U.S. Fish & Wildlife Service

Draft Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon

Draft Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon

(October 2004)

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

Approved: XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

Manager, California/Nevada Operations Office, Region 1,
U.S. Fish and Wildlife Service

Date: _____

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

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

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

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

DISCLAIMER

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

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PLAN PREPARATION

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

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GUIDE TO RECOVERY PLAN ORGANIZATION

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

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EXECUTIVE SUMMARY

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

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

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

use, and inappropriate grazing regimes (overgrazing or undergrazing). Resulting small population sizes are subject to extinction due to random, naturally occurring events.

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

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

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

Interim goals of this draft recovery plan are to:

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

The overall objectives of this draft recovery plan are to:

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

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

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

1. Habitat Protection

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

2. Adaptive Habitat Management, Restoration, and Monitoring

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

3. Status Surveys

Declines in species populations must be halted and/or reversed and threats to the populations ameliorated or eliminated if populations are to be self-sustaining and ultimately warrant delisting. Rangewide species monitoring through use of standardized status surveys will be necessary to determine whether recovery criteria regarding population sustainability and habitat protections are being met. Additionally, standardized status surveys will assist in eliminating data shortfalls regarding whether occurrences are actually extant. The surveys will include the current status of threats, the historical management regimes associated with the species, and may identify additional species occurrences that will contribute to recovery.

4. Research

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

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

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

5. Participation and Outreach

Participation of many groups, including other Federal, State, and local agencies, conservation organizations, private groups, interested stakeholders, and private landowners, will be essential to achieving the recovery goals for the covered species. This draft recovery plan includes establishing regional recovery implementation working groups representing a diversity of partners from

stakeholder groups and Federal, State, and local agencies. These working groups will guide implementation of recovery actions within their regions necessary to achieve recovery goals. In addition to establishing participation of a broad range of partners in recovery implementation, outreach and education will be necessary to inform landowners and partners of recovery opportunities and to garner public support and participation in the recovery process.

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

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

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

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

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

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

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

establishing regional recovery implementation working groups; and 7) develop and implement participation programs in the form of outreach and education.

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

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

Priority 1 actions: $773,048,400

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

Priority 2 actions: $1,107,421,300

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

Priority 3 actions: $202,926,340

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

Date of Recovery: Recovery is defined in relation to a climatological cycle for most species covered in this draft recovery plan. If recovery criteria are met, we estimate most listed species covered in this draft recovery plan could be recovered by 2062 (58 years), based on the interval between the last two droughts of 5 years or longer.

Vernal Pool Recovery Plan Implementation: This draft recovery plan is designed to be implemented in a logical, progressive manner; emphasizing the completion of recovery actions in order of priority in Priority 1 core areas (683,000 acres) first, then in additional core areas (Priority 2 and 3), as necessary, until recovery is achieved. This strategy maximizes the efficiency of recovery and minimizes the costs of recovery by focusing efforts on actions in core areas that will have the greatest benefit to the species. If all recovery actions are implemented in all three priority core area levels and recovery is still not achieved, actions will be implemented, as necessary, within all suitable habitat within the designated "vernal pool regions" until recovery goals are met.

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

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

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I. INTRODUCTION

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

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

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

A. OVERVIEW

1. Species Represented

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

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

Thirteen plant and animal species of concern that occur within vernal pools are fully considered in this draft recovery plan (**Table I-1**). One of these species, *Plagiobothrys hystriculus* (bearded popcorn flower) is presumed extinct.

Critical Habitat

Of the 20 federally listed species included in this draft recovery plan, critical habitat has been designated for 10 plants and 4 animals within the *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon* (U.S. Fish and Wildlife Service 2003). Critical habitat for one plant, *Limnanthes floccosa* ssp. *californica* (Butte County meadowfoam), was dropped from the final designation due to the exclusion of lands within Butte County pursuant to section 4(b)(2) of the Endangered Species Act. Additionally, critical habitat has been designated for the delta green ground beetle (U.S. Fish and Wildlife Service 1980c).

Critical habitat affects Federal agencies by requiring them to evaluate the effects that any activities they fund, authorize, or carry out may have on listed species. Agencies are required to ensure that such activities are not likely to jeopardize the survival of a listed species or adversely modify (*e.g.*, damage or destroy) its critical habitat. By consulting with us, Federal agencies can usually minimize or avoid any potential conflicts and, thus, activities usually proceed in some form. It should be noted that critical habitat designation does not create a wilderness area, preserve, or wildlife refuge. It applies only to activities sponsored at least in part

Table I-1. Species addressed in the Vernal Pool Ecosystem Draft Recovery Plan.

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

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

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

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

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

[2] Vernal Pool Regions based on Keeler-Wolf (1995).

NE Sac= northeastern Sacramento Valley SE Sac= southeastern Sacramento Valley

NW Sac= northwestern Sacramento Valley So.= southern

W.= western

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

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

[5] Klamath Mtn. Vernal Pool Region not based on Vernal Pool Regions from Keeler-Wolf (1995).

by Federal agencies. Such federally-permitted land uses as grazing and recreation may take place if they do not adversely modify critical habitat. Designation of critical habitat does not constitute a land management plan nor does it signal any intent of the government to acquire or control the land. Therefore, if there is no Federal involvement (*e.g.*, Federal permit, funding, or license), activities of a private landowner, such as farming, grazing or constructing a home, generally are not affected by a critical habitat designation, even if the landowners' property is within the geographical boundaries of critical habitat. Without a Federal nexus to a proposed action, designation of critical habitat does not require that landowners of State or other non-Federal lands do anything more than they would otherwise do to avoid take under provisions of section 9 and 10 of the Endangered Species Act.

2. Classification of Vernal Pools

Several efforts are underway to classify vernal pools in California. These efforts will facilitate refinement of important sites for species recovery, but most classifications are not yet complete or are not comprehensive. At this time, the geographic distribution of the endangered, threatened, and rare vernal pool taxa in this draft recovery plan can best be represented by the vernal pool regions defined in the California Department of Fish and Game, *California Vernal Pool Assessment Preliminary Report* (Keeler-Wolf *et al.* 1998). Keeler-Wolf *et al.* (1998) defined the vernal pool regions as discrete geographic regions identified largely on the basis of endemic species, with soils and geomorphology as secondary elements, although there is some overlap of these features among vernal pool regions. Overall, these vernal pool regions are representative of the range of biotic and abiotic features for the ecosystem and species covered in this draft recovery plan.

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

The vernal pool regions described and discussed in this draft recovery plan correspond closely to those regions defined by the California Department of Fish and Game (Keeler-Wolf *et al.* 1998). Deviation from the boundaries of the California Department of Fish and Game vernal pool regions was necessary in certain instances where recent data from the California Natural Diversity Database (2003) and other sources suggest the inclusion of additional areas based on species occurrences, vernal pool habitat, watershed boundary data, topographic features, Holland (1998) data, and the National Hydrography Dataset. Seven vernal pool regions discussed in this draft recovery plan have boundaries that differ slightly from the Keeler-Wolf *et al.* (1998) vernal pool region boundaries. Modified regions include Carrizo, Central Coastal, Lake-Napa, Modoc Plateau, Northeastern Sacramento Valley, Solano-Colusa, and Santa Barbara. Specific modifications are described in the discussion of individual vernal pool regions in the Recovery Chapter. Since the Keeler-Wolf *et al.* (1998) vernal pool regions did not include Oregon, one vernal pool region (Klamath Mountains) has been defined for species occurring in that state based on species occurrence data and watershed boundaries.

The species addressed in this draft recovery plan inhabit 16 of the original 17 vernal pool regions defined by the California Department of Fish and Game (Keeler-Wolf *et al.* 1998) (**Figure I-I**).

3. Factors in the Development of Vernal Pools

The three most important physical factors in the development of vernal pools are climate, soil, and topography. The climate in California and southern Oregon, classified as Mediterranean due to its rainy winters and dry summers, results in the filling and drying of pools during the wet and dry seasons, respectively. Vernal pools form where precipitation and surface runoff become trapped or "perched" above an impermeable or nearly impermeable layer of soil (Smith and Verrill 1998). Sawyer and Keeler-Wolf (1995) classified California vernal pools according to a number of physical, geographic, and biological characteristics. The vernal pool types dealt with in this draft recovery plan were identified as Northern Hardpan, Northern Claypan, Northern Basalt Flow, Northern Volcanic Mudflow, and Northern Volcanic Ashflow vernal pools.

A second major factor in the development of vernal pools is soil. Vernal pools form where a soil layer exists below or at the surface that is impermeable or nearly impermeable to water (Smith and Verrill 1998). The northern hardpan layers are formed on alluvial terraces by leaching, redeposition, and cementing of silica minerals from high in the soil profile to a lower ("B") horizon (Smith and

Vernal Pool Regions

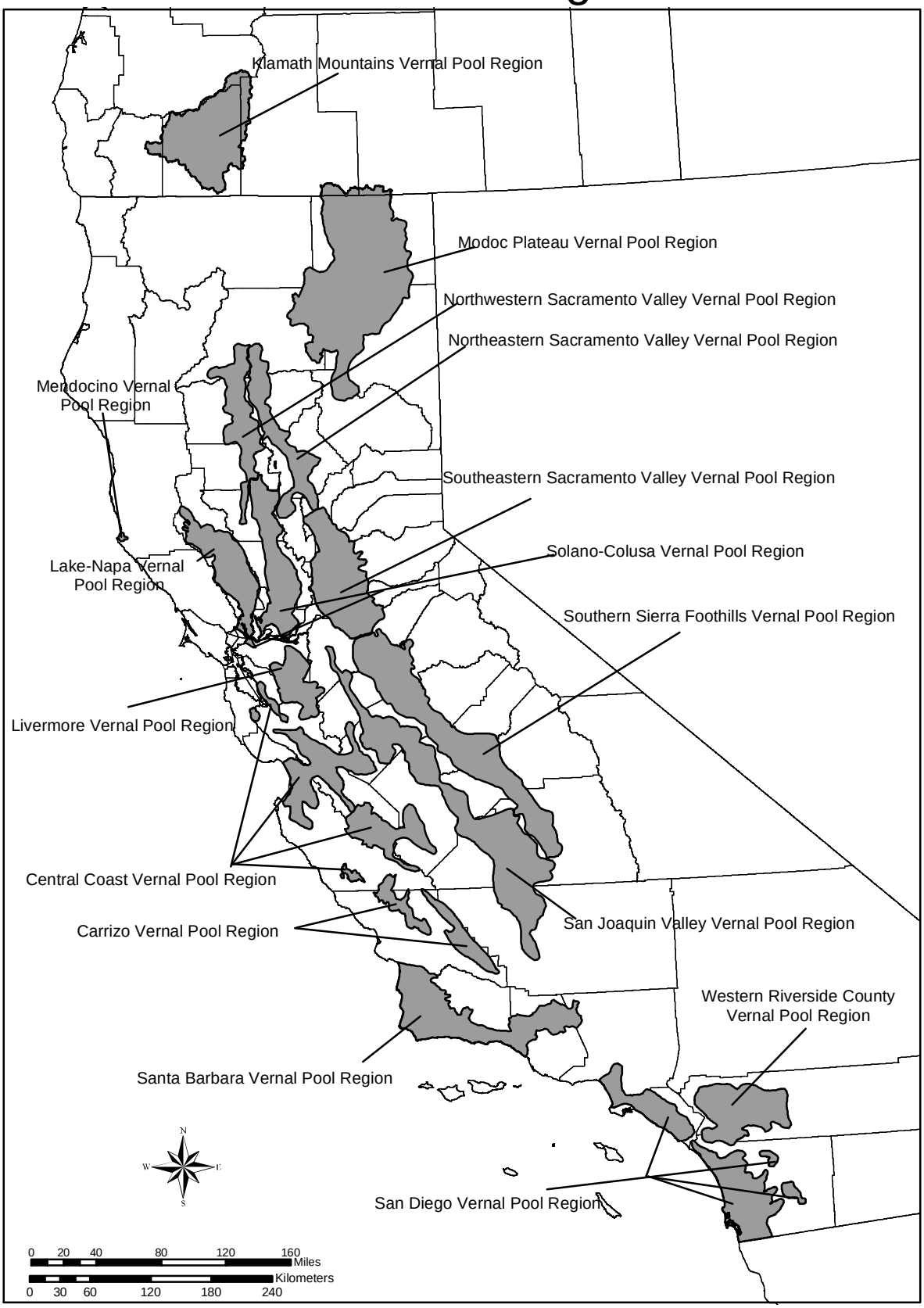

Figure I-1. Map of draft recovery plan area showing location of vernal pool regions.

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

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

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

Vernal pools in California tend to occur in clusters, called "complexes", because appropriate combinations of climate, soil, and topography often occur over continuous areas rather than in isolated spots. Landscapes that support vernal pool complexes are typically grasslands, with areas of obstructed drainage that form the pools. However, vernal pools also can be found in a variety of other habitats, including oak woodland, desert, and chaparral. The pools may be fed or connected by low drainage pathways called "swales." Swales often remain

saturated for much of the wet season, but are not inundated long enough to develop strong vernal pool characteristics. Trees are relatively rare in vernal pool complexes because of their shallow, seasonally saturated or inundated and sometimes alkaline soils, and their characteristic root-restricting subsurface layer. For the same reasons, vernal pool complexes have historically been considered poor farmland.

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

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

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

4. Vernal Pool Communities

The physical characteristics of vernal pools, as described above, influence the type of species found and their life history characteristics, such as the speed with which a species can mature and reproduce, the amount of soil moisture required for germination of plant seeds or hatching of invertebrate eggs or cysts, as well as tolerance to turbidity, total dissolved solids, and other aspects of vernal pool

water chemistry (Holland and Griggs 1976, Zedler 1987, Eng *et al.* 1990, Holland and Dains 1990, Simovich 1998).

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

Plants. Almost all California vernal pool plants are annuals, which means they grow, set seed, and die in a single growing season. These plants are members of genera that contain otherwise mostly perennial plants. The annual life cycle is an adaptation to the short growth period during the pool's drying phase and to extreme year-to-year variation in rainfall (Stone 1990, Zedler 1990). Many vernal pool plants germinate during the wetting phase or under water. Among some plants that can grow under water, many show underwater morphology distinct from parts of the same plant growing above water. Plants that grow underwater face special difficulties with carbon dioxide exchange, which is necessary for photosynthesis. Thus, some vernal pool plants have developed specialized photosynthetic processes.

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

others, the peduncles (stems supporting the flowers and fruits) lengthen and push the fruit and seeds into the soil (Zedler 1990).

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

Animals. Vernal pool animal communities also contain unique species. The most visible crustaceans in vernal pools are the large branchiopods (literally, "gill-foots"), comprising about 20 species in central and northern California of which approximately 8 species are endemic (King *et al*. 1996, Eriksen and Belk 1999) and 4 are federally listed as threatened or endangered.

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

Amphibians and many insect species also live in vernal pools and the surrounding upland habitat, including two rarer amphibians native to vernal pools, the California tiger salamander (*Ambystoma californiense*) and the western spadefoot toad (*Spea hammondii*) (Morey 1998). The insect fauna of vernal pools is numerous, varied, and primarily native, including aquatic beetles (Coleoptera: Dytiscidae, Hydrophilidae, Gyrinidae, Halipidae, Hydraenidae), aquatic bugs, including backswimmers (Hemiptera: Notonectidae), water boatmen (Corixidae), and water striders (Gerridae), springtails (Collembola), mayflies (Ephemeroptera), dragonflies and damselflies (Odonata), and various flies with

aquatic larvae, including midges (Diptera: Chironomidae), crane flies (Tipulidae) and mosquitoes (Culicidae), to name a few.

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

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

5. Major Threats to Vernal Pool Species

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

functional vernal pool ecosystems has threatened the continued existence of the listed species and species of concern addressed in this draft recovery plan. Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These threats are discussed in greater detail below.

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

Current habitat loss and fragmentation. California has both the highest absolute and fastest relative human population growth in the United States. California's population is predicted to grow by almost 18 million by the year 2025, an increase of over 50 percent, the highest of any state in the nation (U.S. Census Bureau 1996). Approximately 73 percent of the land within the Central Valley is privately owned, and in areas containing vernal pool habitats, only 6 percent of the land area is in public ownership (California Department of Fish and Game 1998). According to the 1997 National Resources Inventory (U.S. Department of Agriculture 2000), California ranked sixth in the nation in amount of non-Federal land developed between 1992 and 1997, at over 221,200 hectares (546,700 acres). This predicted population growth will continue to threaten vernal pool habitats, most of which are located on private land.

Conversion of vernal pool habitats to intensive agricultural uses continues to contribute to the decline of vernal pools. From 1992 to 1998, 50,825 hectares (125,591 acres) of grazing land were converted to other agricultural uses in the Central Valley of California. It is likely that much of this land supported vernal pools. Holland estimated that more than 12,950 hectares (32,000 acres) of vernal pool habitats had been lost in the San Joaquin Valley vernal pool region from the

late 1980's until 1997, mostly as a result of agricultural conversion. Through section 7 of the Endangered Species Act, our Sacramento Fish and Wildlife Office has reviewed projects converting more than 6,070 hectares (15,000 acres) of vernal pool habitats to intensive agricultural uses since 1994.

In more recent years, vernal pool habitats have been lost primarily as a result of widespread urbanization. Since 1994, the Sacramento Fish and Wildlife Office has conducted section 7 consultation on impacts to almost 20,250 hectares (50,000 acres) of vernal pool habitats across California. Over half of this loss of habitat, 10,125 hectares (25,000 acres), was the result of residential, commercial, and industrial development projects. The construction of infrastructure associated with urbanization also has contributed greatly to the loss and fragmentation of vernal pool plant and crustacean populations, including the construction of highways, wastewater treatment plants, sewer lines, water supply projects, and other utility projects.

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

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

Agricultural conversion and urbanization, as well as the construction of infrastructure including the construction of new highways, wastewater treatment plants, sewer lines, water supply projects, wind energy development projects, and other utility projects, have also contributed greatly to the destruction and fragmentation of vernal pool habitat. Habitat loss exacerbates the highly fragmented distribution of many of the listed species and species of concern addressed in this draft recovery plan, increases the vulnerability of adjacent populations of such species to random environmental events, and further disrupts gene flow patterns between populations of such species. Habitat fragmentation, alteration, and degradation may effectively serve as a barrier to dispersal for some species and may bisect the range of such species locally. Although genetic evidence suggests movement between historically disjunct vernal pool complexes

was probably low (Hebert 1974, Havel *et al.* 1990, Boileau and Hebert 1991, Fugate 1992, King 1996, Davies *et al.* 1997), current fragmentation of originally intact vernal pool complexes could contribute significantly to the loss of genetic diversity among vernal pool plants and crustaceans, and reduce the likelihood of recolonization events following local population extinctions (Fugate 1998). Some additional effects of fragmentation on vernal pool crustaceans may be indirect, through their effect on an associated species. For example, the fragmentation of vernal pool habitats may decrease habitat suitability for avian species, resulting in decreased use of the smaller, isolated patches, especially those adjacent to incompatible land uses (J. Silveira, pers. comm. 2004). Such an effect on birds can have consequences on the genetic stability of populations of listed branchiopods because avian species are dispersal agents for the vernal pool crustaceans (Proctor 1964, Krapu 1974, Swanson *et al.* 1974, Driver 1981, Ahl 1991).

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

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

asphalt, or irrigated lawns, can alter the duration, volume discharge and frequency of surface flows through increased flooding and runoff.

