo County; on private land in Colusa County; and on the Sacramento NWR in Glenn County (CNDDB 2007).

Southeast Sacramento Valley Vernal Pool Region: The largest concentration of vernal pool tadpole shrimp occurrences is found in the Southeastern Sacramento Valley Vernal Pool Region (Service 2005a). Eighty occurrences have been documented on numerous public and private lands in Sacramento County, on Beale AFB and private land in Yuba County, and on the Lincoln Communication Facility and private land in Placer County (CNDDB 2007).

Southern Sierra Foothills Vernal Pool Region: Twenty-eight occurrences have been documented at the Stone Corral Ecological Reserve in Tulare County, on ranchlands and variously-protected private lands in eastern Merced County, at the Big Table Mountain Preserve in Fresno County, and at a few locations in Stanislaus County (CNDDB 2007).

II.C.1.c. Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):

King (1996) studied genetic variation among 20 vernal pool tadpole shrimp sites in the Central Valley. She found that 91 percent of the genetic variation measured was due to differences among vernal pool complexes. The low rate of exchange between vernal pool tadpole shrimp sites is probably a result of the spatial isolation of their habitats and the species' reliance on passive dispersal mechanisms in which the shrimp or cysts are carried from one area to another for example by waterfowl (King 1996). King (1996) also estimated that gene flow between pools within the same vernal pool complex was much higher than between separated sites and recommended that vernal pool crustacean populations should be defined by vernal pool complex, not by the boundaries of an individual vernal pool. Therefore, the most appropriate way to look at the distribution and abundance of these species is by considering the number of inhabited vernal pool complexes.

Based on genetic differences, King (1996) separated vernal pool tadpole shrimp into two distinct groups. One group was comprised of animals inhabiting the floor of the Central Valley, near the Sacramento and San Joaquin Rivers. The other group contained vernal pool tadpole shrimp from sites along the eastern margin of the valley. King (1996) concluded that these two groups may have diverged because cyst dispersal by overland flooding historically connected populations on the valley floor, while populations on the eastern margin of the valley were not periodically connected by large-scale flooding and were therefore historically more isolated. When dispersal of these foothill populations occurred, it was probably through different mechanisms such as migratory birds. Genetic analyses of vernal pool tadpole shrimp revealed that occurrences from sites along the eastern margin of the valley, particularly those in eastern Merced County in the vicinity of the Flying M Ranch and the proposed U.C. Merced campus, were genetically different from other occurrences (King 1996); of all occurrences studied, these were found to be the most highly divergent genetically from other occurrences. King (1996) concluded that this group, because it is found on very ancient soils, may have been isolated from other populations very early.

II.C.1.d. Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):

Although the vernal pool tadpole shrimp is found on a variety of geologic formations and soil types, Helm (1998) found that, throughout its range, more than 50 percent of vernal pool tadpole shrimp occurrences were on High Terrace (i.e., old terrace) landforms and Redding and Corning soils. The vernal pools that are classified as the old terrace type are located on soils associated with the Laguna geologic formation. The old terrace soils consist of ancient river channel deposits that were laid down from 600,000 to more than one million years ago by the American River. The old terrace formations generally support a higher density of vernal pools, larger and deeper pools, and a greater number of special status plants and crustaceans than other soil formations (Wacker and Kelly 2004). Some special status species found in old terrace pools may have evolved from species inhabiting shores of ancient lakes in the Central Valley. Old terrace pools may have served as refugia for these species as the lakes disappeared (Wacker and Kelly 2004).

The significance of and dependence on the old terrace ecosystem in southeastern Sacramento County by vernal pool tadpole shrimp has been well established in reports and published

literature (Holland 1978; Keeler-Wolf *et al.* 1998; Service 2005a). This area is well known for its vernal pools of exceptional quality, as measured by depth, size, density, and diversity (Rogers 2006). Sacramento County represents important habitat for the vernal pool tadpole shrimp by providing large, nearly contiguous areas of relatively undisturbed, high quality vernal pool habitat. Development in this area is leading to a loss of populations and cyst banks that act as sources of individuals to repopulate extirpated occurrences, increased urban runoff, and increased stormwater discharge into the system, which ultimately affect this entire old terrace system.

II.C.2. Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms):

II.C.2.a. Present or threatened destruction, modification or curtailment of its habitat or range:

Habitat destruction, degradation, and fragmentation are the primary threats to vernal pool tadpole shrimp. Loss of vernal pool habitat occurs due to development and lack of habitat management on lands that have been protected from development (Service 2005a). The 1994 final listing rule stated that 14 of the 18 populations of vernal pool tadpole shrimp known at that time were imperiled by rapid urbanization, land conversion to agricultural use, off-road vehicle use, and changes in hydrologic patterns in the areas they occupy (59 FR 48136). Vernal pool tadpole shrimp continue to be threatened by all of the factors which led to the original listing of this species, primarily habitat loss and fragmentation through agricultural conversion and urban development, as well as by altered hydrology and inappropriate land management.

Habitat Loss and Fragmentation

Vernal pool habitats in the Central Valley now represent approximately 9 percent of their former area (State of California Office of Planning and Research 2003), and remaining habitats are considerably more fragmented and isolated than historically and during the recent past. Habitat loss occurs from direct destruction and modification of pools due to filling, grading, discing, leveling, paving, and other activities. In addition, modification of surrounding uplands impacts vernal pool watersheds and the supporting upland ecosystem.

California's human population is expected to increase by 60 percent between 2000 and 2025 (State of California Department of Finance 2007) and to almost double the 1990 state population by 2040 (Field *et al*. 1999). Much of this population expansion will occur in the Central Valley, where 73 percent of the land is privately owned and only 6 percent of the land is in public ownership (Keeler-Wolf et al. 1998). In areas where habitat remains, increased urban conversion of vernal pool habitat continues to threaten vernal pool tadpole shrimp, and habitat loss is expected to continue as urban boundaries expand further, especially through high and low terrace formations on the eastern side of the valley. Even in areas where habitat is protected, the urbanization of lands surrounding conserved areas results in the fragmentation of protected habitats over the landscape, preventing dispersal between occurrences and increasing edge effects to pool complexes. Studies have not been conducted to determine the minimum area (upland and wetland) needed to sustain vernal pool species in the long term.

The following is a discussion of the threats (associated with habitat loss and fragmentation) to vernal pool tadpole shrimp by vernal pool region across its range.

Central Coast Vernal Pool Region

Relative to the other vernal pool regions, the Central Coast vernal pool region has a higher proportion of its vernal pool resources protected and managed for conservation (Keeler-Wolf *et al.* 1998), so habitat loss and fragmentation are not identified as threats to vernal pool tadpole shrimp in this region.

Northeastern Sacramento Valley Vernal Pool Region

Habitat loss and fragmentation caused by urbanization and road construction are threats to vernal pool tadpole shrimp in the Northeastern Sacramento Valley Vernal Pool Region. Rapid human population growth is predicted for all of Butte County and its urban areas. The City of Chico predicts the construction of approximately 20,000 new housing units and a 61 percent increase in population by 2030, while the population of Butte County is expected to increase by 48 percent by 2030 (Butte County Association of Governments 2006). The need for additional housing and associated development will likely threaten the remaining unprotected occurrences of vernal pool tadpole shrimp, which are mostly located in or near existing urban areas or roads.

Several of the known occurrences of the vernal pool tadpole shrimp are located on Caltrans rights-of-way and are threatened by future road improvement projects in this region (Service 2005a). In Butte County, 10 of the 18 locations where vernal pool tadpole shrimp have been recorded, including several larger vernal pool complexes, are within the Caltrans rights-of-way along Highways 99 and 149 and could be threatened by future expansion of these roads (SAIC 2007). In addition, there are a number of proposed development projects in this vernal pool region which could affect vernal pool tadpole shrimp, including the Sycamore Glen/Mountain Vista project adjacent to the Foothill Park East Preserve within the Chico core area (J. Marr, CDFG, pers. comm., 2007), the Stonegate (LSA Associates, Inc. and Kelley & Associates 1994) and Eastgate (Service 2002b) projects in the Doe Mill core area, and expansion of State Route 32 by the City of Chico (H. Keeler, City of Chico, *in litt.*, 2007).

Northwestern Sacramento Valley Vernal Pool Region

The largest continuing threat to vernal pool tadpole shrimp in the Northwestern Sacramento Valley Vernal Pool Region is agricultural land conversion and urban development along the periphery of urban areas, especially in the Redding area (Service 2005a). Near Redding, the conversion of grazing land into eucalyptus farms has been reported as a threat to vernal pools (Keeler-Wolf *et al.* 1998). Some sites, particularly in the two western units of the Redding core area, are threatened by urban development and pool alteration via fill, draining, or impoundment (B. Bailey, NRCS, pers. comm., 2007).

San Joaquin Valley Vernal Pool Region

Habitat loss and fragmentation caused by urbanization, particularly around the growing cities of Los Banos, Stockton, and Delano, are threats to vernal pool tadpole shrimp in the San Joaquin Valley Vernal Pool Region. For example, a proposed property subdivision within the Grasslands Ecological Area core area poses a threat to the integrity of vernal pool habitat conservation efforts in the area (K. Forrest, Service, *in litt.*, 2007).