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

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

Other causes of altered hydrology include impoundments such as reservoirs, stockponds, and other more permanent pools, which may decrease the period of inundation of a vernal pool complex. The construction of water conveyance systems (*e.g.*, canals) for irrigation, flood control, and other purposes through

vernal pool habitats can dewater vernal pools via conduction of surface and subsurface flows into the canal. In addition to these causes of dewatering, encroachment of exotic grasses and the build-up of a thatch layer on pool margins and throughout vernal swales is an additional factor that decreases the hydroperiod (Marty 2004).

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

Contaminants. Vernal pool plant and crustacean populations also have declined as a result of water contamination. Vernal pool crustaceans are highly sensitive to the chemistry of their vernal pool habitats (Belk 1977, Eng *et al.* 1990, Gonzalez *et al.* 1996). Use of herbicides, fertilizers, and other chemicals are common in urban and agricultural settings. Although there is a general lack of specific studies to assess effects of herbicides, fertilizers, and other chemicals on vernal pool species, such chemicals could have detrimental impacts on these species if such chemicals reach seasonal wetlands via storm or nuisance sheet flow. Specifically, herbicides may completely inhibit growth of listed plant species and plant species of concern. Contamination of vernal pools from adjacent areas may injure or kill vernal pool crustaceans and plants either directly or indirectly via pathways including the alteration of chemical properties of a pool (*e.g.*, pH) and inhibiting and/or disrupting biochemical processes creating less suitable conditions for reproduction or germination and growth. Toxic chemicals, such as petroleum products, pesticides, herbicides, fertilizers and detergents, may wash into vernal pools during the course of activities on adjacent areas. Certain chemicals are not registered to be used in or near aquatic settings due to their toxicities to aquatic organisms. Use of such chemicals in nearby areas may result in drift or runoff into vernal pools. The specific effects of such contamination are

difficult to ascertain unless an accurate assessment can be made regarding the assimilation rate, or rate of decay, of such chemicals in route to the vernal pool. Vernal pools adjacent to existing developments may be contaminated from roadway contaminants in surface runoff (*e.g.*, grease, oil, and heavy metals). Contamination also may result from increased discharge of contaminants such as fertilizers, herbicides, and pesticides into surface waters from golf courses, irrigated agricultural lands, or landscaped residential areas (Petrovich 1990). Fertilizer contamination can lead to the eutrophication of vernal pools, which can kill vernal pool crustaceans by reducing the concentration of dissolved oxygen (Rogers 1998). Fertilizers may benefit the growth of invasive plants and could effectively lead to localized extirpation of listed plant and animal species and species of concern addressed in this draft recovery plan resultant from *competition*, thatch buildup, and effects of eutrophication.

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

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

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

Inappropriate livestock grazing. Considering the historic grazing of native ungulates and other herbivores in vernal pool ecosystems, properly managed livestock grazing can play a significant role as a process surrogate in the protection and enhancement of vernal pool ecosystems. Livestock grazing has three primary effects on vernal pools: consumption of vegetation, trampling, and nutrient input from urine and feces (Vollmar 2002). However, inappropriate levels of grazing, from overgrazing, undergrazing, or inappropriately-timed grazing, can result in significant adverse effects to vernal pool ecosystems. Physical trampling by livestock seriously can affect the viability of a species, especially if the species is restricted to a small area or if grazing occurs during sensitive parts of the growing season, such as during periods when the plants bloom or set seed. Although experts maintain that the relationship between grazing livestock and vernal pool habitat condition is difficult to quantify, the prevailing belief is that livestock grazing can play an important role as a management tool in vernal pool habitat. However, research also indicates that the perceived need for some amount of ecosystem disturbance should not be interpreted as an invitation to indiscriminately graze vernal pool landscapes. Because vernal pool species exhibit a variety of life history strategies, grazing regimes must take these needs into consideration. Grazing inappropriately for target species may result in problems comparable or greater than those encountered by exclusion of grazing (Vollmar 2002). Knowing how many Animal Unit Months (AUM) to graze, what species to use, what season to graze,

and rotation times, as well as understanding seasonal variation and general effects of grazing on listed species and species of concern, are all essential components to developing a beneficial grazing regime. Although grazing can be an excellent management tool for vernal pools, it must be implemented in a way that optimizes long-term functions and processes of the ecosystem. In areas where grazing has been a historic land use, the removal of grazing may actually prove to be a significant threat to the species covered in this draft recovery plan (Marty 2004). Each year that conditions are suitable for germination, a portion of the seedbank of these sensitive species sprouts and is removed from the total store of seeds in the soil. Without grazing or fire to remove the competition of invasive annuals, the native species may set fewer seed, or add fewer seeds to the seedbanks than were removed through germination or other factors. Additionally, in areas that have been grazed for decades, grazing may be serving a role in controlling populations of nonnative annual plant species and maintaining appropriate inundation periods. Therefore a moderate grazing program (moderate in both stocking rates and length of grazing period) in areas which have been grazed historically, may be preferable to no grazing, especially where burning is impractical. Moderation in grazing lessens the potential to do damage while monitoring information is being gathered and the grazing regime is adapted and improved.

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

Random, naturally occurring events. Vernal pool plants and crustaceans existing in small habitat patches are vulnerable to random environmental fluctuations or variation (stochasticity) due to annual weather patterns and

availability of food and other environmental factors superimposed on cumulative threats to the ecosystem. The populations of many vernal pool species are isolated from other populations and are distributed in discontinuous vernal pool systems. Such populations are vulnerable to stochastic extinction. The breeding of closely related individuals may cause genetic problems in small populations of crustaceans, particularly in the expression of deleterious genes (known as inbreeding depression). Individuals and populations possessing deleterious genetic material are less able to withstand environmental changes, even relatively minor ones.

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

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

Inadequate regulatory mechanisms. Current regulatory mechanisms are in place, however, they are not always fully implemented, enforced, or adequate to protect vernal pool habitats to the point that species addressed in the draft recovery plan can be fully recovered. The Endangered Species Act is the primary Federal law providing protection for the listed vernal pool species covered in the draft recovery plan. Since listing, many projects with the potential to destroy, degrade, or fragment vernal pool habitat have undergone consultation pursuant to section 7(a)(2) of the Endangered Species Act. Section 7(a)(2) requires Federal agencies to consult with us prior to authorizing, funding, or carrying out activities that may affect listed species (50 CFR part 402). The Endangered Species Act also provides additional protection for vernal pool species through section 7(a)(1) and section 10(a)(1)(B). Section 7(a)(1) mandates that Federal agencies use their authorities to further the purposes of the Endangered Species Act. Section

10(a)(1)(B) is a mechanism to permit the taking of listed species by persons without a nexus for section 7(a)(2).

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

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

II. BIOLOGY OF COVERED SPECIES

A. *CASTILLEJA CAMPESTRIS* SSP. *SUCCULENTA* (FLESHY OWL'S-CLOVER)

1. Description and Taxonomy

Taxonomy.—Owl's-clovers are members of the figwort or snapdragon family (Scrophulariaceae). Hoover (1936*a*) first named fleshy owl's-clover, giving it the scientific name *Orthocarpus campestris* var. *succulentus.* The type specimen had been collected at Ryer, in Merced County. Hoover (1968) raised fleshy owl's-clover to the rank of species and assigned it the name *Orthocarpus succulentus*. Chuang and Heckard (1991) reconsidered the taxonomy of *Orthocarpus* and related genera. Based on floral morphology, seed morphology, and chromosome number, they transferred many species into the genus *Castilleja*. Furthermore, they determined that the appropriate rank for fleshy owl's-clover was as a subspecies of field owl's-clover (*Castilleja campestris*). Thus, the scientific name currently assigned to fleshy owl's-clover is *Castilleja campestris* ssp. *succulenta*, whereas field owl's-clover is *Castilleja campestris* ssp. *campestris* (Chuang and Heckard 1991). Another common name for fleshy owl's-clover is succulent owl's-clover (Skinner and Pavlik 1994).

Description and Identification.— *Castilleja campestris* ssp. *succulenta* (**Figure II-1**) has rather intricate flowers, with the corolla consisting of two lips. The flower has four sepals that are fused at the base, creating the calyx tube. Together, all the flowers plus the bracts comprise the inflorescence. The plant has erect or decumbent stems up to 30 centimeters (11.8 inches) long. The stems are usually unbranched and without hairs. The leaves at the base of the stem are small and scale-like, whereas those on the upper stem are 1.5 to 4 centimeters (0.6 to 1.6 inches) long, lance-shaped, not lobed, thick, fleshy, and easily broken. The bracts are green, similar to but shorter than the upper leaves, and longer than the flowers. Overall, the inflorescence may occupy as much as half of the plant's height and be 2 to 3 centimeters (0.8 to 1.2 inches) wide. *Castilleja campestris* ssp. *succulenta* has a diploid chromosome number of 24 (Chuang and Heckard 1993).

The brittle leaves are a key characteristic for identification of *Castilleja campestris* ssp. *succulenta*. The most similar taxon is *C. campestris* ssp. *campestris*. *Castilleja campestris* ssp. *campestris* has branched stems; thin, flexible, non-fleshy leaves; larger, lighter yellow flowers; a stigma that protrudes

Figure II-1. Illustration of *Castilleja campestris* ssp. *succulenta* (fleshy owl's clover).

beyond the upper lip of the flower; a lower anther sac that is no more than one-third the size of the upper; and more rounded seeds. *Castilleja campestris* ssp. *campestris* occurs farther north than *C. campestris* ssp. *succulenta* (Hoover 1937, Hoover 1968, Heckard 1977, California Department of Fish and Game 1986). Other *Castilleja* species have lobed leaves and bracts, and the bracts are often colored.

2. Historical and Current Distribution

Historical Distribution.—Between 1937 and 1986, *Castilleja campestris* ssp. *succulenta* was reported from 33 localities (Hoover 1937, Hoover 1968, California Natural Diversity Data Base 2003), all in the Southern Sierra Foothills Vernal Pool Region (Keeler-Wolf *et al.* 1998). Sixteen of those occurrences, including the type locality, were in eastern Merced County. Six occurrences each were in Fresno and Madera Counties and five others were in Stanislaus County (California Natural Diversity Data Base 2003) (**Figure II-2**).

Current Distribution.—Through November 2003, the California Natural Diversity Data Base (2003) had catalogued 93 occurrences of *Castilleja campestris* ssp. *succulenta* (catalogued as succulent owl's clover). About one-third (31) of these occurrences are relatively recent records from Merced County, catalogued in association with rare plant and wildlife surveys of eastern Merced County grass and ranch lands conducted during 2001 by a team of consultants (Vollmar 2002) to the County and California Department of Fish and Game.

Of the 93 total data base occurrences, 92 are presumed to be extant, lacking any evidence to the contrary. One occurrence in Fresno County is considered to be "possibly extirpated" (California Natural Diversity Data Base 2003) because the site had been disced when it was last visited in 1981. Another unreported (to the data base) site in Fresno County may also be extirpated (J. Stebbins *in litt.* 2000*a*). Currently, among the 93 reported occurrences, 70 percent are in Merced County, 13 percent are in Fresno County, 10 are in Madera County, 5 are in Stanislaus County, and 1 is in San Joaquin County (M. Trask *in litt.* 1993, EIP Associates 1994, C. Witham *in litt.* 2000*b*, California Natural Diversity Data Base 2003). All but one of these occurrences are in the Southern Sierra Foothills Vernal Pool Region; one San Joaquin County site is in the Southeastern Sacramento Valley Vernal Pool Region (Keeler-Wolf *et al*. 1998).

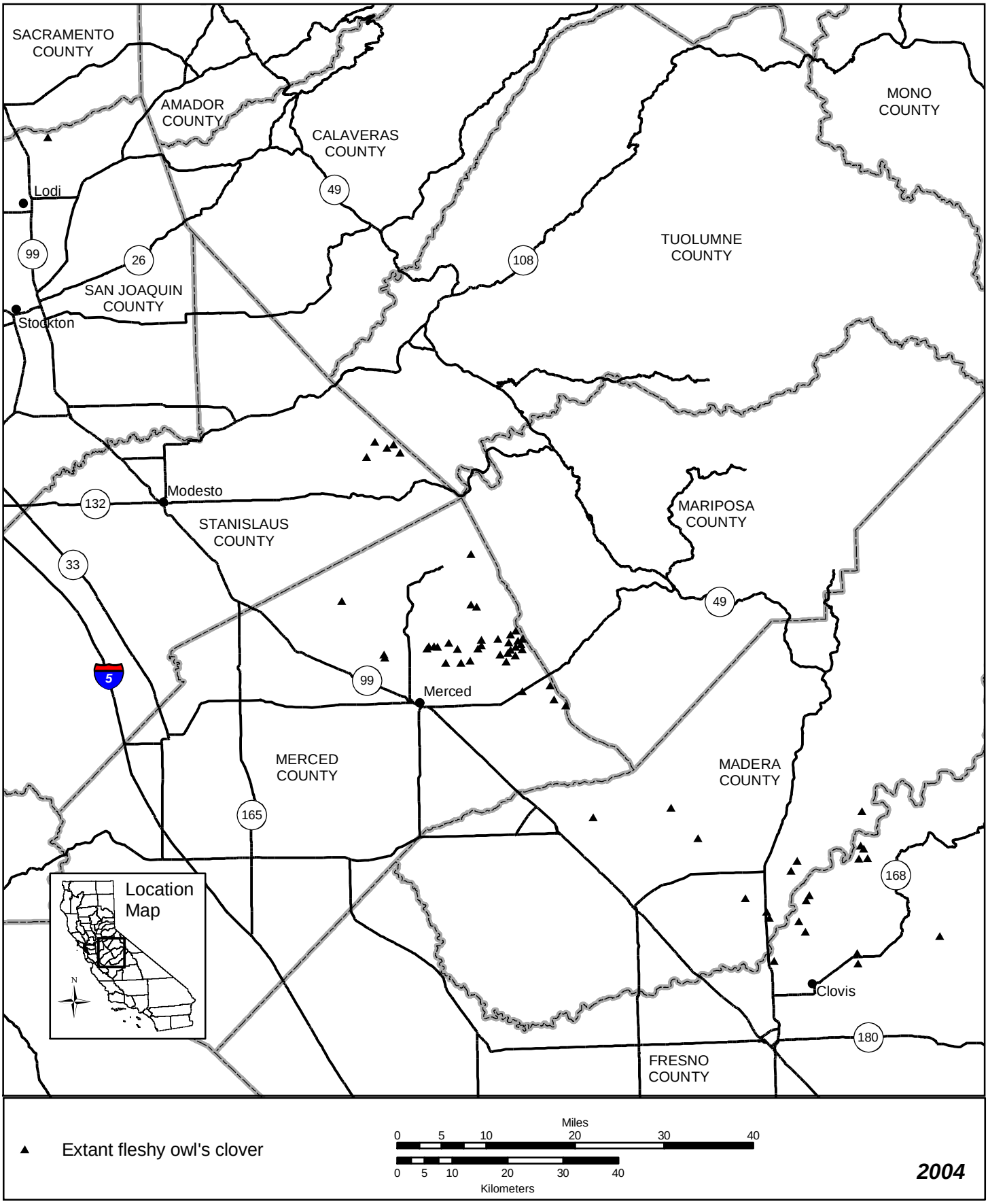

Figure II-2. Distribution of *Castilleja campestris* ssp. *succulenta* (fleshy owl's clover).

This information, and especially the recent records, confirm that the primary area of concentration for *Castilleja campestris* ssp. *succulenta* is in eastern Merced County, especially just northeast of the City of Merced. In particular, many of the known occurrences are between La Paloma Road and Highway 140, east of Yosemite Lake. In addition to the proposed University of California campus area and related community, this area includes the Flying M Ranch and other ranch land. In addition, *C. campestris* ssp. *succulenta* was found in 296 vernal pools in the proposed campus and community area during recent surveys of 34 percent of that area (EIP Associates 1999). A later study of vernal pool habitat in the campus lands area, using a different reporting format that is not directly comparable, nevertheless also found *C. campestris* ssp. *succulenta* at significant levels (3 to 6 percent of the habitat area) (Jones and Stokes 2003). Moreover, Vollmar (2002) concluded that this listed plant is likely to be found throughout much of the range land portion of the eastern Merced County survey area, wherever there are better-developed, dense, interconnected vernal pools, and that this study area clearly represents a very important geographical region for the conservation of *C. campestris* ssp. *succulenta*.

Other occurrences in Merced County are somewhat farther to the north and south. In addition, a secondary area of concentration is located in southern Madera County and northern Fresno County, from just west of Highway 41 east to Academy and north to Miller's Corner, with 17 occurrences. Also, two smaller areas of concentration, which include five occurrences each but contain large numbers of plants, are near Cooperstown in Stanislaus County and the "tabletop" mountains near Millerton Lake in Fresno and Madera Counties. Other more scattered occurrences include two at Castle Airport northwest of Merced, one near Wildcat Mountain in Fresno County, and one in San Joaquin County. Significant areas of suitable habitat remain unsurveyed, particularly in northern Merced County (EIP Associates 1999) and between the northern Stanislaus County and northern San Joaquin County sites (J. Stebbins *in litt.* 2000*b*). Thus, additional occurrences are likely to be found if further surveys similar to those reported by Vollmar (2002) are conducted.

3. Life History and Habitat

Reproduction and Demography.—*Castilleja campestris* ssp. *succulenta* is an annual plant. As with many related species, it is a hemiparasite, meaning that it obtains water and nutrients by forming root grafts with other host plants but manufactures its own food through photosynthesis (Chuang and Heckard 1991). Research on hemiparasitism has focused on related species of *Castilleja*, but not specifically on *C. campestris* ssp. *succulenta*. Many different plants can serve as hosts for a single species or even a single individual of *Castilleja*. Seeds of

Castilleja species do not require the presence of a host to germinate, and form root connections only after reaching the seedling stage. Some seedlings can survive to maturity without attaching to a host's roots, but in general reproduction is enhanced by root connections (Atsatt and Strong 1970).

The conditions necessary for germination of *Castilleja campestris* ssp. *succulenta* seeds have not been studied, nor has the timing of seed germination been documented. Flowering occurs in April and May (Skinner and Pavlik 1994). The importance of pollinating insects is not known for certain. Some aspects of *C. campestris* ssp. *succulenta* biology suggest that it may be self-pollinating (Heckard 1977), but many related taxa of *Castilleja* are pollinated by generalist bees (Superfamily Apoidea) (Chuang and Heckard 1991).

Among close relatives that do not require insect pollinators, flower structure and timing of stigma receptivity maximize the chances for self-fertilization and seed set. Even so, insects may transfer some pollen among individual plants and species occurring in the same area. Self-pollinating species of *Castilleja* typically occur as widely scattered individuals, rather than in dense colonies (Atsatt 1970). *Castilleja campestris* ssp. *succulenta* follows this pattern in part, often occurring in many pools within a complex but with fewer than 100 plants per pool. However, *C. campestris* ssp. *succulenta* also may occur in large populations within a single pool (California Natural Diversity Data Base 2003). Little is known about the demography of *C. campestris* ssp. *succulenta*, although population size can fluctuate greatly from year to year. In the few populations where population size was reported for more than 1 year, fluctuations up to two orders of magnitude were noted (California Natural Diversity Data Base 2003).

Habitat and Community Associations.—*Castilleja campestris* ssp. *succulenta* occurs in Northern Claypan and Northern Hardpan vernal pools (Sawyer and Keeler-Wolf 1995) within annual grassland communities (California Natural Diversity Data Base 2003). The plant is known from both small and large pools (EIP Associates 1999, J. Stebbins *in litt.* 2000*a*). Although not all pools occupied by this taxon have been studied in detail, Stebbins *et al.* (1995) collected data on six occupied pools in Fresno and Madera Counties. Some were typical "bowl-like" pools, whereas others were more similar to swales. Approximate pool area ranged from 0.03 to 0.65 hectare (0.07 to 1.61 acres), depth from 30 to 38 centimeters (11.8 to 15.0 inches), and pH of the soil underlying the pools from 5.00 to 6.24 (Stebbins *et al.* 1995). This subspecies has been reported from pools with both long and short inundation periods (EIP Associates 1999) and from both shallow and "abnormally deep" vernal pools, but approximate depth of these pools was not given (California Natural Diversity Data Base 2003).

The soil types have not been determined for all of the sites where *Castilleja campestris* ssp. *succulenta* occurs. At the one site in the Southeastern Sacramento Valley Vernal Pool Region, the soil is San Joaquin sandy loam. Soil series supporting *C. campestris* ssp. *succulenta* in the Southern Sierra Foothills Vernal Pool Region include Amador, Anderson, Corning, Fallbrook, Hideaway, Keyes, Pentz, Ramona, Redding, San Joaquin, Vista, and Yokohl, as well as the Pollasky-Montpellier complex. Soil textures at those sites range from extremely stony loam to loamy clay. In the proposed University of California-Merced campus and community area, 81.4 percent of the individual pools where this taxon was found were on Redding gravelly loam, 9.5 percent were on Corning gravelly sandy loam, 6.4 percent were on Corning gravelly loam, 1.7 percent were on Keyes gravelly loam, 0.7 percent were on Keyes gravelly clay loam, and 0.3 percent were on Pentz loam (EIP Associates 1999).

Populations of *Castilleja campestris* ssp. *succulenta* have been reported from elevations of 24 meters (80 feet) at the San Joaquin County site to 700 meters (2,300 feet) at Kennedy Table in Madera County (California Natural Diversity Data Base 2003). Plants most commonly reported as occurring with *C. campestris* ssp. *succulenta* are *Lasthenia fremontii* (Fremont's goldfields) (EIP Associates 1999), *Downingia* spp. (downingia), *Mimulus tricolor* (three-colored monkey-flower), *Plagiobothrys stipitatus* (vernal pool popcorn flower), and *Eryngium* spp. (coyote-thistle) (California Natural Diversity Data Base 2003). Other plants featured in this recovery plan that have been reported growing with *C. campestris* ssp. *succulenta* (at one to five sites each) are: *Neostapfia colusana*, *Orcuttia inaequalis*, *O. pilosa*, *Gratiola heterosepala* (EIP Associates 1999, California Natural Diversity Data Base 2003), and *Eryngium spinosepalum* (EIP Associates 1994).

4. Reasons for Decline and Threats to Survival

Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to *Castilleja campestris* ssp. *succulenta* are described below.

One significant specific threat is the proposed construction of the new University of California campus in Merced County. This project, plus associated residential development and access roads, are threats to the primary and relatively extensive population in that area. Of the 12 occurrences recorded in the California Natural Diversity Database on the proposed campus and associated community, 4 are in the area that is expected to be developed within the next 15 years; these 4

occurrences include 226 of the 296 (76 percent) occupied pools in the University planning area (EIP Associates 1999). Additional urban developments that threaten many other known occurrences include planned housing subdivisions in Fresno, Madera, and San Joaquin Counties; a freeway expansion in Madera County; and a proposed landfill in Fresno County (U.S. Fish and Wildlife Service 1997*a*, J. Stebbins *in litt.* 2000*b*, California Natural Diversity Data Base 2003).

Invasive nonnative species pose a significant threat to *Castilleja campestris* ssp. *succulenta*. Exclusion of grazing from sites that have been grazed historically may increase the threat of nonnative plants. About two-thirds of the reported occurrences of the species, including those at the University of California-Merced site, were subject to cattle grazing when first discovered (EIP Associates 1999, California Natural Diversity Data Base 2003). Grazing should be monitored, and adjusted as needed, to maintain and enhance the species.

Threats due to alterations in natural hydrology include the Merced County Stream Channel Project proposed by the U.S. Army Corps of Engineers (U.S. Fish and Wildlife Service 1997*a*) and proposed enlargement of Burns Reservoir in Merced County (California Natural Diversity Data Base 2003), which collectively threaten seven occurrences of *Castilleja campestris* ssp. *succulenta*. Expansion of agricultural operations threatens three occurrences in Fresno and Madera Counties that are surrounded by orchards, vineyards, or citrus groves (California Natural Diversity Data Base 2003). A proposed gravel mine threatens one occurrence of *C. campestris* ssp. *succulenta* in Fresno County. Two other occurrences, at the former Castle Air Force Base in Merced County, are threatened by excavation to remove soil that was contaminated by lead from skeet shooting (California Natural Diversity Data Base 2003).

Threats posed by small population size may also be a significant continuing factor because small size makes populations more vulnerable to chance events. Among the 24 populations of *Castilleja campestris* ssp. *succulenta* for which size estimates have been documented, 10 consisted of fewer than 100 plants each at their peak size (J. Stebbins *in litt.* 2000*b*, California Natural Diversity Data Base 2003).

5. Conservation Efforts

We listed *Castilleja campestris* ssp. *succulenta* as federally threatened on March 26, 1997 (U.S. Fish and Wildlife Service 1997*a*). This taxon has been State-listed as endangered since 1979 (California Department of Fish and Game 1991). The California Native Plant Society considered it to be rare and endangered 5 years earlier (Powell 1974) and still includes *C. campestris* ssp. *succulenta* on its List

1B, noting that it is "endangered in a portion of its range" (California Native Plant Society 2003). In 2003, critical habitat was designated for *C. campestris* ssp. *succulenta* and several other vernal pool species in *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon* (U.S. Fish and Wildlife Service 2003).

Three occurrences of *Castilleja campestris* ssp. *succulenta* are wholly or in part within designated reserves, which are on two "tabletop" mountains near Millerton Lake in Fresno County. The Sierra Foothill Conservancy's Big Table Mountain Preserve includes one of these occurrences and a portion of another, which is shared with the U.S. Bureau of Land Management. The other is in the California Department of Fish and Game's Big Table Mountain Ecological Reserve. A cooperative group consisting of the California Department of Fish and Game, California Department of Parks and Recreation, Sierra Foothill Conservancy, U.S. Bureau of Land Management, and U.S. Bureau of Reclamation has developed a management and monitoring plan for Big Table Mountain. Initial efforts will focus on grazing as a means to control non-native grasses while comparing population trends of threatened and endangered species in grazed and ungrazed portions of the tableland (M. Griggs *in litt*. 2000).

A fourth occurrence, which is on a nearby tabletop, is partially under the control of the U.S. Bureau of Land Management and partly in private ownership. The U.S. Bureau of Land Management has attempted to protect the occurrence there by erecting fencing to prevent trespass by cattle (A. Franklin *in litt.* 1993). This area needs a management plan similar to the other three.

At least seven occurrences of *Castilleja campestris* ssp. *succulenta* on the Flying M Ranch in Merced County are protected from development by a conservation easement negotiated between the landowner and The Nature Conservancy (U.S. Fish and Wildlife Service 1997*a*). Several other occurrences are in public ownership but are not necessarily protected from development, nor are they managed for the benefit of this or other vernal pool taxa. These occurrences include (1) the extensive populations on the proposed University of California campus in Merced County, (2) a large population on property acquired by the California Department of Transportation for mitigation purposes in Madera County (Stebbins *et al.* 1995, California Natural Diversity Data Base 2003), (3) two small populations on Castle Airport, formerly Castle Air Force Base, in Merced County (California Natural Diversity Data Base 2003), (4) a small population on U.S. Bureau of Reclamation property that is managed by the

Madera Irrigation District (Stebbins *et al.* 1995, California Natural Diversity Data Base 2003), and (5) the small population in San Joaquin County that is on land used for educational purposes by the University of California Cooperative Extension (California Natural Diversity Data Base 2003).

B. *CHAMAESYCE HOOVERI* (HOOVER'S SPURGE)

1. Description and Taxonomy

Taxonomy.—Hoover's spurge is a member of the spurge family (Euphorbiaceae). This plant was originally named *Euphorbia hooveri*, based on a specimen collected by Hoover in Yettem, Tulare County (Wheeler 1940). At that time, the genus *Euphorbia* was viewed as comprising several subgenera, including *Chamaesyce* and *Euphorbia*. Webster (1975) subsequently elevated the subgenus *Chamaesyce* to the rank of genus based on growth patterns and physiology. The currently accepted scientific name, *Chamaesyce hooveri*, was validated when Koutnik (1985) published the new combination.

Several other species of *Chamaesyce* have ranges similar to that of *C. hooveri* and may occur in the same habitats. *Chamaesyce ocellata* ssp. *ocellata* (yerba golondrina) is yellowish-green, has untoothed leaves, and lacks appendages on the glands. *Chamaesyce ocellata* ssp. *rattanii* (Stony Creek spurge) has hairy stems and leaves and the gland appendages are entire. *Chamaesyce serpyllifolia* (thyme-leaved spurge) also has entire appendages and further differs from *C. hooveri* in microscopic characters of the female flower (Wheeler 1941, Munz and Keck 1959, Koutnik 1993).

Description and Identification.—*Chamaesyce hooveri* (**Figure II-3**) trails along the ground, forming gray-green mats 5 to 100 centimeters (2.0 to 39.4 inches) in diameter (Broyles 1987, Stone *et al.* 1988). The stems are hairless and contain milky sap. The tiny (2-5 millimeters [0.08-0.20 inch]) leaves are opposite, rounded to kidney-shaped, with an asymmetric base and a toothed margin. In the genus *Chamaesyce*, the structures that appear to be flowers actually are groups of flowers; each group is referred to as a cyathium. The cyathium in *C. hooveri* consists of a tiny, cup-like structure 2 millimeters (0.08 inch) in diameter containing five clusters of male flowers and a single female flower. None of the flowers have petals, but instead have white appendages on the edge of the cup that resemble petals. Each appendage is divided into three-to-five finger-like projections about 1 millimeter (0.04 inch) long. The appendages are attached to four reddish glands situated along the margin of the cup. The tiny, white seeds are contained in a spherical capsule 2 millimeters (0.08 inch) in

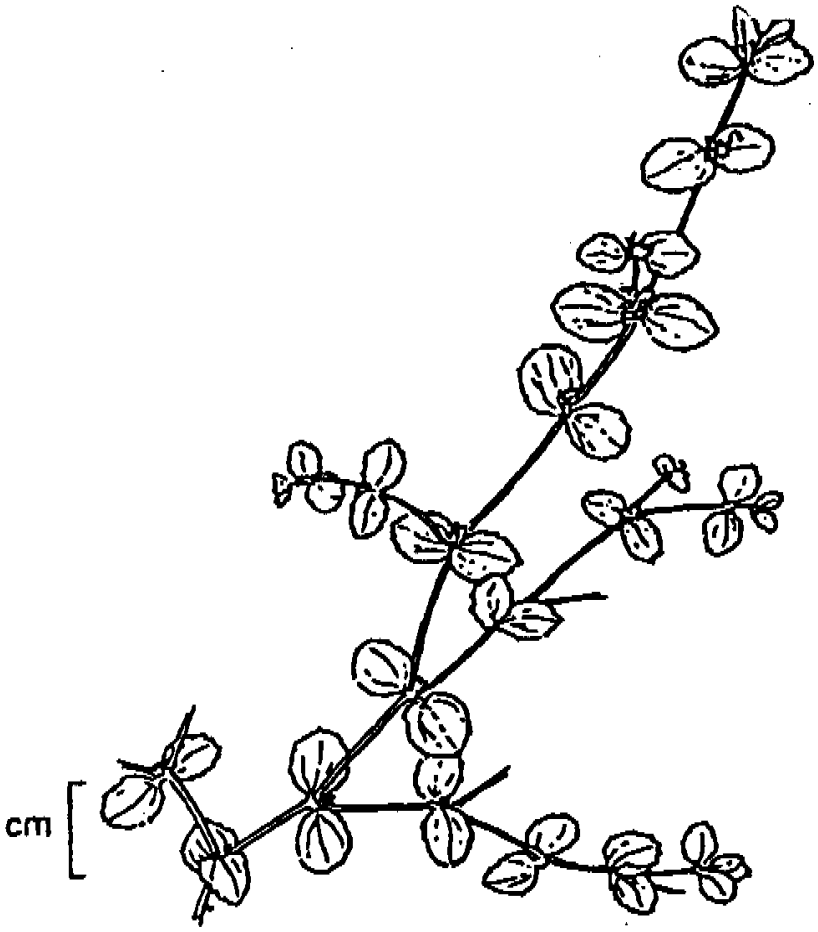

Figure II-3. Illustration of *Chamaesyce hooveri* (Hoover's spurge) (Reprinted from the Jepson Manual, J. Hickman, Ed., 1993, with permission from the Jepson Herbarium. © Regents of the University of California)

diameter on a stalk that hangs over the edge of the cup. One cyathium is located between each pair of leaves (Wheeler 1941, Munz and Keck 1959, Koutnik 1993).

2. Historical and Current Distribution

Historical Distribution.—For decades, *Chamaesyce hooveri* was known from only three localities: near Yettem and Visalia in Tulare County, and near Vina in Tehama County. Collections were made from these three areas in the late 1930's and early 1940's (Wheeler 1941, Munz and Keck 1959, Stone *et al.* 1988). From 1974 through 1987, 21 additional occurrences of *C. hooveri* were reported. The majority of these (15) were in Tehama County. One to three occurrences were discovered during this period in each of Butte, Merced, Stanislaus, and Tulare Counties (Stone *et al.* 1988). The historical localities for this species were in the Northeastern Sacramento Valley, San Joaquin Valley, Solano-Colusa, and Southern Sierra Foothills vernal pool regions (Keeler-Wolf *et al.* 1998) (**Figure II-4**).

Current Distribution.—Through November 2003, the California Natural Diversity Data Base (2003) listed 30 occurrences of *Chamaesyce hooveri*. In addition to these historical records, six occurrences were discovered in 1992 (three each in Glenn and Tulare Counties). Of the 30 California Natural Diversity Data Base (2003) occurrences, one each in Tehama and Tulare Counties are classified as extirpated; two others, in Butte and Tehama Counties, are "possibly extirpated" because this species was not observed for 2 consecutive years (Stone *et al.* 1988, California Natural Diversity Data Base 2003). Of the 26 occurrences presumed to be extant, only 12 have been observed within the past decade (California Natural Diversity Data Base 2003).

The main remaining area of concentration for *Chamaesyce hooveri* is within the Northeastern Sacramento Valley Vernal Pool Region. The Vina Plains of Tehama and Butte Counties contains 14 (53.8 percent) of the 26 known extant occurrences for *C. hooveri* (California Natural Diversity Data Base 2003) in an area of about 91 square kilometers (35 square miles; Stone *et al.* 1988). One other site in the same region is near Chico in Butte County. Seven of the extant occurrences are in the Southern Sierra Foothills Vernal Pool Region, including five in the Visalia-Yettem area of Tulare County and two in the Hickman-La Grange area of Stanislaus County. Three other occurrences are on the Sacramento National Wildlife Refuge in Glenn County, which is in the

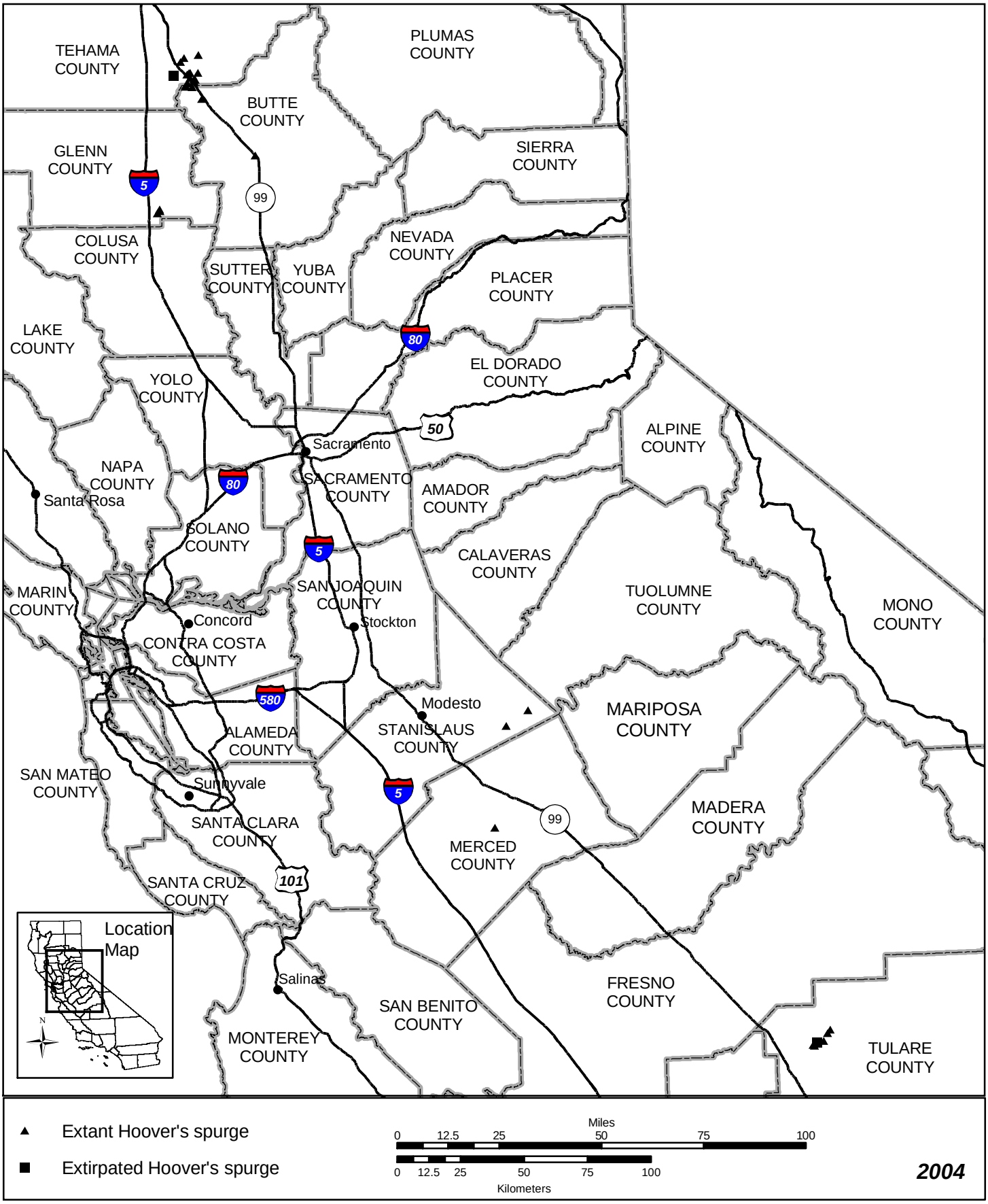

Figure II-4. Distribution of *Chamaesyce hooveri* (Hoover's spurge).

Solano-Colusa Vernal Pool Region. The one other extant occurrence is on the Bert Crane Ranch in Merced County, which is within the San Joaquin Valley Vernal Pool Region (Keeler-Wolf *et al.* 1998, California Natural Diversity Data Base 2003).