Solano-Colusa Vernal Pool Region

Habitat loss and fragmentation caused by urbanization, agricultural land conversion, and road construction is a threat to vernal pool tadpole shrimp in the Solano-Colusa Vernal Pool Region. Some of the sites at Jepson Prairie could be affected by the widening of Highway 12 (Service 2006) and Parker Ranch, a 93-acre agricultural site where vernal pool tadpole shrimp occurs, is proposed for development (S. Forman, LSA, pers. comm., 2007).

Southeastern Sacramento Valley Vernal Pool Region

Habitat loss and fragmentation caused by urbanization and road construction is a threat to vernal pool tadpole shrimp in the Southeastern Sacramento Valley Vernal Pool Region. Of the projects reviewed by the Service pursuant to section 7 of the Act between 1994 and 2000 where biological opinions were issued with incidental take of the vernal pool tadpole shrimp, almost 80 percent were located within this region. These projects resulted in the loss of more than 37,500 acres of vernal pool grasslands, out of a total of almost 56,000 acres of uplands containing vernal pool fairy shrimp *(Branchinecta lynchi)* and vernal pool tadpole shrimp habitat (Service 2005b). These impacts have been minimized by compensation that, in part, includes the preservation and long-term management of vernal pool habitat for the benefit of listed species as terms and conditions of section 7 consultations (Service 2005a). Of the 16 regions potentially affected by habitat loss and fragmentation, the Southeastern Sacramento Valley Vernal Pool Region is the most threatened by development. Although some parcels have been protected for their high quality vernal pool habitat and high concentration of special status species populations, the old terrace area of Sacramento County is diminishing rapidly due to urban development and agricultural conversion (Service 2007; C. Witham, CNPS, pers. comm., 2007; P. Balfour, ECORP, pers. comm., 2007; J. Marty, TNC, pers. comm., 2007; R. Radmacher, Sacramento County, pers. comm., 2007).

Southern Sierra Foothills Vernal Pool Region

Habitat loss and fragmentation caused by urbanization and road construction is a threat to vernal pool tadpole shrimp in the Southern Sierra Foothills Vernal Pool Region. Approximately 318 acres of documented habitat for vernal pool tadpole shrimp occur in the U.C. Merced project region (Jones & Stokes 2007). An estimated 88 percent of this habitat is at a moderate to high risk from land conversion or degradation. The U.C. Merced project, as currently proposed, would eliminate 1,219 acres (less than 1 percent) of suitable vernal pool habitat in the Madera core area; this project, however, has protected 23,524 acres (11 percent) of lands supporting

vernal pool habitat in this core area (Jones & Stokes 2007). Of the proposed protected lands, 14 acres are documented as supporting vernal pool tadpole shrimp (Jones & Stokes 2007).

Altered Hydrology

Timing, frequency, and length of inundation of vernal pools are critical to vernal pool crustaceans. Modification of the watershed surrounding the pools can either disrupt the pools' ecosystem through allowing non-native plants and/or opportunistic invertebrates to become established, or eliminate the vernal pool habitat entirely (Rogers 1998). Hydrology can be altered through direct means, such as damming or construction of roads or canals, or by indirect means, such as diversions of overland flow. Either means can result in decreased runoff to vernal pool complexes, causing the pools to either not fill or to dry prematurely. Change in the upland hydrology that results in shorter inundation periods is of particular concern in vernal pools with vernal pool tadpole shrimp, because this species requires nearly two months to reach maturity (Helm 1998).

Hydrological connections between vernal pools in old terrace areas are being lost (J. Marty, TNC, pers. comm., 2007; C. Witham, CNPS, pers. comm., 2007). Prior to urban development, vernal pools in the Mather core area of Southeastern Sacramento Valley were hydrologically connected during high rainfall years. Vernal pools in this area exist in a "sub-watershed" matrix, roughly delineated by Highway 50 to the north and the Cosumnes River to the south. High rainfall leads to surface flooding, which connects old terrace vernal pools into large, shallow, slow-flowing, temporary lakes. This hydrologic system of connectivity during flooding supports the metapopulation dynamic of recolonization of vernal pools that are subject to localized extirpation during drought years. The hydrological connectivity in this area comprises a functioning ecosystem, underlain by old terrace soils, that is characterized by one of the densest and highest quality vernal pools areas in California (Service 2007; C. Witham, CNPS, pers. comm., 2007; R. Radmacher, Sacramento County, pers. comm., 2007). As this area becomes increasingly urbanized, the vernal pool landscape is reduced and fragmented, and the hydrological connectivity is being lost (J. Marty, TNC, pers. comm., 2007; C. Witham, CNPS, pers. comm., 2007).

In addition to overland flow during high rainfall years, vernal pools located on duripan or claypan in the Central Valley, such as the old terrace vernal pools in eastern Sacramento County, have been shown to be hydrologically connected by a perched aquifer (Rains *et al.* 2006). In these hydrological features, seasonal surface water and perched groundwater hydrologically connect uplands, vernal pools, and streams at the catchment scale (surrounding area draining to the vernal pool). The catchment boundaries of the vernal pools in this area have an irregular shape. At Mather Field in southeastern Sacramento County, part of the catchment boundary of the study pools extended farther than 492 feet from the pools (Rains *et al.* 2006). In addition, Rains *et al.* (2006) found that the connectivity of the perched aquifer with the vernal pools in the area caused the pools "to be inundated over larger areas for longer periods of time than would be the case if they were recharged only by precipitation." Therefore, not only are the vernal pools in the old terrace area large and deep, their inundation period is extended by the perched aquifer that connects them. Development, and particularly an increase in area of impervious surfaces, such as asphalt or concrete, within the catchment basin of vernal pools that are supported by

perched aquifers, can be expected to reduce the catchment area for those pools, thereby inhibiting the ability of the pools to remain inundated for sufficient periods of time.

Conversely, supplemental summer water outside of natural sources, such as from agricultural and urban development, can convert vernal pool habitats into permanent water sources (Balfour and Morey 1999), which are not appropriate for vernal pool crustaceans. Permanent water supports predators, such as bullfrog adults and tadpoles, fish, and predatory insects which can colonize vernal pool habitats (Eriksen and Belk 1999). Urban runoff changes the hydroperiod of vernal pools, so that they become inundated during hot summer months when they would naturally have remained dry. Occasional summer rain does not saturate the soils overlaying hardpan and does not reduce the viability of cysts; however, chronic urban runoff does reduce the viability of vernal pool tadpole shrimp cysts and can extirpate vernal pool tadpole shrimp occurrences (C. Witham, CNPS, pers. comm., 2007; P. Balfour, ECORP, pers. comm., 2007). The Service is aware of instances where urban and agricultural runoff is altering the hydrology of vernal pool habitats in this manner; for example, at the Arena Plains parcel of the Merced NWR and at the San Luis NWR in Merced County (D. Woolington, Service, pers. comm., 2006; CNDDB 2007), at Mather Park in Sacramento County (CNDDB 2007), and at the Stone Corral Ecological Reserve in Tulare County (CNDDB 2007). Small changes in local land use, such as development of irrigated agriculture or parkland, may have considerable impacts on vernal pools, although the degree to which such changes affect pools is poorly understood (Rains *et al*. 2006).

Inappropriate Grazing Regimes

Both lack of grazing and excessive grazing may cause an increase in organic matter in the habitat that can eliminate the natural vernal pool invertebrate community and promote opportunistic and invasive species, such as *Lolium* spp. (rye grass), that out compete the obligate vernal pool species (Rogers 1998; Rogers 2006). Intensive grazing was listed as one of the threats to vernal pool tadpole shrimp in 1994 listing (59 FR 48136) because cattle increase water turbidity, deplete the water levels in the pools, and may directly damage vernal pool tadpole shrimp cysts with their hooves (Marty, undated). An additional threat related to grazing has been identified since the vernal pool tadpole shrimp was listed: the cessation of cattle grazing has been found to exacerbate the negative effects of invasive non-native plants on vernal pool inundation period. Appropriate levels of grazing may help maintain soil conditions and limit the amount of thatch accumulation near vernal pools (Rogers 2006).

The change in vernal pool inundation due to loss of grazing is an emerging threat for this species, especially in the Southeastern Sacramento Valley, where vernal pool inundation was reduced by 50 to 80 percent in a study by Marty (2005) when grazing was discontinued. Increased grass cover in and around ungrazed pools may lead to an increase in evapotranspiration rates, resulting in a decreased hydroperiod (Marty 2005). As mentioned previously, this decreased length of inundation is critical in low rainfall years because the vernal pool tadpole shrimp may require nearly two months to reach maturity and reproduce (Helm 1998).

In areas where long-term grazing has been in effect, moderate grazing (in both stocking numbers and amount of time) may be an important tool in combating non-native plant species, when burning is not an option. Initial results from a CDFG monitoring effort at Stone Creek

Ecological Reserve have shown that grazing does not detrimentally affect vernal pool crustaceans at the Stone Creek Ecological Reserve (C. Selmon, Environmental Science Associates, *in litt.*, 2006). Marty (2005) found that there was a decline of invertebrate species richness in ungrazed pools, which is likely attributable to the increased number of dry-down periods associated with dense grass cover. Moderate grazing may be a necessary tool to maintain the species diversity of the natural vernal pool ecosystem (Marty 2005).

Conservation Efforts in Core Areas

Loss of suitable habitat has been offset to some extent by the development of conservation banks and preserves, with many of these concentrated within core areas for the vernal pool tadpole shrimp. The 24 core areas that pertain to this species are distributed among seven vernal pool recovery regions. The amount of suitable vernal pool tadpole shrimp habitat that is protected within each core area has not been quantified at this time; however, 18 out of the 24 core areas contain some vernal pool tadpole shrimp habitat that is protected on public lands or on private preserves or conservation banks. The following are descriptions of known areas of protected habitat, by core areas, within each of these seven vernal pool recovery regions. Except for the known areas described below, we have no information regarding other properties within these core areas that are protected for the benefit of vernal pool species.

Central Coast Vernal Pool Recovery Region

Southeast San Francisco Bay, Alameda County: The Southeast San Francisco Bay core area is a zone 2 core area. Occurrences of vernal pool tadpole shrimp are protected in the 275-acre Warm Springs Seasonal Wetland Unit of the Service's Don Edwards San Francisco Bay NWR, which was acquired in 1992 (Loredo 2007), as well as in the adjacent Pacific Commons Preserve (WRA 2005).

Northeastern Sacramento Valley Vernal Pool Recovery Region

Chico, Butte County: The Chico core area is a zone 1 area. The 292-acre Foothill Park East Preserve and the 750-acre Bidwell Ranch (a property owned by the City of Chico) are within this core area. The 120-acre area within Bidwell Ranch that supports the vernal pool tadpole shrimp, its watershed, and a 200-foot buffer to the south and southeast from the boundary of the watershed for the Butte County meadowfoam to the boundary of the Bidwell Ranch property will likely be set aside for vernal pool species conservation, although there are still some development interests on the upland portions of the Ranch (Sellers 2006; J. Marr, CDFG, pers. comm., 2007; C. Sellers, *in litt.*, 2007). Vernal pools on the Wildwoods Park, only approximately one-quarter acre in size, have been set aside by the City of Chico; the level of protection and habitat functionality of this site are questionable (J. Marr, CDFG, pers. comm., 2007).

Dales, Shasta and Tehama Counties: The Dales core area is a zone 2 core area. Vernal pool tadpole shrimp occurrences are recorded at CDFG's Dales Lake Ecological Preserve and on lands administered by the BLM at its Hog Lake Plateau and Spring Branch Plains areas (CNDDB 2007; G. Diridoni, BLM, pers. comm., 2007).

Doe Mill, Butte County: The Doe Mill core area is a zone 2 core area. The 15-acre Doe Mill Preserve, which is owned by the City of Chico and preserved by a conservation easement (Sellers 2006), is within this area.

Oroville, Butte County: The Oroville core area is a zone 1 area. Within this core area, vernal pool tadpole shrimp are protected in the 2,400-acre Dove Ridge Conservation Bank and the 665-acre Daley Ranch Conservation Bank (Gallaway Consulting, Inc. 2006; North State Resources, Inc. 2003). The CDFG's 3,000-acre Table Mountain Ecological Reserve may also provide protected habitat for this species, although this is unconfirmed (J. Marr, CDFG, pers. comm., 2007).

Vina Plains, Butte and Tehama Counties: The Vina Plains core area is a zone 1 area. The Vina Plains core area includes: (1) the Vina Plains Botanical Management Area, a Caltrans-managed demonstration area along State Highway 99 extending northward from the Butte/Tehama county border to 4.5 miles north of the border; and (2) TNC's Vina Plains Preserve, a 4,600-acre area established for the protection of vernal pools. The TNC's Vina Plains Preserve provides protected habitat for the species; however, the Vina Plains Botanical Management Area does not have conservation easements or fee title for land in this area to protect any vernal pool tadpole shrimp occurrences. As of the date of this review, TNC's Lassen Foothills Project, which is envisioned to protect 900,000 acres stretching from Lassen Peak to the Sacramento River, has put 80,000 acres, including 10,000 acres of vernal pool grasslands, under easement for protection in perpetuity (R. Reiner, TNC, pers. comm., 2007). If acquired, some of this acreage will be in the Vina Plains core area and will protect any vernal pool tadpole shrimp occurrences there from being destroyed. The 6,000-acre Wurlitzer Ranch (Tuscan Preserve) northwest of Chico has natural and some created pools (Keeler-Wolf *et al.* 1998) which are protected under a conservation easement (D. Kelley, Kelley and Associates, pers. comm., 2007). A 400-acre portion of the 2,000-acre Hamilton Ranch is proposed to be preserved to offset effects from the Sycamore Glen/Mountain Vista project and other projects for the benefit of vernal pool species, including the vernal pool tadpole shrimp known to occur there (Klein 2007).

Northwestern Sacramento Valley Vernal Pool Region

Red Bluff, Tehama: The Red Bluff core area is a zone 2 area. The Service is not aware of properties within this core area that are protected for the benefit of vernal pool species.

Redding, Shasta County: The Redding core area is a zone 2 area. The 834-acre Stillwater Plains Conservation Bank provides protected habitat for vernal pool tadpole shrimp. The Shasta Bible College is proposing to protect a large vernal pool to offset losses of vernal pool shrimp habitat from the North Airport Business Park and Shastina Ranch projects, which has a known occurrence of vernal pool tadpole shrimp (Service 2004, 2005c). The Natural Resource Conservation Service (NRCS), in conjunction with CDFG, holds conservation easements on several parcels within the Stillwater Plains watershed. These parcels, one 136 acres and the other 160 acres, are primarily a combination of vernal pools and vernal swales, and likely have vernal pool tadpole shrimp on-site (B. Bailey, NRCS, pers. comm., 2007). The CDFG has recently acquired title to a site northwest of Corning, to be called the Thomes Creek Ecological Preserve, which may support suitable habitat for vernal pool tadpole shrimp. A 3,000-acre

conservation easement has been obtained at the Thomes Creek Ecological Preserve by Simpson Lumber Co. to offset vernal pool losses associated with its eucalyptus plantation (Keeler-Wolf *et al.* 1998).

San Joaquin Valley Vernal Pool Region

Cross Creek, Kings and Tulare Counties: The Cross Creek core area is a zone 2 area. The Service acquired the 4,040-acre Mapes Ranch as part of the San Joaquin NWR in 2002 (Service 2002a), which may support suitable vernal pool tadpole shrimp habitat.

Grasslands Ecological Area, Merced County: The Grasslands Ecological core area is a zone 1 area. This core area includes the Great Valley Grasslands State Park, San Luis NWR, Merced NWR (including Arena Plains and East Bear Creek Units), and the 333-acre Vieira-Sandy Mush Road Conservation Bank, all of which support vernal pool tadpole shrimp.

Solano-Colusa Vernal Pool Region

Collinsville, Solano County: The Collinsville core area is a zone 1 area. The Montezuma Wetlands Project site, which supports vernal pool tadpole shrimp, is not protected under a conservation easement (J. Vollmar, Vollmar Consulting, pers. comm., 2007; D. Lipton, Lipton Environmental Group, *in litt.,* 2007).

Davis Communications Annex, Yolo County: The Davis Communications Annex core area is a zone 1 area. Ownership of the Davis Communications Annex site is currently being transferred from McClellan AFB, which was closed in 1999, to Yolo County (ESA Associates, Inc. 2005; J. Marr, CDFG, pers. comm., 2007). The vernal pool tadpole shrimp occurrence within the Davis Communications Annex site is managed for the protection of vernal pool tadpole shrimp, but is not yet permanently protected (ESA Associates, Inc. 2005), although the Yolo County NCCP/HCP process has recommended that the Davis Communications Annex site be preserved (ESA Associates, Inc. 2005; M. Wong, Yolo County HCP/NCCP JPA, *in litt.,* 2006).

Dolan, Colusa County: The Dolan core area is a zone 2 area. The 252-acre Dolan Ranch Conservation Bank, owned and managed by Wildlands, Inc., is within this core area and features a wide variety of habitats, including vernal pools that support the vernal pool tadpole shrimp (B. Roper, Wildlands, pers. comm., 2007).

Jepson Prairie, Solano County: The Jepson Prairie core area is a zone 1 area. Within this core area, vernal pool tadpole shrimp have been reported in the following locations: the Solano County Farmland and Open Space Foundation's 1,566-acre Jepson Prairie Preserve; the 160-acre Campbell Ranch Conservation Bank; the 1,862-acre Elsie Gridley Conservation Bank (LSA Associates *in litt.*, 2004); the 609-acre North Suisun Conservation Bank (Wildlands, Inc. *in litt*. 2006); the 2,912-acre Wilcox Ranch (K. Poerner, Solano County Land Trust, in litt., 2007); the proposed 1,400-acre Burke Ranch Conservation Bank; CDFG's 256-acre Barker Slough Ecological Reserve and 965-acre Calhoun Cut Ecological Reserve; Parker Ranch; and Travis AFB (CNDDB 2007). The proposed 460-acre Solano Union Creek Conservation Bank is expected to support occurrences of vernal pool tadpole shrimp (LSA Associates, Inc. 2006).