3. Life History and Habitat

Reproduction and Demography.—*Chamaesyce hooveri* is a summer annual, but few details of its life history are known. Seeds of *C. hooveri* germinate after water evaporates from the pools; the plants cannot grow in standing water (Alexander and Schlising 1997). The indeterminate growth pattern allows the plants to continue growing as long as sufficient moisture is available. The proportion of seedlings surviving to reproduction has not been documented; in years of below-normal rainfall, seedling survival was characterized as "low" (Stone *et al.* 1988). Phenology varies among years and among sites, even for those populations in close proximity (Stone *et al.* 1988). Populations in Merced and Tulare Counties typically flower from late May through July, whereas those farther north in Stanislaus County and the Sacramento Valley flower from mid-June into October (Alexander and Schlising 1997, J. Silveira *in litt.* 2000, California Natural Diversity Data Base 2003). Seed set apparently begins soon after flowering. Seed production has not been quantified or studied in relation to environmental factors, but Stone *et al.* (1988) reported that large plants may produce several hundred seeds.

Demographic data suggest that seeds of *Chamaesyce hooveri* can remain dormant until the appropriate temperature and moisture conditions occur. This dormancy is evident from the fact that plants can be absent from a given pool for up to 4 years and then reappear in substantial numbers (Stone *et al.* 1988).

Beetles (Order Coleoptera), flies (Order Diptera), bees and wasps (Order Hymenoptera), and butterflies and moths (Order Lepidoptera) have been observed visiting the flowers of *Chamaesyce hooveri* and may potentially serve as pollinators (Stone *et al.* 1988, Alexander and Schlising 1997). Related species in the spurge family are pollinated by flies (Heywood 1978). Also, the glands on the cyathium produce nectar (Wheeler 1941), which is attractive to insects. Related species in the genus *Euphorbia* typically are cross-pollinated because the female flowers on each plant mature before the male (Heywood 1978), which may or may not be the case for *C. hooveri*.

Habitat and Community Associations.—*Chamaesyce hooveri* is restricted to vernal pools (Stone *et al.* 1988, Koutnik 1993, Skinner and Pavlik 1994). However, the plant appears to adapted to a wide variety of soils, which range in

texture from clay to sandy loam. Specific soil series from which it has been reported include Anita, Laniger, Lewis, Madera, Meikle, Riz, Tuscan, Whitney, and Willows.

Natural pools in which the plant occurs are primarily classified as Northern Hardpan and Northern Claypan vernal pools (Sawyer and Keeler-Wolf 1995). In the Northeastern Sacramento Valley Vernal Pool Region, occupied pools are generally on acidic soils over iron-silica cemented hardpan. Most pools supporting *Chamaesyce hooveri* in the San Joaquin Valley, Solano-Colusa, and Southern Sierra Foothills vernal pool regions are on neutral to saline-alkaline soils over lime-silica cemented hardpan or claypan (Broyles 1987, Stone *et al.* 1988, Sawyer and Keeler-Wolf 1995, California Natural Diversity Data Base 2003).

Vernal pools supporting *Chamaesyce hooveri* typically occur on alluvial fans or terraces of ancient rivers or streams, with a few on the rim of the Central Valley basin. In addition, *C. hooveri* has been reported from several pools that were formed artificially when small ponds were created in appropriate soil types (California Natural Diversity Data Base 2003).

The pools supporting this species vary in size from 0.19 to 243 hectares (0.47 to 600 acres), with a median area of 0.58 hectare (1.43 acres) (Stone *et al.* 1988). This species may occur along the margins or in the deepest portions of the dried pool-bed (Stone *et al.* 1988, Alexander and Schlising 1997). Deeper pools apparently provide better habitat for this species because the duration of inundation is longer and the deeper portions are nearly devoid of other vegetation, thus limiting competition from other plants (J. Stebbins *in litt.* 2000*a*, Stone *et al.* 1988).

Throughout its range, two of the most frequent associates of *Chamaesyce hooveri* are the rare vernal pool grasses *Tuctoria greenei* and *Orcuttia pilosa*. However, *Chamaesyce hooveri* does tend to grow in different portions of the pools than these grasses (Stone *et al.* 1988, Alexander and Schlising 1997). Other plants addressed in this recovery plan that grow with *Chamaesyce hooveri* are *Atriplex persistens*, *Eryngium spinosepalum*, *Neostapfia colusana*, *Orcuttia inaequalis*, *Astragalus tener* var. *ferrisiae*, and *Gratiola heterosepala* (Oswald and Silveira 1995, Alexander and Schlising 1997, California Natural Diversity Data Base 2003). In the Vina Plains, other common associates of *Chamaesyce hooveri* are *Marsilea vestita* (water shamrock), *Eryngium castrense* (common coyote-thistle), *Convolvulus arvensis* (bindweed), and *Amaranthus albus* (white tumbleweed) (Alexander and Schlising 1997). In Glenn, Merced, and Tulare Counties, *Cressa truxillensis* (alkali weed), *Distichlis spicata* (saltgrass), *Frankenia salina*

(frankenia), *Grindelia camporum* (Great Valley gumplant), and other plants tolerant of saline-alkali soils are typical associates of *Chamaesyce hooveri* (Stone *et al.* 1988, J. Silveira *in litt.* 2000, California Natural Diversity Data Base 2003).

4. Reasons for Decline and Threats to Survival

Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to *Chamaesyce hooveri* are described below.

Agricultural conversions (*i.e.*, from grasslands or pastures to croplands, or from one crop-type to another) are a continuing specific threat, particularly in Stanislaus County (Stone *et al.* 1988). Competition from invasive native and non-native plant species threatens nine of the extant occurrences, including eight in the Vina Plains and one on the Sacramento National Wildlife Refuge in Glenn County. Native competitors of *Chamaesyce hooveri* include *Eryngium* spp., *Malvella leprosa* (alkali mallow, a noxious weed according to Hill 1993), *Phyla nodiflora* (lippia), *Scirpus acutus* var. *occidentalis* (hard-stemmed tule), *Scirpus maritimus* (alkali bulrush), and *Xanthium strumarium* (cocklebur). Non-native competitors include *Convolvulus arvensis* (a noxious weed according to Dempster 1993) and *Crypsis schoenoides* (swamp grass) (J. Silveira *in litt.* 2000, California Natural Diversity Data Base 2003). On the Vina Plains Preserve (in 1995), the pools with *Chamaesyce hooveri* also had the highest frequency of *Convolvulus arvensis* (Alexander and Schlising 1997). Increasing dominance by these competitors may be associated with changes in hydrology and livestock grazing practices (Stone *et al.* 1988, Alexander and Schlising 1997, California Natural Diversity Data Base 2003).

Five of the remaining occurrences of *Chamaesyce hooveri* are subject to specific hydrologic threats; four of the five are in the San Joaquin Valley and the fifth is in the Vina Plains. Hydrology has been altered by (1) construction of levees and other water barriers and (2) by runoff from adjacent agricultural operations, roads, and culverts. Such impacts result in some pools receiving insufficient water, while others remain flooded for too long to allow growth of *C. hooveri*. Although no occurrences have been completely extirpated due to hydrologic changes, the species has been eliminated from one or more individual pools at several sites and a number of the remaining populations appear to be in decline (Stone *et al.* 1988, Stebbins *et al.* 1995, California Natural Diversity Data Base 2003).

Some specific threats also are continuing due to inappropriate livestock grazing practices. While livestock generally do not forage on *Chamaesyce hooveri*, because it grows very close to the ground and contains a toxic, milky sap (Wheeler 1941, Stone *et al.* 1988), cattle trampling has nevertheless been identified as seriously reducing *C. hooveri* populations at one site each in Butte and Stanislaus Counties (Stone *et al.* 1988); relatively high livestock stocking rates such as often prevail during summer months could similarly damage this plant's populations at other locations.

The threat posed by small population size may also be a significant continuing factor. At least five of the known occurrences of this plant total fewer than 100 individuals in years of most-favorable conditions (California Natural Diversity Data Base 2003). Two other occurrences with populations of only a few hundred individuals also may be similarly threatened. Such small populations are subject to extirpation from random events, including extrinsic factors such as weather and intrinsic factors such as genetic drift (Shaffer 1981, Menges 1991).

Another specific threat is the potential lack of pollinators. However, because the specific insects that pollinate *Chamaesyce hooveri* have not yet been identified, assessment of their status and providing them with protection, if necessary, cannot yet be undertaken. If essential pollinators are declining through habitat loss, *C. hooveri* may be declining in response. Another very localized threat to *C. hooveri* on certain public and private lands is direct trampling, particularly in areas that receive high controlled human usage or vandalism activity (U.S. Fish and Wildlife Service 1997*a*).

5. Conservation Efforts

Chamaesyce hooveri was listed as a threatened species on March 26, 1997 (U.S. Fish and Wildlife Service 1997*a*). *Chamaesyce hooveri* is not listed under the California Endangered Species Act (California Department of Fish and Game 1999). The California Native Plant Society included *C. hooveri* on its first list of rare plants (Powell 1974); currently, *C. hooveri* is on List 1B and is considered to be "endangered in a portion of its range" (California Native Plant Society 2001). In 2003, critical habitat was designated for *C. hooveri* and several other vernal pool species in *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon* (U.S. Fish and Wildlife Service 2003).

Ten occurrences of *Chamaesyce hooveri* are in preserves or on public land. The Vina Plains Preserve, managed by The Nature Conservancy, includes four of the extant occurrences and one presumed extirpated occurrence. The California

Department of Fish and Game manages two of the extant Tulare County occurrences as part of the Stone Corral Ecological Reserve complex. Three of the extant occurrences are on the Sacramento National Wildlife Refuge (California Natural Diversity Data Base 2003). The Sacramento National Wildlife Refuge populations have been monitored annually since 1992 (J. Silveira *in litt.* 2000). One additional occurrence of *C. hooveri* in Merced County is on private land (the Bert Crane Ranch) that is protected from development by a conservation easement (J. Silveira *in litt.* 2000).

We funded a status survey for *Chamaesyce hooveri* and other vernal pool plants in 1986 and 1987 (Stone *et al.* 1988), resulting in 10 new occurrences. We and the California Department of Fish and Game jointly funded an ecological study of the Vina Plains Preserve pools, which was conducted by faculty from California State University, Chico (Alexander and Schlising 1997). Independent surveys conducted by Joseph Silveira led to discovery of the Merced and Glenn county occurrences (J. Silveira *in litt.* 2000). Private landowners also have contributed to conservation of this species. One pool in Tehama County was fenced by the property owner in the late 1980's, to exclude livestock (Stone *et al.* 1988).

C. *ERYNGIUM CONSTANCEI* (LOCH LOMOND BUTTON-CELERY)

1. Description and Taxonomy

Taxonomy.—Loch Lomond button-celery, specifically known as *Eryngium constancei* (Sheikh 1983), is a member of the carrot family (Apiaceae). This species was only recently described and therefore has no history of name changes. The common name was derived from the type locality, Loch Lomond, which is in Lake County (Sheikh 1983). Other common names for this species are Loch Lomond coyote-thistle (Skinner and Pavlik 1994) and Constance's coyote-thistle (Smith *et al.* 1980).

Description and Identification.—Certain features are common to species of the genus *Eryngium*. Unlike most vernal pool plants, *Eryngium* species are biennial or perennial, with an overwintering rootstock. The plant parts are often spiny, hence the word "thistle" in the common names. The earliest leaves produced from the rootstock each year are long and tubular with crosswise partitions. Leaves produced later in the growing season typically have a narrow petiole and a broader blade, which is usually lobed. *Eryngium* plants also have leaves at both the base of the plant and on the stem; stem leaves are typically opposite, but the upper leaves may be alternate. The tiny flowers are clustered

into spiny heads. In addition, all members of the carrot family have tiny, scaly, dry fruits that contain two seeds (Mason 1957, Constance 1993).

Eryngium constancei (**Figure II-5**) has slender, loosely branched stems 20 to 30 centimeters (7.9 to 11.8 inches) tall, which may be decumbent or upright. The entire plant is covered with downy hairs. The mature leaves are 11 to 16 centimeters (4.3 to 6.3 inches) long, with the petiole accounting for most of the length. The leaf blade is lance-shaped and may have a smooth, sharply toothed, or lobed margin. The bracts are narrow, spiny-margined, and shorter than the leaves. In this species, the rounded flower heads are only 3 to 5 millimeters (0.12 to 0.20 inch) in diameter; however, the stems supporting the flower heads may be as much as 8 centimeters (3.1 inches) long. Each flower head contains only five to seven tiny flowers. The petals are approximately 1 millimeter (0.04 inch) long and are white or tinged with purple. Fruits of this species are egg-shaped and approximately 2 millimeters (0.08 inch) long. The diploid chromosome number of *E. constancei* is 32 (Sheikh 1983, Constance 1993).

The downy hairs and sparsely-flowered heads of *Eryngium constancei* distinguish it from other *Eryngium* species. All other species in the genus are hairless and have more than 10 flowers per head (Sheikh 1983, Constance 1993).

2. Historical and Current Distribution

Historical Distribution.—For over 5 decades, this species was known only from Loch Lomond, where it was first collected in 1941 (Sheikh 1983). *Eryngium constancei* has always been restricted to the Lake-Napa Vernal Pool Region (Keeler-Wolf *et al.* 1998) (**Figure II-6**).

Current Distribution.—Three additional populations of *Eryngium constancei* were discovered during the late 1990's, bringing the total number of populations to four. Three of the *E. constancei* populations are in Lake County and the other is in Sonoma County; all are in the Lake-Napa Vernal Pool Region (Keeler-Wolf *et al.* 1998). In Lake County, the species grows at Loch Lomond, Dry Lake (California Natural Diversity Data Base 2003), and in an unnamed pool near Cobb (A. Howald *in litt.* 1995, J. Diaz-Haworth pers. comm. 2001). The Sonoma County occurrence is composed of two pools on Diamond Mountain (California Natural Diversity Data Base 2003).

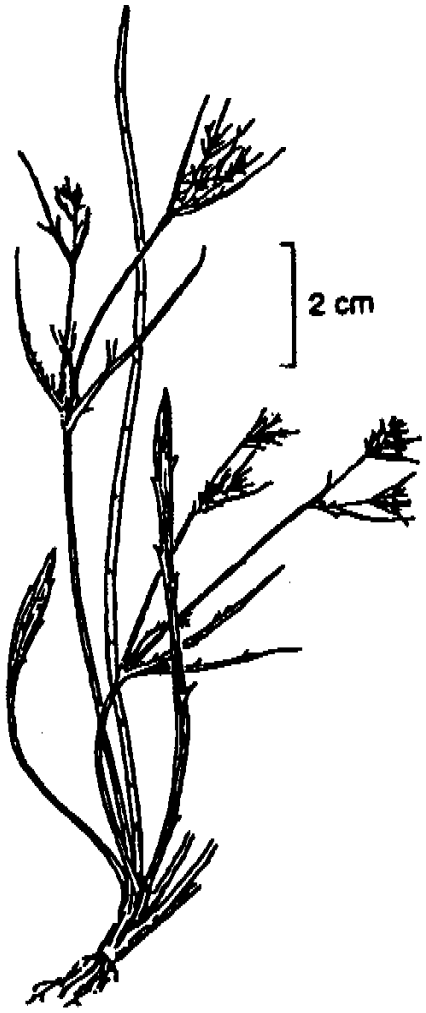

Figure II-5. Illustration of *Eryngium constancei* (Loch Lomond button-celery) (Reprinted from the Jepson Manual, J. Hickman, Ed., 1993, with permission from the Jepson Herbarium. © Regents of the University of California)

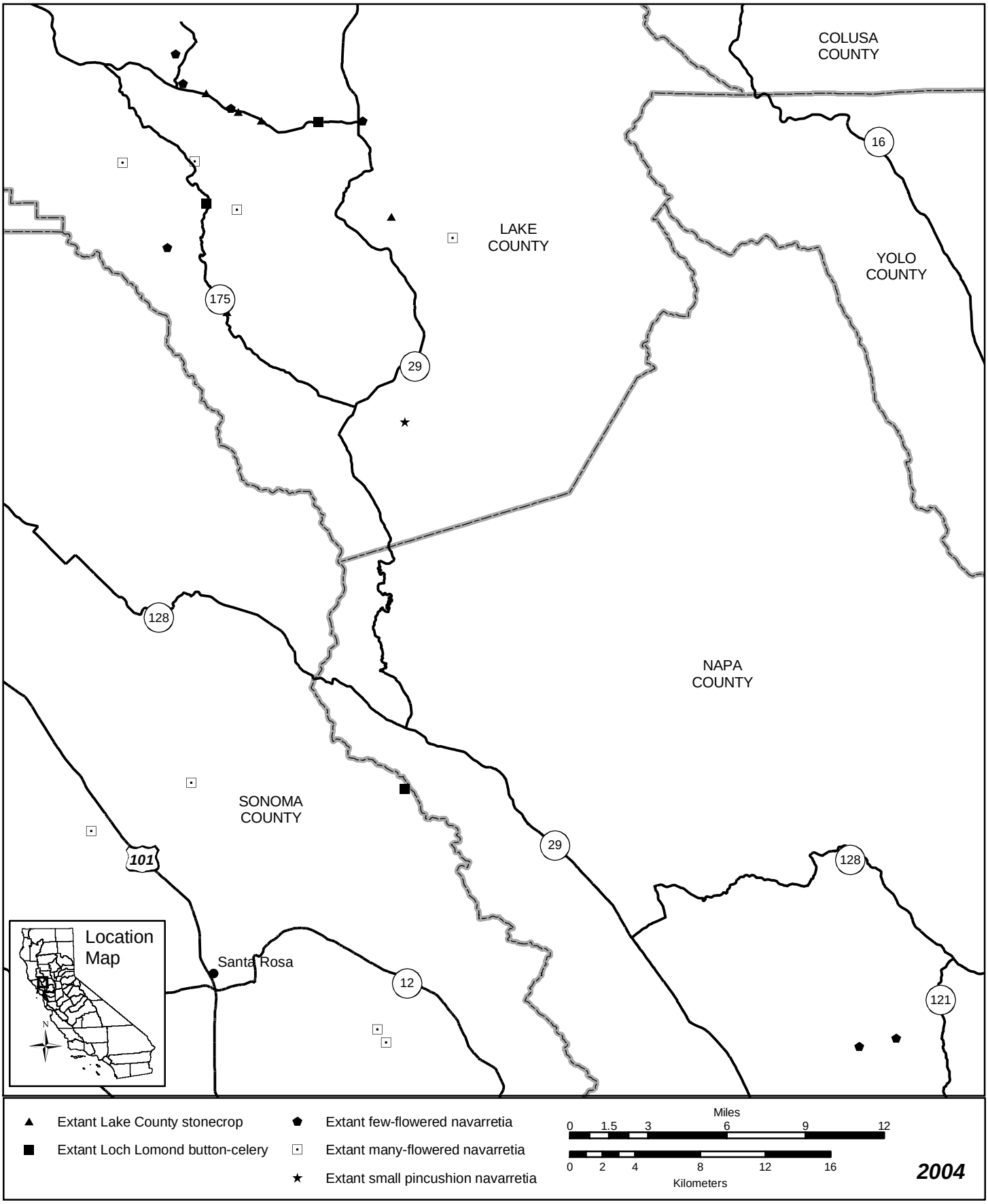

Figure II-6. Distribution of *Parvisedum leiocarpum* (Lake County stonecrop), *Eryngium constancei* (Loch Lomond button-celery), *Navarretia leucocephala* ssp. *pauciflora* (few-flowered navarretia), *Navarretia leucocephala* ssp. *plieantha* (many-flowered navarettia), and *Navarretia myersii* ssp. *deminuta* (small pincushion navarretia).