Most of these sites, except Muzzy Ranch, Solano Union Creek, Parker Ranch, and Travis AFB, are protected under conservation easements. These preserved areas are protected for the benefit of native species, including vernal pool species; however, the amount of suitable vernal pool tadpole shrimp habitat within these preserved areas has not been quantified.

Sacramento NWR, Glenn and Colusa Counties: The Sacramento NWR core area is a zone 1 area. The amount of suitable vernal pool tadpole shrimp habitat that is protected within this core area has not been quantified at this time, although approximately 140 acres of actual vernal pools at the Sacramento, Delevan, and Colusa NWRs, which make up the Sacramento NWR Complex, are managed for their ephemeral wetland value (Keeler-Wolf *et al.* 1998).

Southeast Sacramento Valley Vernal Pool Region

Beale, Yuba County: The Beale core area is a zone 2 area. Beale AFB, which is within this core area, offers some protection to its pools (Keeler-Wolf *et al.* 1998). An Integrated National Resource Management Plan (INRMP) was created for Beale AFB in 2005; this plan is supposed to be reviewed and updated every five years (S. Rolfsness, Beale AFB, pers. comm., 2007). The Environmental Impact Analysis Section at Beale AFB develops impact avoidance measures for construction projects on the base. Beale AFB conducts pre-construction surveys for listed vernal pool shrimp and restoration of vernal pool habitat to offset the loss of listed vernal pool shrimp habitat during project construction (S. Rolfsness, Beale AFB, pers. comm., 2007). Long-term monitoring of the restored vernal pools is occurring; however, the vernal pool habitat is not protected in perpetuity because the land may be transferred to private ownership after base closure (S. Rolfsness, Beale AFB, pers. comm., 2007).

Cosumnes/Rancho Seco Lake, Amador and Sacramento Counties: The Cosumnes/Rancho Seco Lake core area is a zone 1 area. Within this core area, vernal pool tadpole shrimp have been reported in the following locations: the 405-acre Clay Station Conservation Bank, Laguna Creek Conservation Bank, the 1,427-acre Borden Ranch, and the Apple Road Mitigation Site, all of which are protected by conservation easements (Sugnet and Associates 1998; Conservation Resources, LLC. 1998; S. Egan, ECORP, pers. comm., 2007; C. Feldheim, CLNM, pers. comm., 2007; Center for Natural Lands Management 2007). Another occurrence is located on property owned by Sacramento Municipal Utility District (SMUD), south of Rancho Seco Lake. The property has been designated as a 1,200-acre nature preserve and is currently protected under a 30-month temporary conservation easement, recorded on October 18, 2006, and established by a Memorandum of Understanding between SMUD, TNC, and Sacramento Valley Conservancy (SVC) (A. Rutledge, SVC, pers. comm., 2007). The nature preserve was established for the protection of "ecological and agricultural resources including seasonal vernal pools that support threatened and endangered species" (SMUD 2006), and is the first step in establishing the site as a conservation bank, to be protected under a permanent conservation easement (A. Rutledge, SVC, pers. comm., 2007). Other preserved properties just outside this core area provide suitable habitat for vernal pool tadpole shrimp, including Valensin Ranch and Howard Ranch (CNDDB 2007), which are both part of the Cosumnes River Preserve, which is owned by TNC, BLM, and other public and private entities and managed by TNC and BLM.

Mather, Sacramento County: The Mather core area is a zone 1 area. The Anatolia Conservation Bank, 234-acre Kiefer Landfill Wetland Preserve, Arroyo Seco Mitigation Bank, Bryte Ranch Conservation Bank, the Klotz Open Space Preserve, and the Sacramento Prairie Vernal Pool Complex support occurrences of the vernal pool tadpole shrimp and are protected in perpetuity under conservation easements that require the sites to be managed to benefit federally-listed species, including the vernal pool tadpole shrimp (Conservation Resources, LLC. 1998; California Department of Water Resources, *in litt.*, 2000; Hill 1998; Service 2005a). The Sacramento Valley Conservancy owns and manages 44 acres of the Werre Property, a 215-acre parcel within the Sacramento Prairie Vernal Pool Complex and holds a conservation easement over an additional 30.5 acres on the Werre Property. The remainder of the Werre Property is not yet protected but is proposed to be donated in fee title to the Sacramento Valley Conservancy to partially offset the loss of vernal pool habitat (Aimee Rutledge, SVC, pers. comm., 2007). The conservation easement for the Montelena Preserve, a 50-acre property proposed to be protected to offset the loss of vernal pool habitat from the Montelena subdivision in the city of Rancho Cordova (M. Bresnik, Centex Homes, *in litt.*, 2006), has not yet been recorded, and Mather Park has not yet been afforded protection (C. Witham, CNPS, pers. comm., 2007).

There are many other preserved properties just outside this core area that provide suitable habitat for vernal pool tadpole shrimp. Some of these include the Prairie City State Vehicular Recreation Area (managed by the California State Parks' Off-Highway Motor Vehicle Recreation Division), the Churchill Downs Wetland Preserve, the Laguna Stonelake Preserve, and a 10-acre vernal pool preserve owned by Granite Construction Company (CNDDB 2007). Furthermore, some of the Sacramento County pools are privately owned by ranches and corporations that are party to conservation easements for the pools and their rare species (Keeler-Wolf *et al.* 1998).

The Mather core area, within in the Southeastern Sacramento Valley Vernal Pool Region, contains possibly the highest density of vernal pool tadpole shrimp occurrences within the range of the species. The Southeastern Sacramento Valley vernal pool region supports 35 percent (the largest concentration) of vernal pool tadpole shrimp occurrences (CNDDB 2007; Service 2005a), with approximately 74 percent of all the occurrences in this region occurring in the Mather core area (Service 2007). Surveys within the Mather core area report that at least 50 percent of vernal pools were occupied by vernal pool tadpole shrimp (Jones & Stokes 2005). Other studies have found a similar percent occupancy of vernal pool tadpole shrimp in vernal pools on old terrace formations (Helm 1998), which are concentrated in the Mather core area.

Western Placer County, Placer County: The Western Placer County core area is a zone 2 area. The U.S. Air Force's Lincoln Communication Facility, which was part of the McClellan AFB, is now part of the 220-acre Western Placer Schools Conservation Bank.

Southern Sierra Foothills Vernal Pool Region

Cottonwood Creek, Tulare County: The Cottonwood Creek core area is a zone 2 area. The CDFG's 900-acre Stone Corral Ecological Reserve protects a number of high quality hardpan pools (Keeler-Wolf *et al.* 1998) and is a documented location of the vernal pool tadpole shrimp (CNDDB 2007).

Madera, Madera County: The Madera core area is a zone 1 area. The majority of lands within this core zone are privately owned and not protected or managed for the benefit of vernal pool species. Occurrences of vernal pool tadpole shrimp are documented at the Flying M Ranch, the 254-acre Drayer Ranch Conservation Bank, the 1,067-acre Great Valley Conservation Bank at Flynn Ranch, and the Virginia Smith Trust lands (CNDDB 2007). While The Nature Conservancy has conservation easements for vernal pools on two large parcels of the Flying M Ranch (Keeler-Wolf *et al.* 1998), other portions of this property are not protected under a conservation easement at this time (J. Vollmar, Vollmar Consulting, pers. comm., 2007). The Drayer Ranch Conservation Bank and Great Valley Conservation Bank at Flynn Ranch are protected under conservation easements. During the section 7 consultation process for the U.C. Merced campus, U.C. Merced and Merced County committed to preservation of the Virginia Smith Trust and Campus Natural Reserve parcels, which are adjacent to the U.C. Merced Campus and where vernal pool tadpole shrimp are known to occur. At this time, however, none of these sites have been protected (J. Vollmar, Vollmar Consulting, pers. comm., 2006).

Other areas that may support suitable habitat for the vernal pool tadpole shrimp within this core area include the Ichord Ranch, Knapp Ranch, Nelson Ranch, Cunningham Ranch, and Furey Ranch (J. Vollmar, Vollmar Consulting, pers. comm., 2007). While the Ichord Ranch property is not protected under a conservation easement at this time, the other areas listed above are either partially or wholly protected under conservation easements. (J. Vollmar, Vollmar Consulting, pers. comm., 2007).

Merced, Merced County: The Merced core area is a zone 1 area. Vernal pool tadpole shrimp have been found on Robinson Ranch, of which approximately 4,500 acres is protected by a conservation easement (J. Vollmar, pers. comm., 2007).

Table Mountain, Fresno and Madera Counties: The Table Mountain core area is a zone 1 area. In 1992, the CDFG, California Department of Parks and Recreation, BLM, and TNC purchased Big Table Mountain in Fresno County (Skinner 1997), where three occurrences of vernal pool tadpole shrimp are documented. The extensive parcel owned by TNC has been transferred to the Sierra Foothill Conservancy (SFC) (Keeler-Wolf *et al.* 1998), which manages the grazing activities (C. Peck, SFC, pers. comm., 2007).

Turlock, Merced County: The Turlock core area is a zone 2 area. The Service is not aware of any properties within this core area that are protected for the benefit of vernal pool species.

Threats to Vernal Pool Preserves

Some preserves and conservation banks have been set aside for the protection of vernal pool habitats. However, the over-riding issue of habitat loss is compounded by the foundational problem that much of the land preserved and protected for the benefit of the vernal pool tadpole shrimp could be impacted from lack of management, loss of ecological processes and function, drainage and runoff from residential development, and unregulated off-road-vehicle recreation. These impacts are associated with increasing urban encroachment, climate change, introduction of invasive species, altered hydrology on adjacent lands, and other factors beyond the control of the preserve managers.

Several sites are not adequately protected or appropriately managed. For example, lack of active site management and competition with non-native plants (e.g., *Lolium* spp.) threaten the persistence of vernal pool tadpole shrimp at the Wildwoods Park in the **Chico core area** (J. Marr, CDFG, pers. comm., 2007). Similarly, the BLM's Hog Lake Plateau and Spring Branch Plains areas in the **Dales core area** are variably managed, with some vernal pool sites fenced, under-grazed, and protected from off-highway vehicle use, while others are unfenced and adequately grazed but subject to off-highway vehicle use (G. Diridoni, BLM, pers. comm., 2007). Mather Park in the **Mather core area**, because it has not yet been afforded protection, is subject to damage from illegal off-road vehicle use (C. Witham, CNPS, pers. comm., 2007).

Other sites, some of which may be protected and managed, are subject to threats from activities occurring on adjacent parcels. Vernal pool tadpole shrimp are threatened by recent inundation by poultry manure at the Arena Plains parcel within the Merced NWR (D. Woolington, Service, pers. comm., 2006) in the **Grasslands Ecological Area core area**. Suitable habitats in the **Sacramento NWR core area** could be indirectly affected by changes in hydrology caused by rice farming adjacent to the NWR boundary (J. Silveira, Service, pers. comm., 2006). The Anatolia Conservation Bank in the **Mather core area** has had at least two incidents of excess and unauthorized runoff from the detention basin on the north side (California Regional Water Quality Control Board 2005). The Kiefer Landfill Wetland Preserve, also within the **Mather core area** and adjacent to the future expansion site of the Kiefer Landfill, currently receives wind-blown trash from County trucks transporting garbage to the landfill (Carol Witham, CNPS, pers. comm., 2007; Jones & Stokes 2005). Trash, especially plastic bags, can act as a barrier for rainwater, deter seed germination, and trap emerged juvenile shrimp, thereby reducing survivorship. This site is further threatened by nutrient runoff from the adjacent landfill, proposed developments on adjacent parcels, and landfill management and expansion activities that may breach the clay hardpan and adversely impact hydrological function in the area (C. Witham, CNPS, pers. comm., 2007).

In addition, the protection of vernal pool habitats within conservation banks and preserves may not adequately protect the rare landform types associated with specific species or meet the functional equivalence of the original wetlands ecosystems (see discussion in Wacker and Kelly 2004). In the Southeastern Sacramento Valley Region, Wacker and Kelly (2004) found that the majority of project site characteristics were replicated at the corresponding conservation sites. However, when compared at the landscape scale across all development projects, they found that both the relative percentage and area of relatively rare pool types, such as Northern Volcanic Mudflow pools, are decreasing, while the relative percentage and area of "drainageway" pools, a less specialized pool type with lower species richness, are becoming more common. Although development projects have occurred fairly equally on high and low terrace sites, compensation sites were established disproportionately on low terrace formations (Wacker and Kelly 2004). Such shifts in availability of landform types could have negative consequences for persistence of the vernal pool tadpole shrimp because of the demonstrated importance of old terrace formations to this species (Holland 1978; Keeler-Wolf *et al.* 1998; Service 2005a); the degree of risk, however, is unknown.

The **Mather core area,** which supports high densities of vernal pool tadpole shrimp in vernal pools on old terrace formations, has a limited amount of remaining habitat that could be preserved. All occurrences in the Mather core area are within the area that is covered by the

Draft South Sacramento Habitat Conservation Plan (HCP) (Sacramento County 2006). The Draft South Sacramento HCP states that it will not be possible to meet the Recovery Plan's land goals for the species in the Mather core area. This determination is based on previous land use decisions in the area, and the Draft South Sacramento HCP further notes that the goal of protecting all known occurrences in preserves as large as possible is already restricted by adjacent land use designations and development (Rogers 2006). All occurrences within this core area, many of which are not protected in preserves, are thought to be threatened by surrounding urbanization, hydrological alteration of vernal pools, potentially inappropriate management (including use of herbicides and inappropriate levels of grazing), and competition with introduced and native vegetation. The Draft South Sacramento HCP has proposed a conservation strategy for this area that includes establishing large core vernal pool preserves that are based on watershed boundaries and connected to each other via corridors in order to maintain a contiguous vernal pool ecosystem in south Sacramento County (Sacramento County 2006). This strategy would help to protect the remaining portions of the Mather core area for which preservation may still be attainable.

In summary, despite protection of vernal pool habitat in conservation areas, available information suggests the distribution of these areas is not yet sufficient to provide for their recovery. The existing preserves may represent only a small percentage of the remaining vernal pool habitats, and may not be adequate to ensure the long-term viability of vernal pool tadpole shrimp (ECOS 2002). Many preserves are too small and disconnected from the larger vernal pool landscape to support hydrological function and are subject to numerous edge effects, including invasive plant species and altered site hydrology (J. Marty, TNC, pers. comm., 2007). The emphasis should be on not only protecting additional vernal pool habitats, particularly in the old terrace formation areas that are currently disproportionately under-represented, but also on establishing connective corridors between preserves to restore and maintain relatively contiguous vernal pool landscapes within core areas in order to support the population dynamics of vernal pool tadpole shrimp.

II.C.2.b. Overutilization for commercial, recreational, scientific, or educational purposes:

Overutilization for commercial purposes was not known to be a factor in the 1994 final listing rule (59 FR 48136). Overutilization for any purpose does not appear to be a threat at this time.

II.C.2.c. Disease or predation:

The 1994 final listing rule stated that there were no known diseases affecting the vernal pool tadpole shrimp (59 FR 48136). The Service is not aware of any new information regarding disease as threats to this species. The 1994 final rule also stated that, at the Vina Plains in Tehama County, vernal pool tadpole shrimp experienced decreased fecundity due to parasitization by flukes *(Trematoda)* of an undetermined species (Ahl 1991). It is not known if this is still a limiting factor at this location, or if any other sites are affected.

The 1994 final listing rule noted that predation of vernal pool crustaceans by non-native bullfrogs (*Rana catesbeiana*) potentially increased the threat of predation beyond that found naturally by waterfowl and other native animals. Juvenile bullfrogs disperse readily into vernal

pool complexes from permanent waters during the rainy season, and can spend several weeks or more at pools consuming aquatic invertebrates. In such cases, bullfrogs selectively preyed on macro-crustaceans, such as the California clam shrimp (*Cyzicus californicus*), and coleopterans (beetles), even when other prey was much more abundant (Balfour and Morey 1999). Opportunities for bullfrog dispersal into vernal pool habitats increase as additional permanent water sources are created by urban runoff and irrigated agriculture; however, the effect of such predation on the prey populations in these pools has not been determined (Balfour and Morey 1999). Vernal pool crustaceans lack predator-avoidance mechanisms, and are continuously moving their phyllopods, which may attract bullfrogs and other visual predators. Bullfrog predation of vernal pool tadpole shrimp has been documented (Balfour and Morey 1999).

The use of mosquitofish (*Gambusia affinis*) to control mosquito larvae may be a new and emerging threat for the shrimp that was not identified at the time of the listing in 1994. Human diseases, including malaria, western equine encephalitis, and the West Nile Virus, are transmitted by mosquito species present within the range of the vernal pool tadpole shrimp. Mosquitofish are not native to California, but are introduced into permanent and temporary waters, including roadside ditches, rice fields, and vernal and woodland pools, to control larval mosquitoes. Mosquitofish are typically stocked into waters that are near to human-occupied areas if mosquito larvae become abundant. Although mosquitoes do not typically breed in undisturbed vernal pools, they will breed in pools where the aquatic community or the habitat has been disturbed or degraded (Wright 1991). Mosquitofish have dispersed into vernal pool complexes from adjacent permanent waters (Griggs *et al.* 1991). In addition, mosquito and vector control districts provide mosquitofish to the public, although guidelines generally stipulate that the public only put the fish in artificial water bodies. Introduced mosquitofish have been shown to significantly reduce fairy shrimp abundance when introduced to pools with active shrimp (Leyse *et al.* 2004). Vernal pool fairy shrimp are cool-water species (Ericksen and Belk 1999), and generally pass through their active life-phase before mosquito and vector control districts in the Central Valley stock the mosquitofish in spring. However, mosquitofish are routinely stocked in rice fields and are abundant in canals and other permanent water sources within the vicinity of extant vernal pool habitat. Under normal winter weather conditions, stocked mosquitofish could invade vernal pool habitats through overland flow or drainage ways when the vernal pool fairy shrimp are active. Small numbers of adult mosquitofish can significantly reduce abundance of fairy shrimp within five weeks (Leyse *et al.* 2004), and could potentially be a substantial threat at sites where fairy shrimp abundance is low. Mosquitofish are able to move into vernal pools from nearby canals or other permanent water sources, or from where they are placed into temporary waters during the shrimp's active period (Griggs *et al*., 1991).