The Sonoma County plants differ slightly from the description above in that the heads have more flowers and some individuals have stout stems, but their identity was verified by species expert Dr. Lincoln Constance (Hrusa and Buckmann 2000). The site near Cobb is not yet listed as an occurrence in the California Natural Diversity Data Base (2003), but Dr. Constance has confirmed the identity of the specimens (A. Howald *in litt.* 1995). Based on an analysis of soils, slope, elevation, and climate, only a very limited area in Lake and Napa Counties is considered to be suitable habitat for *Eryngium constancei* (Holland 2003).

3. Life History and Habitat

Reproduction and Demography.—*Eryngium constancei* flowers after the water evaporates from the pools, typically between June and August (California Department of Fish and Game 1985, 1994). Little else is known about the reproductive ecology or demography of this species. However, its life history may be quite similar to that of *E. vaseyi* (Vasey's coyote-thistle): producing a tuft of tubular leaves underwater from the perennial rootstock or from a newly-germinated seed in the late winter or early spring; developing broad terrestrial leaves later in the spring as the water evaporates; flowering in the summer; and developing fruits in July or August (Jepson 1922).

The demography of *Eryngium constancei* has not been studied. However, population size would not be expected to vary substantially among years because it is a perennial. The Dry Lake and Sonoma County populations numbered in the tens of thousands in both 1996 and 1997. However, in 1996, the Loch Lomond population was at least two orders of magnitude larger than in 1997 (California Natural Diversity Data Base 2003). The size of the fourth population has not been reported. Germination dates and conditions for *E. constancei* have not been determined, nor have pollinators or seed dispersal agents been identified.

Habitat and Community Associations.—Habitat information is available only for the three occurrences catalogued by the California Natural Diversity Data Base (2003). Loch Lomond is a small, intermittent lake with a surface area of about 3 hectares (7 acres) at maximum inundation (U.S. Fish and Wildlife Service 1985*b*). This wetland is classified as a Northern Volcanic Ashflow Vernal Pool (Sawyer and Keeler-Wolf 1995, California Natural Diversity Data Base 2003) and is on Collayomi-Aiken-Whispering complex soils. The lake is at an elevation of 853 meters (2,800 feet). The surrounding area is mountainous and supports a mixed forest dominated by *Pinus ponderosa* (ponderosa pine), *Quercus kelloggii* (black oak), *Pseudotsuga menziesii* (Douglas fir), and understory of *Arctostaphylos* spp. (manzanita) and *Ceanothus* spp. (California lilac) (California Department of Fish and Game 1994, K. Aasen *in litt.* 1995, California Natural

Diversity Data Base 2003). *Eryngium constancei* occurred throughout the lakebed in 1994, but grew most densely towards the center, where it was one of the most abundant species. Other plants that were abundant in Loch Lomond that year included *Perideridia gairdneri* ssp. *gairdneri* (Gairdner's yampah), *Cuscuta howelliana* (Boggs Lake dodder), *Mentha pulegium* (pennyroyal), *Plagiobothrys stipitatus*, *Plagiobothrys tener* (slender popcorn flower), and a species of navarretia (California Department of Fish and Game 1994) that has been identified as an intergrade between *Navarretia leucocephala* ssp. *plieantha* and *N. leucocephala* ssp. *pauciflora* (A. Day *in litt.* 1997). *Eryngium aristulatum* (Jepson's button-celery), a close relative of *E. constancei*, also co-occurred in the lakebed (California Department of Fish and Game 1994).

On Diamond Mountain, the pools where *Eryngium constancei* grows are shallow and spring-fed (California Natural Diversity Data Base 2003); they are classified as Northern Basalt Flow Vernal Pools (Sawyer and Keeler-Wolf 1995, California Natural Diversity Data Base 2003). The surface area of the occupied pools and the soil type have not yet been determined. The surrounding plant community consists of *Quercus garryana* (Oregon oak), *Q. lobata* (valley oak), and *Pseudotsuga menziesii* (Hrusa and Buckmann 2000). The elevation of the site has been variously reported as 628 meters (2,060 feet) (California Natural Diversity Data Base 2003) or 685 meters (2,247 feet) (Hrusa and Buckmann 2000). *Eryngium constancei* was dominant in both pools in 1996 (B. Hunter *in litt.* 1996). Associated plant species that year included *Pogogyne douglasii* (Douglas' pogogyne), *Perideridia kelloggii* (Kellogg's yampah), *Perideridia howellii* (Howell's yampah), *Eleocharis* spp. (spikerush), *Madia elegans* ssp. *densifolia* (leafy common madia), and *Clarkia purpurea* (winecup clarkia) (California Natural Diversity Data Base 2003).

Less information is known about the Cobb and Dry Lake occurrences. The surface area of the Cobb pool is approximately 2 hectares (5 acres) (J. Diaz-Haworth pers. comm. 2001), but its elevation and soil type is not known. The endangered plant *Navarretia leucocephala* ssp. *pauciflora* is the only associate that has been reported at the Cobb pool (A. Howald *in litt.* 1995). The Dry Lake pool is at an elevation of 463 meters (1,520 feet) and is surrounded by *Quercus douglasii* (blue oak) woodland. In 1997, *Eryngium constancei* was the dominant species and was associated with unidentified rushes (California Natural Diversity Data Base 2003). Soils underlying Dry Lake are in the Sobrante-Guenoc-Hambright complex.

4. Reasons for Decline and Threats to Survival

Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to *Eryngium constancei* are described below.

One specific threat is that at least one of the occupied pools at Diamond Mountain may be converted to a vineyard, and the owner of Dry Lake has proposed excavating the pool for a reservoir (California Natural Diversity Data Base 2003). Changes in hydrology threaten three of the four occurrences. In addition, runoff from adjacent roads and swimming pools creates excess water flow, whereas drainage ditches, culverts, and diversion of a natural spring are reducing the flow of water to *Eryngium constancei* habitat (Hrusa and Buckmann 2000, California Natural Diversity Data Base 2003).

Larger-scale hydrological alterations, including commercial development and timber harvesting, are also occurring in all the watersheds where *Eryngium constancei* grows, thus posing added hydrological threats (U.S. Fish and Wildlife Service 1985*b*, 1986, 1993*b*; California Department of Fish and Game 1994; K. Aasen *in litt.* 1995; B. Hunter *in litt.* 1996; California Natural Diversity Data Base 2003).

The extremely restricted distribution of *Eryngium constancei* is an additional threat to this species. Although the individual populations of *E. constancei* are sufficiently large that intrinsic problems such as genetic drift are not a concern, other random events could cause the species to go extinct. Catastrophic weather events, climate change, or other unforeseen circumstances potentially could eliminate all of the populations, due the very limited distribution of this plant.

A more subtle threat that could cause decline of *Eryngium constancei* populations would be a lack of pollinators, if they are necessary for seed-set. Pollinating insects may require habitat outside of the vernal pools, which could be lost if it is not identified and targeted for protection. However, neither the importance nor status of pollinators have been identified at this time.

5. Conservation Efforts

In 1985, we declared *Eryngium constancei* to be endangered under emergency listing provisions of the Endangered Species Act (U.S. Fish and Wildlife Service 1985*b*). Following this emergency listing, we published a final rule on December

23, 1986 determining *E. constancei* to be an endangered species (U.S. Fish and Wildlife Service 1986). However, due to conservation efforts directed at Loch Lomond (see below), we later proposed to downlist the species to threatened status (U.S. Fish and Wildlife Service 1993); action on this proposal is still pending.

The California Fish and Game Commission listed *Eryngium constancei* as endangered in 1987 (California Department of Fish and Game 1991). The California Native Plant Society has considered the plant rare and endangered since 1980 (Smith *et al.* 1980). *Eryngium constancei* currently is on the California Native Plant Society's List 1B, with the highest endangerment rating possible (California Native Plant Society 2001).

California's Wildlife Conservation Board and Public Works Board acquired Loch Lomond and a small adjacent buffer in 1988 to prevent its conversion to a recreational lake. The site is now known as the Loch Lomond Vernal Pool Ecological Reserve. In 1989, the California Department of Fish and Game, with financial assistance from us, fenced the perimeter of the lake to exclude off-road vehicles and other detrimental recreational use (U.S. Fish and Wildlife Service 1993, California Department of Fish and Game 1994). In 1994, the California Department of Fish and Game prepared a management plan for the reserve and obtained a baseline population estimate for *Eryngium constancei*. Periodic monitoring of the population and interpretive displays about the species are planned (California Department of Fish and Game 1994).

A local citizen with an interest in conservation bought the Cobb parcel where *Eryngium constancei* grows. She intends to protect the vernal pool and its associated species (J. Diaz-Haworth pers. comm. 2001, B. Flynn pers. comm. 2001). The California Department of Fish and Game has reviewed timber harvest plans and other land uses for areas adjacent to any of the populations and has provided recommendations on how to avoid impacts to *E. constancei* (*e.g.*, K. Aasen *in litt.* 1995, B. Hunter *in litt.* 1996, A. Buckmann *in litt.* 1998). In addition, their biologists conducted surveys for this species (U.S. Fish and Wildlife Service 1985b), and the agency is investigating ways to protect the Diamond Mountain occurrence (Hrusa and Buckmann 2000).

D. *LASTHENIA CONJUGENS* (CONTRA COSTA GOLDFIELDS)

1. Description and Taxonomy

Taxonomy.—Greene (1888) first described Contra Costa goldfields, naming this species *Lasthenia conjugens.* The type locality is Antioch, in Contra Costa County (Greene 1888). Hall (1914) later lumped Contra Costa goldfields with the common species Fremont's goldfields, which at that time was called *Baeria fremontii*. Ferris (1958) proposed the name *Baeria fremontii* var. *conjugens* to recognize the distinctiveness of Contra Costa goldfields. Finally, Ornduff (1966) restored Greene's original name and rank, returning this species to the genus *Lasthenia*. The two closest relatives of *Lasthenia conjugens* are *L. burkei* (Burke's goldfields) and *L. fremontii* (Fremont's goldfields).

Description and Identification.—The stems of *Lasthenia conjugens* (**Figure II-7**) are 10 to 30 centimeters (4 to 12 inches) tall, somewhat fleshy, and usually branched. The leaves are opposite and narrow; the lower leaves are entire, but stem leaves have one or two pairs of narrow lobes. The daisy-like flower heads are solitary. Both the disk and ray flowers are golden-yellow, and the ligules are 5 to 10 millimeters (0.20 to 0.39 inch) long. Each head has numerous disk flowers and 6 to 13 ray flowers. The club-shaped achenes are no more than 1.5 millimeters (0.06 inch) long and are shiny, olive-green, hairless, and lack a pappus (Greene 1888, Ornduff 1993*b*). *Lasthenia conjugens* has a diploid chromosome number of 12 (Ornduff 1966, Ornduff 1993*b*).

Whereas all other species of *Lasthenia* have either completely free phyllaries or phyllaries fused more than two-thirds of their length, *L. conjugens* has phyllaries fused from one-quarter to one-half their length. The free phyllaries and presence of a pappus distinguish both *L. burkei* and *L. fremontii* from *L. conjugens* (Ornduff *1969*, Ornduff 1979, Ornduff 1993*b*). *Blennosperma* species can be differentiated from *L. conjugens* by the alternate leaves, clustered (as opposed to solitary) flower heads, and paler yellow ligules of the former (Ornduff 1993*a*, Ornduff 1993*b*).

2. Historical and Current Distribution

Historical Distribution.—*Lasthenia conjugens* occurred historically in seven vernal pool regions: Central Coast, Lake-Napa, Livermore, Mendocino, Santa Barbara, Santa Rosa, and Solano-Colusa (**Figure II-8**) (Keeler-Wolf *et.al*. 1998). In addition, several historical occurrences in Contra Costa County are outside of the defined vernal pool regions (Keeler-Wolf *et al.* 1998, California Natural Diversity Data Base 2003). Many collection sites from the late 19th and

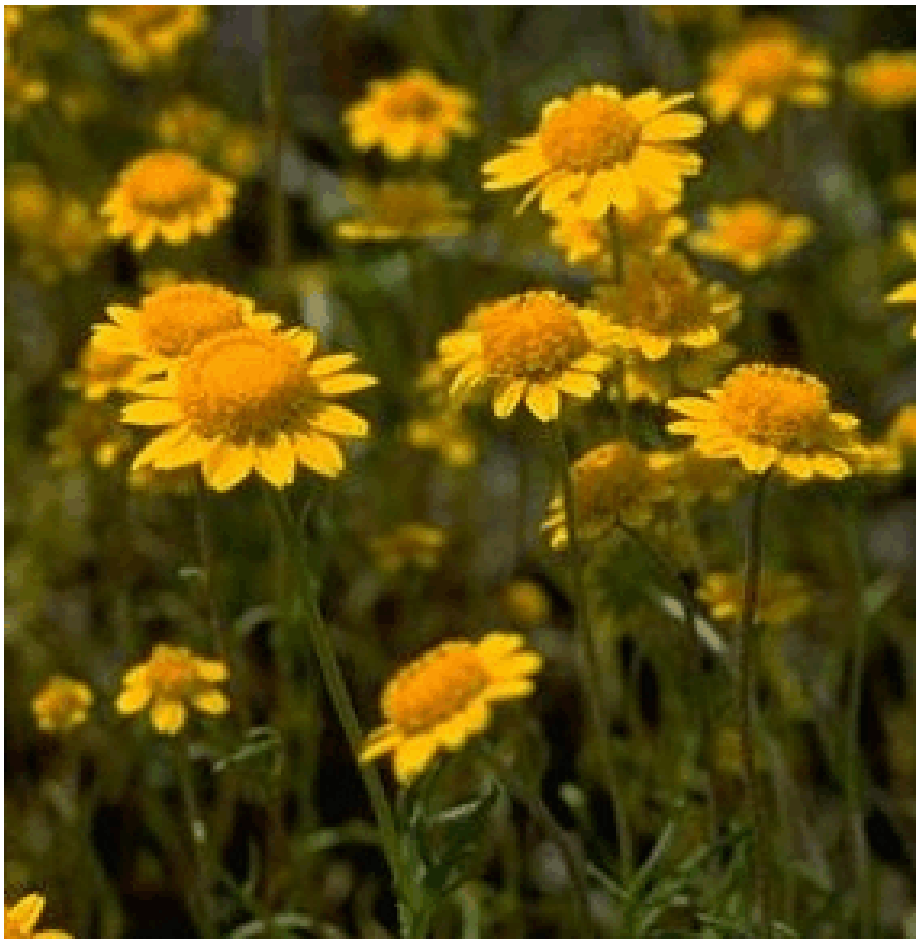

Figure II-7. Photograph of *Lasthenia conjugens* (Contra Costa goldfields). (Reprint with permission from John Game, 1998)

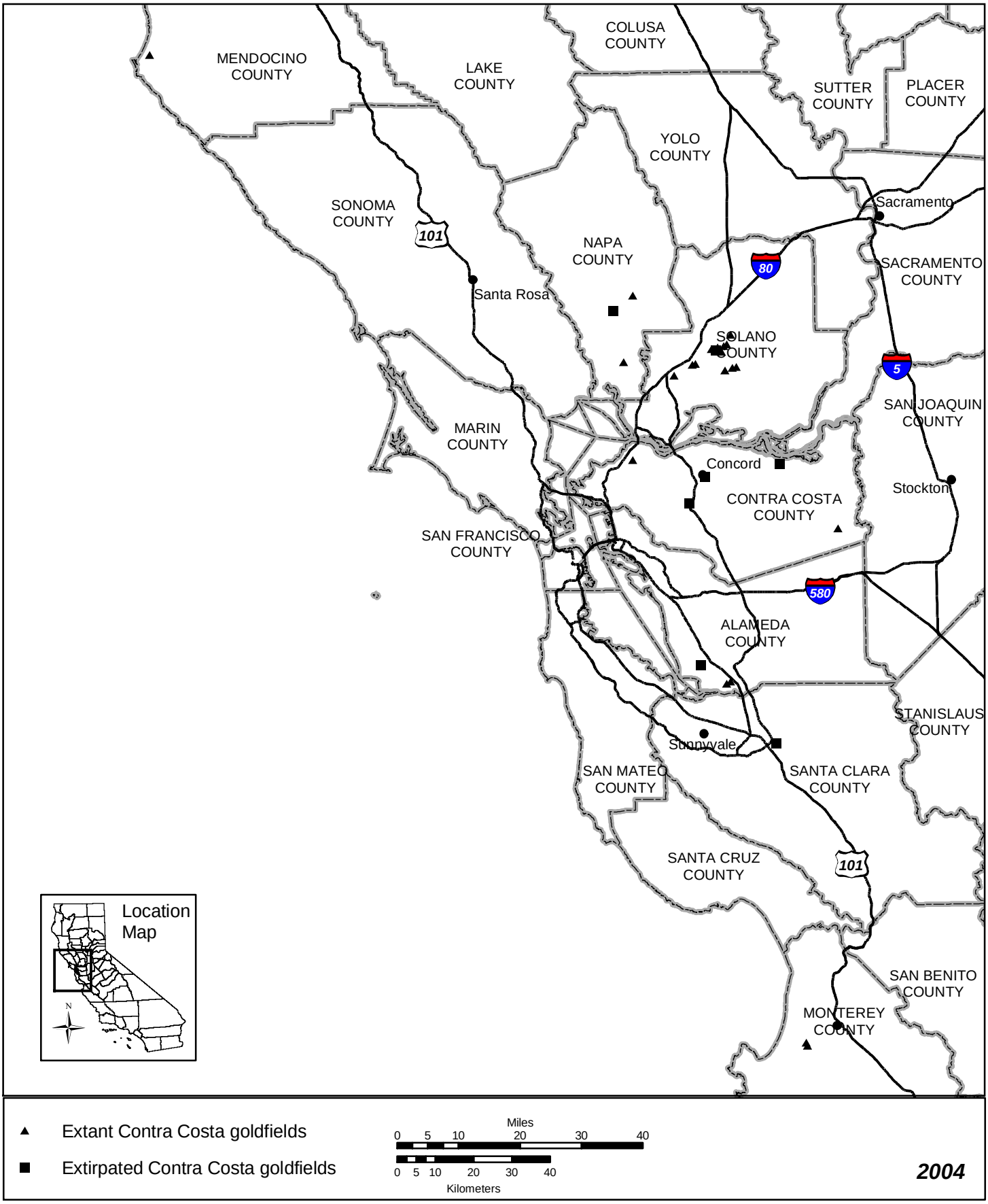

Figure II-8. Distribution of *Lasthenia conjugens* (Contra Costa goldfields).

early 20th centuries are difficult to pinpoint because locality information on specimen labels often was vague. Ornduff (1966) reported collections from 13 sites in Alameda, Contra Costa, Mendocino, Napa, Santa Barbara, Santa Clara, and Solano Counties. Although he cited three specimens each from Contra Costa (including the type) and Santa Barbara Counties, Ornduff (1966, 1979) noted that the species was most common in Solano County. One additional site in Alameda County was documented in 1959 by G. Thomas Robbins, who collected a specimen (# 3963, housed at the Jepson Herbarium) on the "shore of San Francisco Bay" south of Russell.