In summary, two introduced predators, bullfrogs and mosquitofish, are known to disperse into vernal pool habitat during the time of year when vernal pool tadpole shrimp are active. These predators are good dispersers and are found throughout the range of the shrimp. The permanent-water habitat for these species is known to be increasing within the state due to the increased presence of irrigation and drainage canals and reservoirs around vernal pool habitats, as well as increased runoff from agricultural and urban developments. These conditions may convert vernal pool habitats into permanent water sources (Balfour and Morey 1999), which support predators such as bullfrogs and mosquitofish (Eriksen and Belk 1999). Both introduced species

pose a continuing threat to the vernal pool tadpole shrimp, but the magnitude of the threat is unknown at this time; therefore, more research on this is necessary.

II.C.2.d. Inadequacy of existing regulatory mechanisms:

Federal Protections

Endangered Species Act: The Endangered Species Act of 1973, as amended (Act), is the primary Federal law that provides protection for vernal pool tadpole shrimp. Section 7(a)(2) requires Federal agencies to consult with the Service to ensure any project they fund, authorize, or carry out does not jeopardize a listed species. Since 1994, the Sacramento Fish and Wildlife Office has issued approximately 496 biological opinions under section 7 of the Act that minimize development impacts to the vernal pool tadpole shrimp. The majority of the vernal pools covered under these biological opinions have not been surveyed, and the project proponents have simply assumed presence of the vernal pool tadpole shrimp. Impacts to the vernal pool tadpole shrimp would not necessarily be addressed if the species were removed from protection under the Act.

Similarly, if a Federal agency is not involved in a proposed project, and federally-listed species may be taken as part of the project, then project proponents may apply for an incidental take permit pursuant to section 10(a)(1)(B) of the Act. The Service may issue such a permit upon completion of a satisfactory habitat conservation plan (HCP) for the listed species that would be taken by the project. HCPs are designed to minimize and mitigate the effects of authorized incidental take. To date, there are three Service-approved HCPs that cover the vernal pool tadpole shrimp. These plans are the Kern Water Bank HCP, the Natomas Basin Revised HCP and Litigation Resolution, and the San Joaquin Multi-Species Habitat Conservation and Open Space Plan (ECOS 2007). The majority of the vernal pools covered under these HCPs have not been surveyed and the project proponents have assumed presence of vernal pool tadpole shrimp. Vernal pool tadpole shrimp also will be a covered species for the East Contra Costa County HCP/Natural Communities Conservation Plan, Solano County Multi-species HCP, and South Sacramento HCP (Sacramento County 2006), which are currently in development and not yet finalized.

Clean Water Act: Section 404 of the Clean Water Act may afford some protection to vernal pool tadpole shrimp if it were to be delisted. The U.S. Army Corps of Engineers (Corps) issues permits for the discharge of dredged or fill material into navigable waters of the United States. The Corps interprets “the waters of the United States” expansively to include not only traditional navigable waters, but also other defined waters (including some types of wetlands) that are adjacent or hydrologically connected to traditional navigable waters. Before issuing a 404 permit to a project applicant that may affect federally listed species, the Corps is required under section 7 of the Act to consult with the Service. However, recent Supreme Court rulings have called into question the Corps’ definition of Waters of the U.S. On June 19, 2006, the U.S. Supreme Court vacated two district court judgments that upheld this interpretation as it applied to two cases involving “isolated” wetlands. Currently, the Corps regulatory oversight of vernal pools is in doubt because of their “isolated” nature. If the Corps loses its regulatory authority

over vernal pools, unmitigated destruction of potential habitat for vernal pool tadpole shrimp may increase over the range of the species.

National Environmental Policy Act: The National Environmental Policy Act (NEPA) (42 U.S.C. 4321 et seq.) requires all Federal agencies to formally document, consider, and publicly disclose the environmental impacts of major federal actions and management decisions that have significant effects on the human environment. NEPA requires agencies to consider the need for mitigation but does not require or guide implementation of mitigation for impacts. Additionally, NEPA applies only to actions by Federal agencies, so private landowners are not required to comply with NEPA unless a Federal agency is involved by funding or permitting a proposed project or action. Although NEPA requires public disclosure of the effects of Federal actions, it does not afford direct protection to the vernal pool tadpole shrimp.

Sikes Act Improvement Act: In 1997, Section 101 of the Sikes Act (16 U.S.C. 670a (a)) was revised to authorize the Secretary of Defense to implement a program to provide for the conservation and rehabilitation of natural resources on military installation. To do so, the Department of Defense (DOD) was required to work with Federal and State fish and wildlife agencies to prepare Integrated Natural Resource Management Plans (INRMPs) for each facility with significant natural resources. The INRMPs provide a planning tool for future base improvements, and also provide for sustainable multipurpose use of natural resources, including activities such as hunting, fishing, trapping, and non-consumptive uses; INRMPs also must allow some public access to military installations to facilitate the use of natural resources. The implementation of these plans is subject to funding availability. On DOD lands, including Beale and Travis Air Force Bases, vernal pool habitat is generally protected from large-scale development. However, the primary purpose for military lands is to provide for military support and training, and vernal pool habitat is subject to impacts from military operations. At Beale AFB, Travis AFB, and other bases, INRMPs provide direction for project development and for the management, conservation, and rehabilitation of natural resources.

Other Federal Lands. Management plans may also provide direction for management of natural resources, including the vernal pool tadpole shrimp, on National Forests, BLM lands, and NWR lands. The vernal pool tadpole shrimp is present on the Sacramento NWR in Glenn and Colusa Counties; the Sacramento River NWR, Llano Seco Unit, in Butte County; the Don Edwards San Francisco Bay NWR; the San Luis NWR; the San Joaquin River NWR; and the Merced NWR. The administrative draft Comprehensive Conservation Plan (CCP) for the Sacramento NWR addresses surveys and habitat management for the species (J. Silveira, NWR, *in litt.*, 2007). San Joaquin River NWR has completed their CCP which addresses the vernal pool tadpole shrimp (Eric Hobson, San Joaquin River NWR, pers. comm., 2007). CCPs for the Don Edwards, San Luis, and Merced NWRs; however, are either in the early stages of development or work is not yet slated to begin (J. Silveira, *in litt.*, 2007; Ivette Loredo, Don Edwards San Francisco Bay NWR, pers. comm., 2007; K. Stromayer, San Luis NWR, pers. comm., 2007); therefore, on these refuges, it is not yet known how conservation of the tadpole shrimp will be addressed. On these Federal lands, effects to vernal pool tadpole shrimp are addressed during section 7 consultations with the Service.

State Protections

California State Laws: The State's authority to conserve wildlife includes the California Endangered Species Act (CESA) and the California Environmental Quality Act (CEQA). While the vernal pool tadpole shrimp is not listed under CESA, it must be considered under CEQA as a rare species (Section 15380, Public Resources Code). CEQA (chapter 2, section 21050 *et seq.* of the California Public Resources Code) requires government agencies to consider and disclose environmental impacts of projects and to avoid or mitigate them where possible. Under CEQA, public agencies must prepare environmental documents to disclose environmental impacts of a project and to identify conservation measures and project alternatives. Through this process, the public can review proposed project plans and influence the process through public comment. However, CEQA does not guarantee that such conservation measures will be implemented.

II.C.2.e. Other natural or manmade factors affecting its continued existence:

Other natural or manmade threats cited in the 1994 final listing rule for vernal pool tadpole shrimp include stochastic (random or unpredictable) extinction and genetic bottlenecking due to the high degree of isolation and small population sizes of this species (59 FR 48136). Habitat for vernal pool tadpole shrimp continues to be highly fragmented throughout its range due to conversion of natural habitat for urban and agricultural uses. This fragmentation, along with the isolated nature of vernal pool tadpole shrimp occurrences, increases the chance of extinction for this species. Such isolated occurrences may be highly susceptible to extirpation due to chance events or additional environmental disturbance (Gilpin and Soulé 1986; Goodman 1987). If an extirpation event occurs in an occurrence that is isolated or has been fragmented, the opportunities for recolonization will be greatly reduced due to physical isolation from other source occurrences.

Current threats to the vernal pool tadpole shrimp include stochastic extinction as discussed in the 1994 final rule. In addition, new threats that were identified after the listing are discussed below. These include threats from contaminants, invasive plants, and drought and climate change.

Contaminants

The CNDDB (2007) reports occurrences being threatened by biocides in the Solano-Colusa and Southeastern Sacramento Valley Vernal Pool Regions, although the magnitude of this threat is not known at this time.

Petroleum products, pesticides, herbicides, and other chemicals can be conveyed into the vernal pool habitats by overland runoff during the rainy season, thereby adversely affecting water quality and altering the water chemistry of vernal pools (e.g., pH), which may make conditions unsuitable for vernal pool crustaceans (Johnson 2005; C. Johnson, *in litt.*, 2007; Weston *et al*., 2005; Weston *et al*. 2006). Many of these chemical compounds are thought to have adverse effects on all of the listed vernal pool crustaceans and/or their cysts, with individuals being killed directly or suffering reduced fitness through physiological stress or a reduction in their food base due to the presence of these chemicals (Sheldon *et al.* 2003). 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).

The introduction of pesticides and other contaminants into vernal pool waters may threaten occurrences of the vernal pool tadpole shrimp. Vernal pools are hydrated by winter precipitation, which often includes pesticides (e.g., herbicides, insecticides, fungicides) that have volatized and are atmospherically transported. In 2003, approximately 175,127,171 pounds of pesticides were applied in California and the greatest use was in Central Valley counties with extensive vernal pool habitat (Johnson 2005). Although little information exists on the effects of pesticides to vernal pool tadpole shrimp, studies have considered the effects on other macro-invertebrates, including crustaceans (Brausch and Smith 2005, Weston *et al*., 2005, Lawrenz 1984). Such studies have shown that exposure to pesticides may include sub-lethal deleterious effects, including behavioral impairments related to foraging, movement, and predator avoidance.

Brausch and Smith (2005) looked at the acute toxicity levels of four commonly used agricultural pesticides (Tempo [cyfluthrin], methyl parathion, Roundup [glyphosate], and Karmex [diuron]) in three different strains of the fairy shrimp, *Thamnocephalus platyurus*. One strain of the shrimp experienced lethal toxicity at 1.19 micrograms per liter for Tempo and 801.61 micrograms per liter for Roundup. Pesticide effects include the effects of the surfactants formulated with the active ingredient. For example, polyethoxylated tallowamine (POEA) is a surfactant that is commonly used in herbicide formulations to increase the efficacy of active ingredients. It is also known to cause alterations in respiratory surfaces of animals. POEA use has increased recently with the advent of "Roundup-Ready" crops; however, its potential effects on aquatic invertebrates are relatively unknown. Brausch and Smith (2007) used *T. platyurus* to assess the acute toxicity of POEA and found it to be extremely toxic at low concentrations. Based on these results, we consider POEA has the potential to adversely affect vernal pool tadpole shrimp in areas in which it is used.

Additional pesticides that are found in vernal pools due to atmospheric deposition have been found to be toxic to another vernal pool crustacean, the cladoceran *Ceriodaphnia dubia*. The pesticides bromoxynil, dicamba, 2,4-D, MCPA, triallate, trifluralin, pentachlorophenol, lindane, and 4,4´-DDT have been detected in appreciable quantities as mixtures(?) in dry atmospheric deposits. The toxicity of this pesticide mixture was determined to be due to the DDT component, which is commonly detected in surface waters (George *et al.* 2003). Concentrations of the pesticide Diazinon, found in vernal pools on NWR complexes in the Sacramento and San Joaquin Valleys, occur at levels that could have adverse effects on vernal pool species, including the vernal pool tadpole shrimp. Detectable levels of Endosulfane, Hexazinone, Trifluralin, and Simazine were also present in sampled pools at levels which could be also be toxic to the shrimp, although their effects on listed vernal pool species have not been studied (Johnson 2005).

Recent research suggests that pyrethroid insecticide use in residential developments will cause toxicity, and even mortality, to aquatic species (Weston *et al.* 2005). The application of these insecticides and subsequent runoff into aquatic features surrounding residential developments was demonstrated to be a limiting factor for aquatic invertebrates; in fact, the abundance of

resident macroinvertebrates was inversely correlated with concentrations of pyrethroid insecticides (Weston *et al.* 2005).

Non-native Invasive Plants

Non-native grasses occur commonly in vernal pool complexes and have become a threat to native vernal pool species through their capacity to change pool hydrology. Non-native grasses maintain dominance at pool edges, sequestering light and soil moisture. Italian ryegrass (*Lolium multiflorum*) and waxy mannagrass (*Glyceria declinata*) increase thatch buildup, which leads to increased oxygen depletion in the pools (Dunne and Leopold 1978) and contributes to the shortening of inundation periods through increased evapotranspiration (Marty 2005) and reduces the amount of water entering the system through surface and subsurface flows (Robins and Vollmar 2002).

As vernal pool complexes become surrounded by residential development and disturbed habitat, the likelihood of invasion by non-native plants increases (Zedler and Black 2004). Residential and municipal landscaping provides a constant seed-source of non-native plants. Urban runoff, combined with the urban seed-source, are likely to convert the vernal pools to patches of non-native weeds and grasses. Activities such as deep-ripping (breaking up the clay pan by thrusting metal prongs into the soil and dragging them with heavy machinery so water can drain from the area) and gravel mining disturb the habitat and allow non-native species to become more easily established (Service 2005a). Small reserves may be particularly susceptible to degradation by non-native species, particularly when the reserves are located in a matrix of development and are associated with chronically disturbed transportation corridors (Zedler and Black 2004).

Non-native plants are becoming an increasing threat to vernal pool communities. The Recovery Plan identifies the encroachment of non-native annual grasses on the San Francisco Bay NWR in the Central Coast Vernal Pool Region as a particular problem for the vernal pool habitat supporting the vernal pool tadpole shrimp (CNDDB 2007). Non-native plant species have been identified as a threat to vernal pool tadpole shrimp habitat at the Davis Communication Center Site, Yolo County; Vina Plains, Tehama County; Big Table Mountain, Fresno County; and the Sacramento Vernal Pool Preserve and Mather Field, Sacramento County (CNDDB 2007).

At Vina Plains and Big Table Mountain, the increase of non-native grasses has been attributed to the lack of grazing, and it has been suggested that a carefully monitored grazing program may decrease the threat posed by non-native plants (J. Marty, TNC, pers. comm., 2007; C. Peck, SFC, pers. comm., 2007; R. Reiner, TNC, pers. comm., 2007). Otherwise, fire management may be employed at some sites to reduce invasive plants (J. Silveira, Service, *in litt.*, 2007). Studies in San Diego (Wells *et al.* 1997) suggest that fire does not destroy vernal pool crustacean cysts, and that they re-hydrate in similar densities to cysts not exposed to fire. It is more likely that the lack of fire, coupled with the lack of grazing, would increase the densities of non-native herbaceous vegetation surrounding the pools, degrading the habitat (Wells *et al.* 1997).

Climate Change

Climate scientists expect California's climate will become warmer within the 21st century (Cayan *et al*. 2005; Field *et al*. 1999). Even modest changes in warming could result in a reduction of the spring snowpack, earlier snowmelt, more runoff in winter with less runoff in spring and summer, more winter flooding, and drier summer soils (Cayan *et al.* 2005; Field *et al*. 1999). Vernal pool tadpole shrimp are dependent upon ephemeral freshwater habitats such as vernal pools and seasonal wetlands, signifying the importance of water availability on the survival and recovery for this species.

Climate change is expected to contribute to prolonged drought conditions in some part of California (Lenihan *et al.* 2003; Pyke 2004). The vernal pool tadpole shrimp is dependent on vernal pools that have sufficient volume to remain wet throughout the annual reproductive phase of the species, and is therefore dependent on vernal pools that hold water during drought years and especially during drought sequences. The larger and deeper vernal pools will hold water during the driest years and thus are essential for the survival of the species as these pools provide source populations following periods of drought. As discussed above in sections II.C.1.d. and III.C.2.a., large and deep vernal pools, particularly ones that are adequately protected, are limited throughout the range of the species. Where populations persist on only marginal habitat, the addition of drought conditions may result in high rates of mortality in the short term, with the effects of low reproductive output and survivorship persisting after the drought has ceased. It is unknown how quickly vernal pool tadpole shrimp populations may rebound after severe climatic conditions.

Climate change also may result in the alteration of vernal pool habitats through warmer temperatures, and greater winter precipitation and increased winter runoff, which would increase the periods and frequencies of inundation of vernal pools in the Central Valley of California (Pyke 2005b). As discussed above in sections III.C.2.a. and II.C.2.c., increased periods and frequencies of inundation in vernal pools transform these ephemeral habitats into more permanently flooded features, promoting habitat for invasive and predatory species, such as bullfrogs and mosquitofish, and reducing the suitability of habitat for vernal pool tadpole shrimp.

Scientists expect shifts in the distribution and abundance of many species in response to climate change (McLaughlin *et al*. 2002; Pyke 2004), including vernal pool species. Some species may be incapable of range shifts due to low dispersal ability combined with factors such as the loss of potential habitat from development, occupation of potential habitat by non-native species, and lack of appropriate soil substrates (Field *et al*. 1999). Remnant suitable habitats, even within conservation banks, may be too far apart to allow dispersal or natural re-colonization after a disturbance (Field *et al*. 1999). Pyke (2004, 2005b) found that existing preserves for three vernal pool crustaceans in California tended to be located in drier areas; therefore, if wetter areas are not protected, the existing preserves would likely not be able to sustain vernal pool species that require longer periods of inundation. The continued fragmentation of vernal pool tadpole shrimp habitat throughout its range will result in small isolated occurrences of this species. If a local extirpation event, such as a prolonged drought cycle, occurs in a population that has been fragmented and isolated, the opportunities for recolonization will be greatly reduced due to physical isolation from other source populations. Further, we expect that loss of viability of

individual vernal pools and the loss of connectivity between the pools with remaining vernal pool tadpole shrimp habitat would lead to a reduction of range for the species

Drought-caused decreases in water depth and inundation period at vernal pools may also facilitate invasion of pools by non-native plants and lead to altered competitive outcomes (Gerhardt and Collinge 2003). On the small scale, these changes could alter the habitat so that non-native species have a competitive advantage over native species, because climate and landscape factors are of ultimate importance in determining the range of a species (Lenihan *et al.* 2003; Pyke 2005a).