Current Distribution.—Of the 31 occurrences of *Lasthenia conjugens* between 1884 and 2002 that are currently (through November 2003) catalogued in the California Natural Diversity Data Base (2003), 20 are likely extant. However, there is uncertainty due in part to the difficulty of relocating sites based on early vague site descriptions and also because this species may reappear on a site after several years, even if it is absent during a given survey. *Lasthenia conjugens* presumably remains in all of the vernal pool regions where it occurred historically, except for the Santa Barbara Vernal Pool Region. However, by far the greatest concentration of this species is in the Solano-Colusa Vernal Pool Region; the specific area east of Fairfield in Solano County contains 11 occurrences that are presumed extant, plus 3 that may be extirpated. Another extant occurrence is near Rodeo in Contra Costa County (California Natural Diversity Data Base 2003) which was captured within the Solano-Colusa Vernal Pool Region. Four occurrences are extant in the Central Coast Vernal Pool Region, including two at Fort Ord in Monterey County, one at San Francisco Bay National Wildlife Refuge, and one near Fremont, both in Alameda County (California Natural Diversity Data Base 2003). One occurrence is presumed to remain extant in the Mendocino Vernal Pool Region near Manchester in Mendocino County. In the Lake-Napa Vernal Pool Region, one occurrence is presumed to remain extant at Suscol Ridge in Napa County. Another Napa County site, Milliken Canyon, also in the Lake-Napa Vernal Pool Region contained only a single plant in 1987 and may or may not be extant (California Natural Diversity Data Base 2003).

3. Life History and Habitat

Little is known about this plant. However, germination, growth, reproduction, and demography are likely to be similar to *Lasthenia burkei*, a close relative that has been studied more intensively.

Reproduction and Demography.—As a vernal pool annual plant, seeds of *Lasthenia conjugens* would be expected to germinate in response to autumn rains,

with the plants maturing in a single growing season, setting seed, and dying back during the summer. However, detailed research on the life cycle has not been conducted. Laboratory germination tests on the related species *L. burkei* (Rancho Santa Ana Botanical Garden unpublished data), indicated that germination occurs rapidly in a single flush (peak germination date the same as first germination date), with relatively high germination rates (49 to 100 percent). *Lasthenia burkei* plants that establish in autumn under natural conditions may tolerate prolonged submergence but do not begin rapid stem growth until vernal pools and swales drain down during late winter or early spring (Ornduff 1969, Patterson *et al.* 1994).

Lasthenia conjugens flowers from March through June (Ornduff 1966, Ornduff 1979, Skinner and Pavlik 1994). The flowers are self-incompatible (Crawford and Ornduff 1989). Although *L. conjugens* has not been the subject of pollinator studies, observations suggest that the same insects visit all outcrossed species of *Lasthenia*, rather than concentrating on particular species (Thorp 1976). Insect visitors to flowers of *Lasthenia* belong to five orders: Coleoptera, Diptera, Hemiptera (true bugs), Hymenoptera, and Lepidoptera (Thorp and Leong 1998). Most of these insects are generalist pollinators. All of the specialist pollinators of *Lasthenia* are solitary bees (family Andrenidae); these pollinators include two species in the subgenus *Diandrena* (*Andrena submoesta* and *A. puthua*) and five or six species in the subgenus *Hesperandrena* (*Andrena baeriae, A. duboisi, A. lativentris*, and two or three undescribed species) (Thorp and Leong 1998). The extent to which pollination of *L. conjugens* depends on host-specific bees or more generalist pollinators is currently unknown.

Seed dispersal mechanisms in *Lasthenia conjugens* are unknown. However, the lack of a pappus or even hairs on the achenes makes wind dispersal unlikely (Ornduff 1976). Seed longevity, survival rates, fecundity, and other demographic parameters have not been investigated. However, as with other vernal pool annuals, population sizes have been observed to vary by up to four orders of magnitude from year-to-year (California Natural Diversity Data Base 2003). Thus, this species most likely forms a persistent soil seed bank. Seeds of the related species *L. burkei* have been stored artificially for many years with little loss of viability (C. Patterson pers. comm.). However, the maximum duration of viable seed in the soil is not known.

Habitat and Community Associations.—*Lasthenia conjugens* typically grows in vernal pools, swales, moist flats, and depressions within a grassland matrix (California Natural Diversity Data Base 2003). However, several historical collections were from populations growing in the saline-alkaline transition zone between vernal pools and tidal marshes on the eastern margin of

the San Francisco Bay (P. Baye *in litt.* 2000*a*). The herbarium sheet for one of the San Francisco Bay specimens notes that the species also grew in evaporating ponds used to concentrate salt (P. Baye *in litt.* 2000*b*). The vernal pool types from which this species has been reported are Northern Basalt Flow, Northern Claypan, and Northern Volcanic Ashflow (Sawyer and Keeler-Wolf 1995). The landforms and geologic formations for sites where *L. conjugens* occurs have not yet been determined. Most occurrences of *L. conjugens* are at elevations of 2 to 61 meters (6 to 200 feet), but the recently discovered Monterey County occurrences are at 122 meters (400 feet) and one Napa County occurrence is at 445 meters (1,460 feet) elevation (California Natural Diversity Data Base 2003).

The soil types have not yet been identified for most *Lasthenia conjugens* localities. However, soil series from which it is known are: Aiken, Antioch, Concepcion, Conejo, Crispin, Haire, Linne, Los Robles, Rincon, Solano, and San Ysidro, plus the Arnold-Santa Ynez, Hambright-rock outcrop, and Los Osos complexes. Soil textures, where known, are clays or loams. At least in Solano County and on the shores of San Francisco Bay, *L. conjugens* grows in alkaline or saline-alkaline sites (P. Baye *in litt.* 2000*a*, P. Baye *in litt.* 2000*b*, California Natural Diversity Data Base 2003).

Many plant species grow in association with *Lasthenia conjugens* in various parts of its range, but no comprehensive survey of associates has been undertaken. The two most commonly reported associates are *Lolium multiflorum* (Italian ryegrass) and *Plagiobothrys* spp. (popcorn flower). Other plant species that occur at several *Lasthenia conjugens* sites include *Cotula coronipifolia* (brass buttons), *Downingia pulchella* (valley downingia), *Eryngium aristulatum*, *Lasthenia glaberrima* (smooth goldfields), *Myosurus minimus* (common mousetail), and *Pleuropogon californicus* (California semaphore grass). Among the rare plants addressed in this recovery plan, those that co-occur with *Lasthenia conjugens* include *Astragalus tener* var. *tener* at two sites and *Navarretia leucocephala* ssp. *pauciflora* and *Legenere limosa* at one site each (California Natural Diversity Data Base 2003).

4. Reasons for Decline and Threats to Survival

Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to *Lasthenia conjugens* are described below.

Except for Travis Air Force Base, the entire concentration area in Solano County is in the City of Fairfield's sphere of influence and is subject to relatively intense development under the City's general plan. Numerous construction projects, including residential development, landfill expansion, and drainage channels, are proposed and pose specific threats (U.S. Fish and Wildlife Service 1997*b*). Some projects, such as proposed highways, may disturb habitat on Travis Air Force Base as well as in the Fairfield area (U.S. Fish and Wildlife Service 2002). Urbanization also specifically threatens one of the two remaining Alameda County/San Francisco Bay occurrences of this plant (Duncan & Jones 1996). Threats due to conversions to vineyards are also continuing. The largest Napa County occurrence of this plant, at Suscol Ridge (California Natural Diversity Data Base 2003), is imminently threatened by vineyard conversion; the site already is under a 25-year lease to a winery (P. Baye *in litt.* 2000*a*).

Competition from non-native plants, particularly *Lolium multiflorum*, threatens at least eight occurrences of *Lasthenia conjugens*, several of which are also targeted for development (California Natural Diversity Data Base 2003). Nonnative grasses like *Lolium multiflorum* not only shade out short-statured plants like *Lasthenia conjugens*, but can also negatively impact vernal pool hydrology by decreasing inundation periods in invaded pools (Marty 2004). In addition, the encroachment by non-native plants often follows surface-disturbing activities, such as discing, grading, filling, ditch construction, and off-road vehicle use, which can alter hydrology and microhabitat conditions. Such surface disturbances are visually apparent at nine sites, four of which do not yet have reported problems with non-native species (California Natural Diversity Data Base 2003). Management strategies including grazing, mowing, and burning are vital to controlling these weed species. The California Natural Diversity Data Base (2003) also cites inappropriate livestock grazing practices as a threat to seven occurrences of *Lasthenia conjugens*. However, the removal of livestock grazing from at least one site in Contra Costa County has caused significant population declines in this species (Marty, pers. comm. 2004). Therefore, removal of grazing as well as overgrazing may have adverse impacts to the *Lasthenia conjugens* and other species in this plan.

5. Conservation Efforts

We listed *Lasthenia conjugens* as endangered on June 18, 1997 (U.S. Fish and Wildlife Service 1997*b*). This species does not currently have any State listing status. The California Native Plant Society has considered *L. conjugens* rare and endangered since the organization's first list was published (Powell 1974); *L. conjugens* currently is on List 1B, the highest endangerment rating possible (Skinner and Pavlik 1994). In 2003, critical habitat was designated for

L. conjugens and several other vernal pool species in *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon* (U.S. Fish and Wildlife Service 2003).

Four occurrences are on public lands: two at Fort Ord, and one each at San Francisco Bay National Wildlife Refuge, and Travis Air Force Base, which are administered by the U.S. Bureau of Land Management, the U.S. Fish and Wildlife Service, and the U.S. Air Force, respectively. One of the two Fort Ord occurrences is on land managed as a preserve, which has been fenced to exclude motorized vehicles (California Natural Diversity Data Base 2003). The population at Travis Air Force Base, including over 20 acres of adjacent restored vernal pools, is protected as a Preserve.

Seasonal managed cattle grazing has been returned to two conservation sites supporting the *Lasthenia conjugens*: 1) the Warm Springs Seasonal Wetland Unit of the Don Edwards San Francisco Bay National Wildlife Refuge in Alameda County and 2) the State Route 4 Preserve managed by the Muir Heritage Land Trust in Contra Costa County. The *L. conjugens* population at the Warm Springs Unit has declined during the last ten years due to many factors including competition by nonnative plant species. During this time period, grazing, which occurred intermittently at the Warm Springs Unit since the 1800's, has been excluded by the Refuge until a management plan could be developed. The decline in the *L. conjugens* population at the Warm Springs Unit cannot be attributed to a single factor, but most likely result from the complex interaction of several variables including the current and historic land use, the abiotic environment, and annual climatic variation. The increasing dominance of nonnative grasses, however, coincides with the suspension of livestock grazing, suggesting that the lack of a disturbance regime may be a primary factor in the degradation of habitat for *L. conjugens* (U.S. Fish and Wildlife Service 2004). The population of *L. conjugens* at the State Route 4 Preserve, which was protected as part of compensation for the construction of the State Route 4 Gap Closure Project, also declined in recent years. The decline may be due to a number of causes including below normal precipitation and competition from nonnative species (Pardieck 2003). The site had been grazed heavily for many years resulting in stream channel erosion. Grazing was suspended in 2000 and the numbers of plants dropped sharply in 2001 and continued to decline the following year. Controlled grazing has been reintroduced to control the amount of seed and thatch produced by nonnative plants.

E. *LIMNANTHES FLOCCOSA* SSP. *CALIFORNICA* (BUTTE COUNTY MEADOWFOAM)

1. Description and Taxonomy

Taxonomy.—Before 1973, Butte County meadowfoam was not differentiated from the more widespread woolly meadowfoam (*Limnanthes floccosa* ssp. *floccosa*). Then, Arroyo (1973) determined that Butte County meadowfoam was a distinct taxon and gave it the scientific name *Limnanthes floccosa* ssp. *californica*. The type locality is in Butte County between Chico and Oroville, near the intersection of State Highway 99 and Shippee Road (Arroyo 1973). An alternative common name, Shippee meadowfoam, is derived from the type locality (California Department of Fish and Game 1987*a*, Ornduff 1993*c*). *Limnanthes floccosa* ssp. *californica* is a member of the meadowfoam or false mermaid family (Limnanthaceae), which is a small family comprising only 2 genera and 10 species (Ornduff 1993*c*).

Description and Identification.— *Limnanthes floccosa* ssp. *californica* is a small annual with erect stems less than 25 centimeters (9.8 inches) tall. The stem and leaves are densely pubescent. The alternate leaves are pinnately compound, up to 8 centimeters (3.1 inches) long, and consist of 5 to 11 leaflets on a long petiole. The individual leaflets are approximately 1 centimeter (0.4 inch) long and vary from narrow to egg-shaped; their margins may be smooth, toothed, or lobed. A single flower arises in the axil of each upper leaf. The fragrant flowers are cup- or bowl-shaped and consist of 5 petals, 5 sepals, 5 pistils, and 10 stamens on a long flower stalk. The petals are 8 to 10 millimeters (0.31 to 0.39 inch) long, white with yellow veins, and have two rows of hairs at the base. The sepals are about the same length as the petals and are densely pubescent on both their inner and outer surfaces. Although the sepals are not fused, the dense hairs hold them together, preventing the flower from opening fully. The pistils are separate at the base, but the upper parts are fused. Each pistil is capable of producing a nutlet; the nutlets are egg-shaped, 3 to 4.5 millimeters (0.12 to 0.18 inch) long, and covered with cone-shaped tubercles. As the nutlets mature, the petals turn inward, and at maturity the entire flower, including the nutlets, falls off the plant as a unit. The diploid chromosome number for all *Limnanthes* species is 10 (Mason 1952, Arroyo 1973, McNeill and Brown 1979, Ornduff 1993*c*).

Limnanthes floccosa ssp. *californica* has longer sepals, petals, anthers and filaments than *L. floccosa* ssp. *floccosa*. Moreover, *L. floccosa* ssp. *floccosa* lacks rows of hairs at the petal base; the nutlet is covered with narrow, sharp-pointed tubercles; and the flowers do not open as wide as in *L. floccosa* ssp. *californica*. Among the other species that occur in the same region as *L. floccosa* ssp. *californica* are *L. alba* (white meadowfoam) and *L. douglasii* ssp. *rosea* (pink

meadowfoam). *Limnanthes alba* has petals that are longer than the sepals at flowering. *Limnanthes douglasii* ssp. *rosea* has longer petals that are veined with pink and notched at the tip, and the petals turn outward as the nutlets mature.

2. Historical and Current Distribution

Historical Distribution.— *Limnanthes floccosa* ssp. *californica* has always been confined to the Northeastern Sacramento Valley Vernal Pool Region, and in fact defines the extent of the region (Keeler-Wolf *et al.* 1998) (**Figure II-9**). This plant was first collected in 1914 at a site 13 kilometers (8 miles) north of Oroville (BioSystems Analysis, Inc. 1993), although it had not been recognized as a separate subspecies at that time. In her original description, Arroyo (1973) mentioned six collections, which ranged from 16 kilometers (10 miles) north of Chico south to the type locality and east to Table Mountain, which is north of Oroville. By 1988, 14 occurrences of *L. floccosa* ssp. *californica* had been reported (Arroyo 1973, McNeill and Brown 1979, Dole 1988, Jokerst 1989). Eight were within the city limits of Chico, four (including the type locality) were from the vicinity of Shippee, one was from Table Mountain, and one was from a site northeast of the town of Nord.

Current Distribution.—At least one new occurrence of *Limnanthes floccosa* ssp. *californica* has been discovered since 1988, while two occurrences have been extirpated (Jokerst 1989, Dole and Sun 1992, U.S. Fish and Wildlife Service 1992, California Natural Diversity Data Base 2003, C. Sellers *in litt.* 2001). Furthermore, the California Natural Diversity Data Base (2003) no longer considers the Table Mountain population to be *L. floccosa* ssp. *californica* because Jokerst (1983) did not find this subspecies during his floristic inventory of Table Mountain and later suggested that the specimen had been misidentified (U.S. Fish and Wildlife Service 1992). The California Natural Diversity Data Base (2003) still presumes that the Nord site has an extant occurrence of *L. floccosa* ssp. *californica*, a conclusion bolstered by the finding of 500 plants in this vicinity in 1999. The other 10 occurrences are presumed to be extant (California Natural Diversity Data Base 2003), although not all have been visited recently. Among the occurrences that have been revisited, many have been reduced in extent. Conversely, additional occupied habitat has been identified and thus expanded the boundaries of several other occurrences (California Natural Diversity Data Base 2003, C. Sellers *in litt.* 2001).

Counting the formerly questionable population in the Nord area, *Limnanthes floccosa* ssp. *californica* is thus now found in five natural centers of concentration: the Shippee Road area between Chico and Oroville; near the

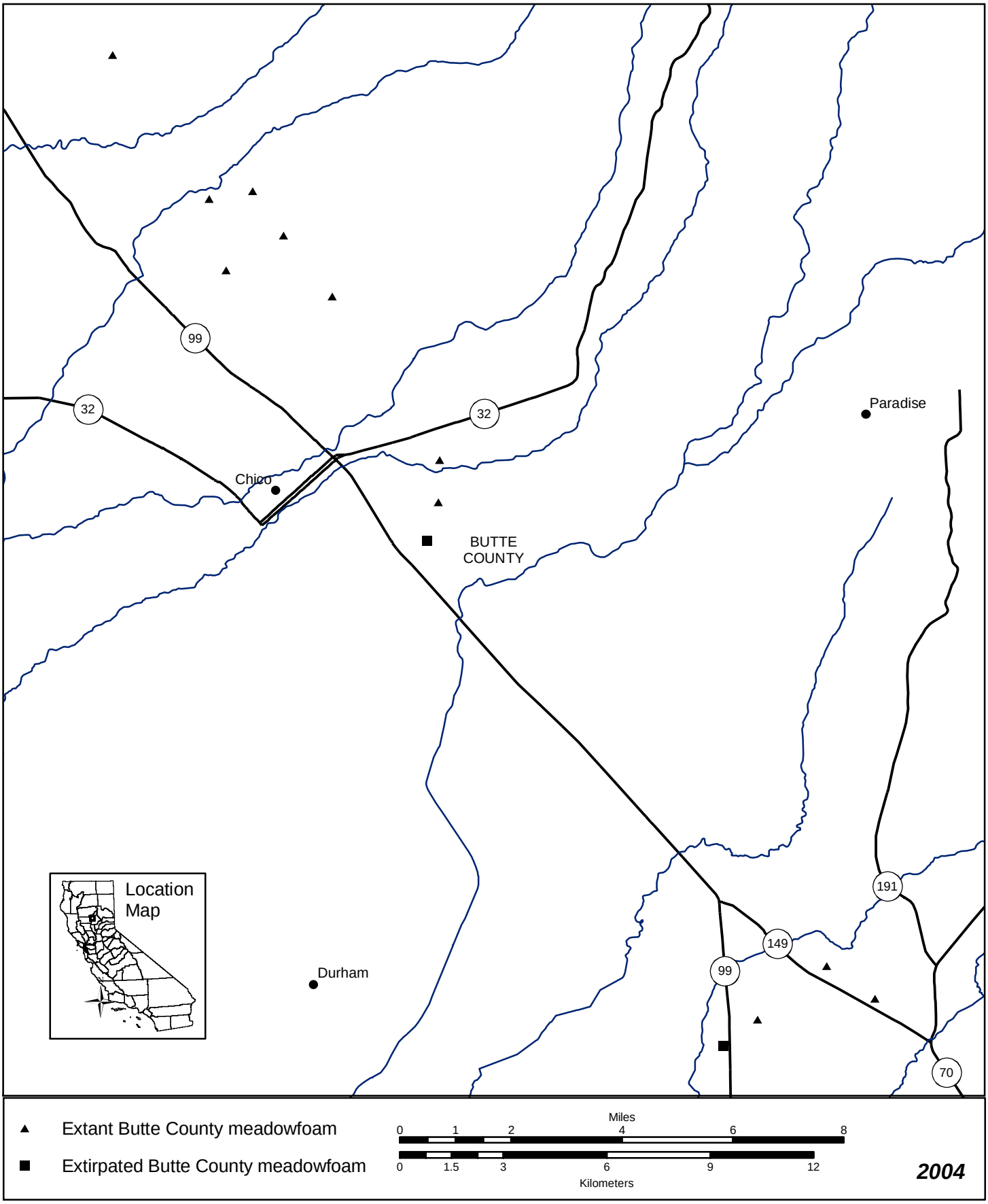

Figure II-9. Distribution of *Limnanthes floccosa* ssp. *californica* (Butte County meadowfoam).

intersection of Highways 99 and 149, where there are three extant occurrences (California Natural Diversity Data Base Element Occurrences 1, 5, and 40); and three other centers of concentration within the City of Chico. The northern center is near the Chico Municipal Airport and consists of four occurrences (Element Occurrence 36- 39); the northeastern center has a single occurrence (Element Occurrence 35) and is known as Rancho Arroyo or Bidwell Ranch; and the southeastern center consists of two extant occurrences (Element Occurrence 7 and 34). Local planners consider these sites to represent 16 populations (C. Sellers *in litt.* 2001) rather than 10 occurrences as defined by the California Natural Diversity Data Base. The extirpated occurrences included the type locality (Element Occurrence 6) from the Shippee Road area of concentration and Element Occurrence 20, which was in the southeastern center of occurrence.

In addition to the 11 naturally occurring populations, an experimental population of *Limnanthes floccosa* ssp. *californica* has been introduced on the Tuscan Preserve in northwestern Butte County (Kelley *et al.* 1994, C. Sellers *in litt.* 2001). The introduction site was just outside of the historical range of the taxon and thus marginally increased its range.

3. Life History and Habitat

Various species in the genus *Limnanthes* have been studied extensively because meadowfoam seeds produce an oil that is potentially valuable for many industrial and pharmaceutical uses. Research has been underway for at least 2 decades to identify the taxa with the most desirable features for commercial use and to cross-breed them (Pierce and Jain 1977, Brown and Jain 1979, Dole 1988). However, most of the research has been on taxa other than *L. floccosa* ssp. *californica*. Life-history traits of related species are presented below when no information is available specifically for *L. floccosa* ssp. *californica*. However, it is recognized that only taxon-specific information should be used in making management decisions (Holland 1987).

Reproduction and Demography.—*Limnanthes floccosa* ssp. *californica* seeds germinate in the late fall after the rainy season begins. The earliest reported observation of seedlings is from December (BioSystems Analysis, Inc. 1993). Dole and Sun (1992) successfully germinated *L. floccosa* ssp. *californica* seeds under 12 hours of daylight at 15 degrees Celsius (59 degrees Fahrenheit), alternating with 12 hours of darkness at 10 degrees Celsius (50 degrees Fahrenheit). However, the optimum length of daylight and germination temperature under natural conditions have not been investigated.

Seed that does not germinate in the first year following its production may still be viable. In laboratory tests on the more common *Limnanthes floccosa* ssp. *floccosa*, two-thirds of the seed remained dormant even after exposure to favorable conditions, and some ungerminated seed remained in soil samples after 3 years (Ritland and Jain 1984). Seed dormancy also would explain population fluctuations of up to two orders of magnitude between years in *L. floccosa* ssp. *californica* (see below).

Limnanthes floccosa ssp. *californica* seedlings can apparently tolerate short periods of submergence (Jokerst 1989, Dole and Sun 1992). The seedlings develop into rosettes, which do not begin producing flowering stems immediately (McNeill and Brown 1979, Ritland and Jain 1984). *Limnanthes floccosa* ssp. *californica* typically begins flowering in February, reaches peak flowering in March, and may continue into April if conditions are suitable. Nutlets are produced in March and April, and the plants die back by early May (Jokerst 1989, Dole and Sun 1992).

Limnanthes floccosa ssp. *californica* has floral adaptations that allow for cross-pollination by insects, but self-pollination mechanisms take over to ensure seed set if insect pollination is unsuccessful. Insects are attracted by the large flowers and production of nectar. The stamens begin shedding pollen 1 day before the stigma is receptive. Thus, during this period a given flower could not self-pollinate. If insects visit the flower during this period, they remove the pollen (Arroyo 1975). However, if pollen remains in the anthers when the stigma matures, gravity can carry it to the stigma, which is situated below the anthers (Arroyo 1973). The rate of self-pollination may vary among years or among sites, depending on the size of insect populations (Kalin 1971 *in* Arroyo 1973, Dole and Sun 1992). Arroyo (1975) estimated that approximately 26 percent of *L. floccosa* ssp. *californica* flowers were self-pollinated in the field during her study. However, when she excluded insects in a greenhouse study, overall seed set in *L. floccosa* ssp. *californica* was the same as that observed under natural conditions (Arroyo 1975). Cross-pollination by insects would allow opportunities for genetic recombination, unlike self-pollination.

Although most populations of *Limnanthes floccosa* ssp. *californica* have *bisexual* flowers, the population at the type locality contains a small percentage of male-sterile plants (Dole and Sun 1992). Pollination of male-sterile flowers can be achieved only by insects. Male sterility also has been observed in populations of two different subspecies of *L. douglasii* (Douglas' meadowfoam). In that species, male-sterile plants produced smaller flowers than were found on bisexual plants (Jain *et al.* 1978, Kesseli and Jain 1984). Moreover, in *L. douglasii* ssp. *rosea* the male-sterile flowers differed in color from the bisexual flowers, and

male-sterile plants grew faster, flowered 2 to 3 days later, and produced more flowers per plant than did bisexual individuals. Seeds produced by male-sterile plants survived longer than those produced by bisexual flowers (Kesseli and Jain 1984).

The particular pollinators of *Limnanthes floccosa* ssp. *californica* have not been identified. Other meadowfoam species are pollinated by the native burrowing bees *Andrena limnanthis* and *Panurginus occidentalis* (Thorp and Leong 1998) and by honeybees (Kesseli and Jain 1984), beetles, flies, true bugs (Order Hemiptera), butterflies, and moths (Mason 1952, Thorp and Leong 1998). Hybridization between *Limnanthes* taxa is limited in natural settings, due to differences in flower structure, phenology, and microhabitat (Arroyo 1973, Jain 1976*b*, Ritland and Jain 1984, Dole and Sun 1992). However, some hybrids between *L. floccosa* ssp. *californica* and *L. alba* have been produced under laboratory conditions (Dole and Sun 1992).

Nutlets of *Limnanthes floccosa* ssp. *californica* apparently are dispersed by water; they can remain afloat for up to 3 days (Hauptli *et al.* 1978). *Limnanthes* taxa that grow in wet sites have larger tubercles than those adapted to dry sites. Hauptli *et al.* (1978) speculated that the tuberculate surface of such nutlets may aid in flotation by trapping air. However, most meadowfoam nutlets are dispersed only short distances. In an experiment where nine meadowfoam taxa were seeded into artificial vernal pools (Jain 1978), only four taxa colonized other parts of the pools where they had been introduced, and only two appeared in pools where they had not been seeded, even after 2 years. *Limnanthes floccosa* ssp. *californica* was not included in the study; however, *L. floccosa* ssp. *floccosa* was not found outside of the areas where it had been seeded. Thus, *L. floccosa* ssp. *californica* nutlets would not be expected to disperse beyond their pool or swale of origin. Birds and livestock are potential sources of long-distance seed dispersal, but specific instances of dispersal have not been documented (Jain 1978).

Demographic data on *Limnanthes floccosa* ssp. *californica* include population sizes as well as estimates of survival and fecundity. Population highs for *L. floccosa* ssp. *californica* are not necessarily reached in the same year at all sites because the amount and timing of rainfall interacts with soil and topography to determine site-specific population size.

The average number of flowers and nutlets per plant also differ among sites and years. Overall, the largest populations of *Limnanthes floccosa* ssp. *californica* produce the greatest number of nutlets per plant (Dole 1988, Dole and Sun 1992). However, the number of flowers per plant is reduced in dense colonies of

L. floccosa ssp. *californica* because individuals produce fewer branches and therefore fewer flowers. Competition from other plant species also reduces flower production (Crompton 1993, Kelley and Associates Environmental Sciences 1993*b*). Reproduction of *L. floccosa* ssp. *californica* may be reduced by insufficient moisture (Brown and Jain 1979) or inappropriate livestock grazing practices (Dole 1988, Dole and Sun 1992).

Several races of *Limnanthes floccosa* ssp. *californica* exist. Jokerst (1989) identified "north" and "south" races of *L. floccosa* ssp. *californica* in the Chico "sphere of influence" based on morphology. Later, in studies of enzyme systems, Dole and Sun (1992) confirmed that these races differed genetically. They also identified genetically distinct races that they called "northeast" and "southwest," with the latter referring to the type locality. Although Arroyo (1975) had concluded that *L. floccosa* exhibited considerable genetic diversity within populations, Dole and Sun (1992) evaluated many more enzyme systems and refuted her conclusions. They found that 96 percent of genetic diversity in *L. floccosa* ssp. *californica* existed among populations and that little variability was evident within populations. Dole and Sun speculated that the low genetic diversity was due to bottlenecks and subsequent inbreeding. In other words, if populations were reduced to only a few plants at certain times in their history, only those individuals would have passed on their genes. Self-pollination among the remaining plants would have further restricted the gene pool. Dole and Sun (1992) used mathematical formulas to estimate an average generation time of 2 years for *L. floccosa* ssp. *californica* and to predict that a seed would be transferred between populations only once every 100-200 years. Although considerable morphological variability has been observed within populations, it apparently is attributable to differences in environmental response by plants of the same genetic makeup (Jain 1976*a*, Jokerst 1989).

Habitat and Community Associations.—*Limnanthes floccosa* ssp. *californica* is found primarily in vernal swales and to a lesser extent on the margins of vernal pools (Arroyo 1973, Dole 1988, Jokerst 1989, BioSystems Analysis, Inc. 1993, California Natural Diversity Data Base 2003). Both the swales and vernal pools where it grows are on alluvial terraces in annual grasslands with a mima mound topography (Kelley and Associates Environmental Sciences 1992*b*, BioSystems Analysis, Inc. 1993). Swales vary in width from narrow channels to broad, pool-like areas (LSA Associates, Inc. 1994). They may connect in branching, tree-like patterns or in net-like patterns around low mounds. Occupied swales are inundated periodically by water from the surrounding uplands, causing the soil to become saturated. However, *L. floccosa* ssp. *californica* does not persist in pools or swales that are inundated for prolonged periods or remain wet during the summer months, nor does it occur in drainages

where water flows swiftly (Jokerst 1989, Kelley and Associates Environmental Sciences 1993*a*). One *L. floccosa* ssp. *californica* site near the Chico Municipal Airport is unusual in that it does not contain vernal pools or recognizable swales (Dole 1988, Dole and Sun 1992), which were most likely obliterated by earlier grading (Jokerst 1989).

The swales that support *Limnanthes floccosa* ssp. *californica* are generally less than 10 centimeters (3.9 inches) deep (LSA Associates, Inc. 1994) and pools are typically less than 30 meters (100 feet) long (Jokerst 1989). In vernal pools, *L. floccosa* ssp. *californica* more often grows on the margins than in the bottom, but the pattern is reversed in swales, with the plants more often growing in the center (BioSystems Analysis, Inc. 1993). This plant typically occurs in long, narrow bands in connected swales or on pool margins but can be found in irregular clusters in isolated drainages (Crompton 1993). *Limnanthes floccosa* ssp. *californica* has also been found occasionally in disturbed areas, such as drainage ditches, firebreaks, and graded sites (McNeill and Brown 1979, Jokerst 1989, Kelley and Associates Environmental Sciences 1992*b*, BioSystems Analysis, Inc. 1993, Kelley and Associates Environmental Sciences 1993*a*).

Limnanthes floccosa ssp. *californica* occurs on soils of the Tuscan-Anita and the Redding-Igo complexes, specifically on the Anita and Igo soils, which are confined to the pools and swales. Tuscan and Redding soils are restricted to the mounds. Anita soils can be up to 50 centimeters (19.7 inches) deep, whereas Igo soils are no more than 18 centimeters (7.1 inches) deep; the two soils are underlain by iron-silica cemented and indurated hardpan, respectively (Kelley and Associates Environmental Sciences 1993*a*). Large cobbles are often present throughout pools and swales in such areas (Jokerst 1989). *Limnanthes floccosa* ssp. *californica* has been observed on Anita clay soils annually regardless of rainfall but appears on Igo soils only in years of above average rainfall (Kelley and Associates Environmental Sciences 1992*a*, 1992*b*; Crompton 1993; R. Schonholtz *in litt.* 1995), presumably because the former can hold roughly twice as much moisture (Kelley and Associates Environmental Sciences 1993*a*). Confirmed occurrences have been found at 50 to 90 meters (165 to 300 feet) in elevation (McNeill and Brown 1979, California Natural Diversity Data Base 2003).

Associated species vary somewhat through the range of *Limnanthes floccosa* ssp. *californica*. In most of the occupied habitat within the City of Chico, *Limnanthes floccosa* ssp. *californica* grows with *Layia fremontii* (Fremont's tidy-tips), *Navarretia leucocephala* (whiteflower navarretia), *Blennosperma nanum* (yellow carpet), and *Lasthenia californica* (California goldfields) (Dole 1988, Dole and Sun 1992). In the Shippee area, *Limnanthes floccosa* ssp. *californica* is

associated most frequently with *Juncus bufonius* (toad rush), *Erodium botrys* (long-beak heron's bill), and *Eryngium vaseyi* ssp. *vallicola* (Vasey's coyote thistle) (BioSystems Analysis, Inc. 1993). *Limnanthes floccosa* ssp. *californica* also co-occurs with *Limnanthes alba* at two occurrences and with *Limnanthes douglasii* ssp. *rosea* at five occurrences (McNeill and Brown 1979, Dole and Sun 1992, California Natural Diversity Data Base 2003). *Limnanthes floccosa* ssp. *floccosa* was observed not far from a population of *Limnanthes floccosa* ssp. *californica*, but the two subspecies were not growing together (California Natural Diversity Data Base 2003).

4. Reasons for Decline and Threats to Survival

Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to *Limnanthes floccosa* ssp. *californica* are described below.

At least seven more urbanization actions are being considered within occupied *Limnanthes floccosa* ssp. *californica* habitat in the City of Chico (Kelley and Associates Environmental Sciences 1992*c*). These projects include various proposals for residential developments and expansion of the Chico Municipal Airport (U.S. Fish and Wildlife Service 1992, C. Sellers *in litt.* 2001, E. Warne pers. comm. 2001, California Natural Diversity Data Base 2003); these projects would affect two occurrences of the southeastern race and one of the northern race. Outside of the City, residential developments and agricultural conversions are also continuing threats to some populations.

A proposed project to widen Highway 149 and build interchanges potentially threatens portions of California Natural Diversity Data Base Element Occurrence 1 and 40 of *Limnanthes floccosa* ssp. *californica* (Finn 2000, California Natural Diversity Data Base 2003), which represent the Shippee race. The California Department of Transportation plans to avoid altering the patterns of surface water flow along Gold Run Creek when they widen Highway 149, but individual pools and swales could be filled and the watersheds of others could be reduced (Finn 2000).

Another ongoing degradation of *Limnanthes floccosa* ssp. *californica* habitat involves illegal trash dumping and off-highway vehicle use (U.S. Fish and Wildlife Service 1992). Also, competition from grasses and other weedy non-native plants poses a potential problem to four occurrences of *L. floccosa* ssp. *californica* (California Natural Diversity Data Base 2003). For example, at the

Doe Mill Preserve, competition from the non-native grass *Taeniatherum caput-medusae* (medusahead) apparently has reduced population size and seed set in *L. floccosa* ssp. *californica* (Center for Natural Lands Management 1997). In addition, threats are also continuing due to inappropriate grazing practices in certain instances such as insufficient grazing at the Doe Mill Preserve. Finally, two populations of *L. floccosa* ssp. *californica* are small enough (fewer than 500 plants even in favorable years) that random events could lead to their extirpation (C. Sellers *in litt.* 2001, California Natural Diversity Data Base 2003). Moreover, the narrow geographic range of the taxon increases the likelihood that a single catastrophic event could destroy all or most of the occurrences.

Another potential threat is lack of pollinators. Although *Limnanthes floccosa* ssp. *californica* is capable of setting seed in the absence of insect pollinators, continuing adaptation to environmental changes is not possible without the genetic recombination that occurs during cross-pollination. Considering the widespread habitat destruction and degradation in the area where *L. floccosa* ssp. *californica* is endemic, breeding habitat for pollinators could well be declining. However, the identity of pollinators for this subspecies must be determined before their population and habitat status can be evaluated.

5. Conservation Efforts

We listed *Limnanthes floccosa* ssp. *californica* as an endangered species on June 8, 1992 (U.S. Fish and Wildlife Service 1992). The California Fish and Game Commission had previously listed this taxon as endangered under the California Endangered Species Act in 1982 (California Department of Fish and Game 1991). *Limnanthes floccosa* ssp. *californica* has been included on the California Native Plant Society's list of rare and endangered plants for almost 2 decades (Smith *et al.* 1980) and is currently on List 1B with the highest endangerment rating (California Native Plant Society 2001). In 2002, critical habitat was proposed for *L. floccosa* ssp. *californica* and several other vernal pool species in *Proposed Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon* (U.S. Fish and Wildlife Service 2002); however, it was eliminated from the final designation (U.S. Fish and Wildlife Service 2003).

In 1988, the City of Chico funded surveys to determine the status of *Limnanthes floccosa* ssp. *californica* (Dole 1988). Money from the California Endangered Species Tax Check-Off Fund then was used to prepare a plan for conserving *L. floccosa* ssp. *californica* within the City, while allowing for continued development (Jokerst 1989). The City prepared a supplement to the conservation plan presenting a schedule for acquisition and other details of management (City

of Chico 1989). The City was developing a Habitat Resources Conservation Plan for *L. floccosa* ssp. *californica* and other listed species, but has abandoned the effort (J. Knight pers. comm. 1997).

Nevertheless, several areas have been set aside for *Limnanthes floccosa* ssp. *californica*. These areas include the 6-hectare (15-acre) Doe Mill Preserve, a conservation easement of about 14 hectares (35 acres) on Humboldt Road, and a 2.8-hectare (7-acre) conservation easement on the publicly owned Gillick-Evans Firing Range (U.S. Fish and Wildlife Service 1992, K. Tarp pers. comm. 1997, C. Sellers *in litt.* 2001). The City of Chico also has a conservation easement on 118 hectares (292 acres) of habitat that appears to be suitable for *L. floccosa* ssp. *californica*, although very few of the plants are present (C. Sellers *in litt.* 2001).

Other conservation efforts for *Limnanthes floccosa* ssp. *californica* have been accomplished through mitigation programs. The Bruce-Stilson population was enhanced by spreading nutlets to unoccupied areas within a proposed preserve (Stern 1992, K. Stern *in litt.* 1994). *Limnanthes floccosa* ssp. *californica* also was introduced onto suitable, unoccupied habitat on the Tuscan Preserve (also known as Lower Wurlitzer Ranch) in 1992 and 1993 (Kelley *et al.* 1994). The population has continued to reproduce and expand, increasing to approximately 200,000 plants by the spring of 2000 (C. Sellers *in litt.* 2001).