II.D. Synthesis

We have no information to suggest that threats to vernal pool tadpole shrimp have been substantially reduced since the time of listing in 1994. Some threats, such as habitat loss and fragmentation, have continued and increased over a substantial portion of the range, particularly in expanding urban areas such as Chico in Butte County, southern Sacramento County, and in the University of California Merced area in Merced County. The modification and destruction of occupied habitat caused largely by urban development and conversion of natural lands to agriculture and the resulting habitat fragmentation over the landscape were the primary threats to the vernal pool tadpole shrimp at the time of listing and continue to be the primary threats to the species today. Additionally, altered site hydrology, inappropriate levels of grazing, contaminant runoff into vernal pools, stochastic extirpation, and prolonged drought are also major threats which were known at the time of listing and remain as threats today. Since the time of listing; however, several new threats have become known, including invasive plants, mosquito fish (*Gambusia affinis*), and climate change.

There are currently 226 known occurrences of this species recorded in the CNDDB (2007), of which at least two are thought to be extirpated (CNDDB 2007; P. Balfour, ECORP, pers. comm., 2007). Many occurrences on private property were last surveyed 10 to 15 years ago and their current status is unknown. Since the time of listing, the species has been discovered in four additional counties (Contra Costa, Fresno, Kings, and Tulare Counties), extending the range by approximately 100 miles to the south into Tulare County. The greatest number of vernal pool tadpole shrimp occurrences are located in Sacramento County (CNDDB 2007), and the Mather core area, within in the Southeastern Sacramento Valley Vernal Pool Region, likely contains the highest density of vernal pool tadpole shrimp occurrences within the range of the species (CNDDB 2007; Service 2007). This area, well known for its vernal pools of exceptional quality and representing important, high quality habitat for the vernal pool tadpole shrimp (Rogers 2006), has a limited amount of remaining habitat that is able to be preserved (Sacramento County 2006; R. Radmacher, Sacramento County, pers. comm., 2007).

The overall trend of the species is difficult to assess due to lack of systematic surveys (S. Foreman, LSA, pers. comm., 2007; C. Witham, CNPS, pers. comm., 2007). Species experts agree, however, that the status of the vernal pool tadpole remains precarious because the prime habitat for this species, particularly in Southeastern Sacramento Valley Vernal Pool Region where some of the most important and highest quality habitat for this species is located, is rapidly being lost, degraded, and fragmented as a result of urbanization, agricultural conversion,

and road construction and expansion (C. Witham, CNPS, pers. comm., 2007; J. Marty, TNC, pers. comm., 2007).

Although preserves and conservation banks have been set aside for the protection of vernal pool habitats, the long-term sustainability and viability of vernal pool tadpole shrimp within these preserves is not yet known. At sites that have management and monitoring plans in place, the plans in most cases are too new to determine whether they adequately facilitate maintenance of vernal pool ecosystem function. Studies have demonstrated that the current configuration of vernal pool habitats within conservation banks and preserves may not adequately protect the rare landform types associated with the vernal pool tadpole shrimp or meet the functional equivalence of the original wetlands ecosystems (Wacker and Kelly 2004), and such configurations are not likely to sustain vernal pool species that require longer periods of inundation in the event of a prolonged drought (Pyke 2004, 2005b). Therefore, despite protection of vernal pool habitat in conservation areas, available information suggests the distribution of these areas is not yet sufficient to provide for the species' recovery.

The distribution of the vernal pool tadpole shrimp remains patchy and sporadic throughout its range, often inhabiting only one or a few vernal pools in otherwise more widespread vernal pool complexes (Rogers 2001). Habitat for vernal pool tadpole shrimp continues to be highly fragmented throughout its range due to conversion of natural habitat for urban and agricultural uses. This fragmentation, along with the isolated nature of the vernal pool tadpole shrimp populations, increases the chance of extinction for this species.

Despite progress toward meeting recovery criteria (such as protected occurrences in core areas and newly discovered occurrences since listing), without the protections of the Act the vernal pool tadpole shrimp would be at risk of extinction from habitat loss and fragmentation associated with urban development and other threats. Based on the rare nature of this species, the continuing loss and fragmentation of its habitat to urban and agricultural development, threats from altered hydrology, non-native invasive or predatory species, reduced dispersal of the shrimp eggs and adults, contaminated runoff, inappropriate grazing, climate change, and the risk of local extirpations from stochastic events, we conclude that the vernal pool tadpole shrimp still meets the Act's definition of endangered. No status change is recommended at this time.

III. RESULTS

III.A. Recommended Classification:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist (*Indicate reasons for delisting per 50 CFR 424.11):*
____ *Extinction*
____ *Recovery*
____ *Original data for classification in error*
_X_ No change is needed

III.B. New Recovery Priority Number: N/A

We recommend that the recovery priority number remain 2C.

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

The following recommendations for future actions are from the Recovery Plan (Service 2005a) and discussions on the species' status and needs with several recognized vernal pool tadpole shrimp experts (P. Balfour, ECORP, pers. comm., 2007; C. Feldheim, CLNM, pers. comm., 2007; J. Marty, TNC, pers. comm., 2007; R. Radmacher, Sacramento County, pers. comm., 2007; C. Witham, CNPS, pers. comm., 2007; C. Rogers, Eco-Analysts, pers. comm., 2007):

1. Additional preservation of known extant occurrences is needed to reduce threats and reach recovery goals outlined in the Recovery Plan. Thus, preservation of Zone 1 and 2 core areas should be pursued. The areas requiring the highest conservation action due to loss of habitat and/or lack of protected areas include: the Northwestern Sacramento Valley (where there are limited protected areas, limited restoration possibilities, and rapid urban expansion, particularly in the Redding area); the Northeastern Sacramento Valley (where, despite the presence of some large preserves, there are limited protected areas in much of the region, a high number of sensitive species, and a high urban-conversion rate); the Southeastern Sacramento Valley (where there are limited protected areas and a high urban-conversion rate); the San Joaquin Valley (where greater emphasis on pool conservation is needed in the northeastern and south portions of the valley); and the Southern Sierra Foothills (where large areas of the region are being urbanized or converted to agriculture without vernal pool resource mitigation). The Service should work with private landowners for the conservation of vernal pool tadpole shrimp through conservation easements or other methods.

2. A standardized formal monitoring program should be developed and implemented to collect data in sufficient detail to evaluate species status, and examine changes in population dynamics and community composition. Monitoring should be conducted in areas with known occurrences throughout the range of this species, including revisiting historical survey sites. Many occurrences reported in the CNDDB (2007) have not been visited in over a decade. An updated status-review of all known occurrences should be completed. In addition, a state-wide vernal pool habitat mapping inventory should be implemented to quantify the actual acreage of vernal pools and acres protected.

3. Research should be conducted on the extant distribution of the vernal pool tadpole shrimp, to better understand why it is absent from seemingly suitable vernal pools that are located between areas that are known to be occupied by this species and to understand the specifics of pools where this species occurs. Additional research should be conducted at regularly surveyed sites to incorporate research recommendations outlined in the Recovery Plan.

4. Results from monitoring and research should be included in the management plans for protected sites supporting occurrences of this species. There is a need to develop management indicators for identifying potential problems and assessing ecosystem health as it pertains to vernal pool crustaceans. Requirements for appropriate management of vernal pool landscapes

also must be established. Because of urban encroachment and resulting hydrological changes, conservation efforts should be focused on managing for unseasonable sources of water that infiltrate vernal pool preserves, resulting in changed site hydrology. Improved guidelines and success criteria also should be established for the monitoring of constructed and restored pools.

5. Presence-absence survey guidelines should be improved. The current methodology is not always effective for documenting the presence of the species with confidence, given the species adaptations to environmental fluctuations. Surveys, monitoring of conservation areas, and reporting should be standardized so that data can be systematically compared across sites.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW OF VERNAL POOL TADPOLE SHRIMP (*Lepidurus packardi*)

Current Classification: Endangered
Recommendation resulting from the 5-Year Review

____ **Downlist to Threatened**
____ **Uplist to Endangered**
____ **Delist**
__X__ **No change is needed**

Appropriate Listing/Reclassification Priority Number, if applicable __N/A___

Review Conducted By ___Sacramento Fish and Wildlife Office Staff_

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve _____ Date 9·25·07

REGIONAL OFFICE APPROVAL:

Lead Regional Director, Fish and Wildlife Service

Approve _____ Date 9/28/07