F. *NAVARRETIA LEUCOCEPHALA* SSP. *PAUCIFLORA* (FEW-FLOWERED NAVARRETIA)

1. Description and Taxonomy

Taxonomy.—Navarretias are members of the phlox family (Polemoniaceae). Mason (1946) first gave few-flowered navarretia the Latin name *Navarretia pauciflora*. He had collected the type specimen "5 miles north of Lower Lake, Lake County" in 1945 (Mason 1946). Day (1993*a*) subsequently reduced few-flowered navarretia in rank and assigned it the name *Navarretia leucocephala* ssp. *pauciflora*.

Some plants exhibit characteristics intermediate between *Navarretia leucocephala* ssp. *pauciflora* and ssp. *plieantha*. According to Dr. Alva Day (A. Day *in litt.* 1993, *in litt.* 1997, pers. comm. 1997), such plants cannot be assigned definitively to either subspecies. She does not consider these intergrades (intermediate plants) to be hybrids because there is no evidence that they resulted from crosses between the two subspecies. Thus, the characterization of these intermediate plants as "intercrosses" in the final rule (U.S. Fish and Wildlife

Service 1997*b*) was misleading. The existence of such intermediate forms was Dr. Day's primary reason for reducing several taxa previously treated as full species to subspecies within *N. leucocephala* (Day 1993*a*, A. Day pers. comm. 1997). The distribution, life history, threats, conservation efforts, and recovery strategy for intergrades are discussed in the species account for *N. leucocephala* ssp. *plieantha*.

Description and Identification.—Navarretias are annual herbs with alternate, usually lobed leaves that also may have secondary lobes. The small, funnel-shaped flowers have four or five corolla lobes and a tubular calyx with four or five sepals joined at the base by a papery membrane. *Navarretia* flowers are clustered into head-like inflorescences that are surrounded by spine-tipped bracts similar to the leaves. The small capsules are egg-shaped and contain one or more tiny seeds (Day 1993*b*). All *Navarretia* species and subspecies that occur in vernal pools apparently evolved from a single ancestor and share a suite of characteristics including short stature, simple stem anatomy, few glands, very short stigmas, a single vein leading to each corolla lobe, stamens attached near or at the top of the corolla tube, a membranous-walled capsule that does not split along predetermined lines, and few seeds (Crampton 1954, Spencer 1993).

Navarretia leucocephala ssp. *pauciflora* (**Figure II-10**) is only 1 to 4 centimeters (0.4 to 1.6 inches) tall but is twice as wide due to branches originating near the base of the stem. The stem is white with purple streaks and has few hairs. Although the majority of the stem is very slender (less than 0.5 millimeter [0.02 inch] thick), the portion at and just below ground level is two to four times as thick. The narrow leaves are 1 to 2.5 centimeters (0.4 to 1.0 inch) long and may have a few narrow lobes. Each flower head is 4 to 10 millimeters (0.16 to 0.39 inch) wide and contains between 2 and 20 pale blue or white flowers. *Navarretia leucocephala* ssp. *pauciflora* has a papery capsule that breaks open in an irregular pattern only when it is wet. Each capsule contains one or two reddish-brown seeds that stick together until water washes them apart (Mason 1946, Day 1993*b*). The chromosome number of this taxon has not been determined.

Navarretia leucocephala ssp. *pauciflora* has fewer flowers per head and fewer lobes on the outer bracts than *N. leucocephala* ssp. *plieantha*. Also, the latter has narrower, needle-like tips on the bract lobes (A. Day *in litt.* 1993). Other navarretias that occur in vernal pools differ in growth habit or have more flowers per head, longer corollas with the tube extending beyond the calyx lobes, branching veins in the corollas, or stamens attached farther down the corolla tube. Those growing outside of vernal pools typically are covered with glandular hairs and have many corolla veins, longer stigma branches, and leathery capsules that

Figure II-10. Illustration of *Navarretia leucocephala* ssp. *pauciflora* (few-flowered navarretia).

split apart when dry; they also may differ in flower color or number of corolla and calyx lobes (Mason 1946, Crampton 1954, Day 1993*b*).

2. Historical and Current Distribution

Historical Distribution.—Between 1923 and 1988, typical *Navarretia leucocephala* ssp. *pauciflora* was collected from as many as nine sites in southern Lake County (A. Day *in litt.* 1997). The actual number of collection localities may have been fewer because some vaguely-described sites may in fact be the same as others described in greater detail. Manning Flat is presumed to be the type locality (California Natural Diversity Data Base 2003), even though it is actually west-northwest, rather than north, of Lower Lake. The California Natural Diversity Data Base (2003) has assigned element occurrence numbers to only five of the eight possible Lake County sites, due to the likelihood that some of the varying location descriptions represent the same site. The specimens of typical *N. leucocephala* ssp. *pauciflora* were collected in the area between the towns of Clearlake, Kelseyville, and Middletown (Niehaus and Fruchter 1977, Bittman 1989, A. Day *in litt.* 1997). All of the historical sites were in the Lake-Napa Vernal Pool Region (Keeler-Wolf *et al.* 1998) (**Figure II-6**).

Intermediates between *Navarretia leucocephala* ssp. *pauciflora* and ssp. *plieantha* were collected historically from Loch Lomond and from the Siegler Springs Road area of Lake County. Those specimens have been cited as *N. leucocephala* ssp. *pauciflora* in some reports (*e.g.*, Niehaus and Fruchter 1977, Bittman 1989). The California Natural Diversity Data Base (2003) treats Loch Lomond as an occurrence of both *Navarretia leucocephala* ssp. *pauciflora* and ssp. *plieantha*. However, Day (*in litt.* 1993, *in litt.* 1997) does not consider collections from either Loch Lomond or Siegler Springs Road to represent *N. leucocephala* ssp. *pauciflora*.

Current Distribution.—Existing information is insufficient to clearly assess whether or not *Navarretia leucocephala* ssp. *pauciflora* has, in fact, significantly declined. Although three of the historical sites in Lake County are not confirmed to have extant populations, the vague original location information leaves open the possibility that they were actually the same occurrences where the taxon is known currently.

Navarretia leucocephala ssp. *pauciflora* is restricted to the Lake-Napa Vernal Pool Region (Keeler-Wolf *et al.* 1998). Six populations of typical *N. leucocephala* ssp. *pauciflora* are known or presumed to be extant (A. Day *in litt.* 1993, California Natural Diversity Data Base 2003), including three that were newly discovered during the past decade (A. Howald *in litt.* 1995, California

Natural Diversity Data Base 2003). Four of the six extant occurrences are in Lake County and the other two are in Napa County. Among the Lake County occurrences, three are between Clear Lake and State Highway 29, within the area where the taxon was reported historically. The fourth site in Lake County is farther south near the town of Cobb and was discovered in 1995 (J. Diaz-Haworth pers. comm. 2001). According to Howald (*in litt.* 1995), Dr. Day verified the identity of the Cobb occurrence. The two Napa County occurrences also were discovered within the past decade. Both are in the Foss Valley-Milliken Canyon area east of Yountville (A. Day *in litt.* 1997, California Natural Diversity Data Base 2003).

In addition to the occurrences that Dr. Day (*in litt.* 1997) considers to be true *Navarretia leucocephala* ssp. *pauciflora*, several populations of plants intermediate between *N. leucocephala* ssp. *pauciflora* and ssp. *plieantha* remain extant. These populations are in the vicinity of Loch Lomond and near Siegler Springs (A. Day *in litt.* 1993, *in litt.* 1997; California Department of Fish and Game 1994; California Natural Diversity Data Base 2003). The species account for *N. leucocephala* ssp. *plieantha* discusses these populations in more detail.

3. Life History and Habitat

Reproduction and Demography.—Little is known about the life history and demography of *Navarretia leucocephala* ssp. *pauciflora*. Like many vernal pool annuals, *N. leucocephala* ssp. *pauciflora* seeds germinate underwater (Crampton 1954) and flower after the pools dry (Day 1993*a*). The plants flower in May and June (California Department of Fish and Game 1994, Skinner and Pavlik 1994). The flowers are probably insect-pollinated. Navarretias with similar flowers that occur outside of vernal pools are pollinated by a variety of bees and bee flies (family Bombyliidae), although other insects may visit to collect nectar (Grant and Grant 1965). The seeds of *N. leucocephala* ssp. *pauciflora* do not disperse far from the parent plant because they have a gelatinous coating and stick together when the fruit ruptures (Crampton 1954, Day 1993*b*). Population sizes fluctuate widely among years (California Natural Diversity Data Base 2003).

Habitat and Community Associations.—*Navarretia leucocephala* ssp. *pauciflora* grows in vernal pools that form on substrates of volcanic origin (Bittman 1989, California Natural Diversity Data Base 2003), specifically in Northern Basalt Flow and Northern Volcanic Ashflow Vernal Pools (Sawyer and Keeler-Wolf 1995). Extant occurrences in Lake County are in “flats” of recent alluvium in mountainous areas; site-specific details are not available for Napa County sites. The vernal pools where *N. leucocephala* ssp. *pauciflora* occurs are

interspersed with grassland or marsh and chaparral (Mason 1946, California Natural Diversity Data Base 2003). Pool sizes have not been well characterized, although this taxon has been reported from both small pools and large, shallow, playa-type lakes. Soils underlying the pools typically are shallow and rocky, and obsidian often is present on the surface (Mason 1946, California Natural Diversity Data Base 2003). The Manning Flat site has volcanic ash soil mapped as Oxalis variant silt loam, whereas one Milliken Canyon site has Aiken loam. Soil types are not known for the other occurrences. *N. leucocephala* ssp. *pauciflora* has been reported from elevations ranging from 445 to 707 meters (1,460 to 2,320 feet).

Associated plants differ among sites. In Lake County, associates include other rare plants–*Gratiola heterosepala* (at two sites), *Parvisedum leiocarpum*, *Lasthenia burkei*, and *Eryngium constancei*–one site each (A. Howald *in litt.* 1995, California Natural Diversity Data Base 2003). Napa County associates include *E. aristulatum* (at two sites), *L. conjugens*, and several species of *Downingia* (California Natural Diversity Data Base 2003).

4. Reasons for Decline and Threats to Survival

Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to *Navarretia leucocephala* ssp. *pauciflora* are described below.

Continuing specific threats involving potential loss or fragmentation of habitat include: (1) various disturbances of the volcanic ash soils, which accelerates erosion, at Manning Flat (Bittman 1989, A. Buckmann pers. comm. 2001); (2) off-road vehicle use continuing to degrade certain habitat (Bittman 1989, California Natural Diversity Data Base 2003); (3) land-use conversions for residential development or agriculture threatening all but two occurrences (J. Diaz-Haworth pers. comm. 2001, B. Flynn pers. comm. 2001, California Natural Diversity Data Base 2003); (4) possible inappropriate grazing practices at certain sites; and (5) possible population reductions of important insect pollinators.

5. Conservation Efforts

Navarretia leucocephala ssp. *pauciflora* was federally-listed as an endangered species on June 18, 1997 (U.S. Fish and Wildlife Service 1997*b*). The California Fish and Game Commission had previously listed *N. leucocephala* ssp. *pauciflora* as threatened in 1990 (California Department of Fish and Game 1991). The

California Native Plant Society included this plant in their first listing of rare plants (Powell 1974). Currently, *N. leucocephala* ssp. *pauciflora* is on the California Native Plant Society's List 1B and has the highest endangerment rating possible (California Native Plant Society 2001).

The Mead Ranch population of *Navarretia leucocephala* ssp. *pauciflora* in Napa County is protected from development by a conservation easement (California Natural Diversity Data Base 2003). A private citizen bought the Cobb-area vernal pool that supports *N. leucocephala* ssp. *pauciflora* and *Eryngium constancei* specifically to protect these species from potential threats (J. Diaz-Haworth pers. comm. 2001, B. Flynn pers. comm. 2001). One of the sites near Loch Lomond is now protected by the California Department of Fish and Game as a Vernal Pool Ecological Reserve and is managed for the benefit of several rare plants (California Department of Fish and Game 1994, California Natural Diversity Data Base 2003). However, the *Navarretia* at that site is an intermediate form (A. Day *in litt.* 1997).

Surveys conducted by California Native Plant Society members and California Department of Fish and Game personnel in the 1990's led to the discovery of several new or historical populations. In 1988, the California Native Plant Society petitioned the California Fish and Game Commission to list *Navarretia leucocephala* ssp. *pauciflora* (Bittman 1989, California Department of Fish and Game 1990*a*).

G. *NAVARRETIA LEUCOCEPHALA* SSP. *PLIEANTHA* (MANY-FLOWERED NAVARRETIA)

1. Description and Taxonomy

Taxonomy.—Many-flowered navarretia is in the phlox family. The name first assigned to many-flowered navarretia was *Navarretia plieantha*. The type locality for the species is Boggs Lake, in Lake County (Mason 1946). Day (1993*a*) later reduced many-flowered navarretia to the rank of subspecies, under the name *Navarretia leucocephala* ssp. *plieantha*.

As explained in the species account for *Navarretia leucocephala* ssp. *pauciflora*, some populations of *Navarretia* consist of individuals intermediate in characteristics between two subspecies. According to Dr. Alva Day (*in litt.* 1997, pers. comm. 1997), these plants are not properly called hybrids nor "intercrosses," as the final rule (U.S. Fish and Wildlife Service 1997*b*) described them. Dr. Day (*in litt.* 1997) has distinguished two types of intermediate specimens, which

others have identified as *N. leucocephala* ssp. *plieantha*. One group is intermediate between *N. leucocephala* ssp. *pauciflora* and *N. leucocephala* ssp. *plieantha*, and the other is intermediate between *N. leucocephala* ssp. *plieantha* and *N. leucocephala* ssp. *bakeri* (Baker's navarretia). For convenience, we refer to all of these plants as *N. leucocephala* ssp. *plieantha* throughout this plan, but the population at the type locality is referred to as "typical" *N. leucocephala* ssp. *plieantha* .

Description and Identification.—Characteristics common to all members of this genus were presented in the *Navarretia leucocephala* ssp. *pauciflora* account. *Navarretia leucocephala* ssp. *plieantha* (**Figure II-11**) forms mats 5 to 20 centimeters (2.0 to 7.9 inches) across and 1 to 3 centimeters (0.4 to 1.2 inches) high. The stems have a peeling, white surface and are highly branched. Stem thickness is 0.8 to 1.4 millimeters (0.03 to 0.06 inch) and is more or less uniform throughout its length. The leaves are 3 to 4 centimeters (1.2 to 1.6 inches) long and are either entire or have a few thread-like lobes. Flower heads are 1.5 to 2 centimeters (0.6 to 0.8 inch) across and contain between 10 and 60 pale blue flowers. Each flower in the head is 5 to 6 millimeters (0.20 to 0.24 inch) long. The capsule and seeds are similar to those of *N. leucocephala* ssp. *pauciflora*; each fruit may contain as many as three seeds (Mason 1946, Day 1993*b*). The chromosome number is unknown.

Navarretia leucocephala ssp. *plieantha* has up to twice as many flowers per head as *N. leucocephala* ssp. *pauciflora*, and the former also has more highly branched outer bracts with needle-like tips on the lobes (A. Day *in litt.* 1993). Moreover, *N. leucocephala* ssp. *plieantha* does not have a thicker stem below ground level and its corolla is about the same length as its calyx. *Navarretia leucocephala* ssp. *bakeri* differs from *N. leucocephala* ssp. *plieantha* in that the former has an erect habit, stems up to 15 centimeters (5.9 inches) tall, and white corollas. Other vernal pool navarretias have corolla lobes with more veins, corolla tubes longer than the calyx, calyx lobes of unequal length, or different stamen attachment (Mason 1946, Crampton 1954, Munz and Keck 1968, Day 1993*b*). Identifying features of upland navarretias were described under *N. leucocephala* ssp. *pauciflora*.

2. Historical and Current Distribution

Historical Distribution.—The California Natural Diversity Data Base (2003) includes nine occurrences of *Navarretia leucocephala* ssp. *plieantha*, all of which had been discovered by 1987 (California Natural Diversity Data Base 2003) (**Figure II-6**). The final rule for *N. leucocephala* ssp. *plieantha* (U.S. Fish and Wildlife Service 1997*b*) erroneously reported eight historical locations

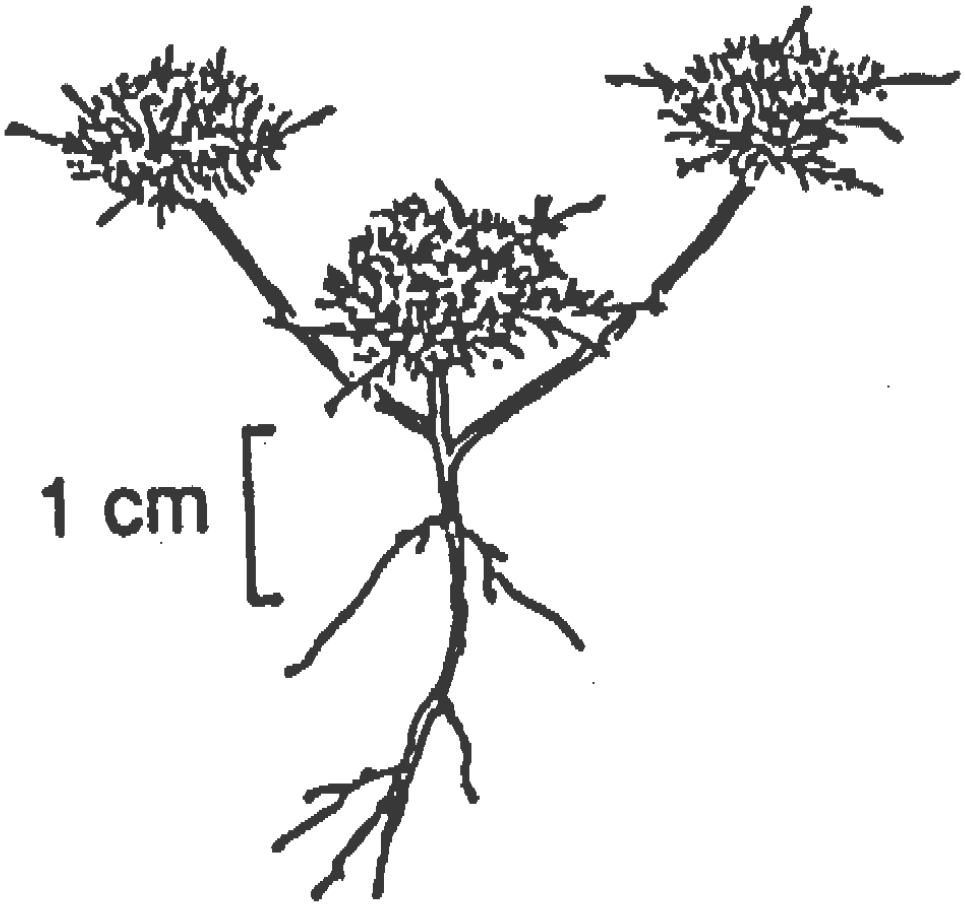

Figure II-11. Illustration of *Navarretia leucocephala* ssp. *plieantha* (many-flowered navarretia) (Reprinted from the Jepson Manual, J. Hickman, Ed., 1993, with permission from the Jepson Herbarium. © Regents of the University of California)

instead of the nine catalogued by the California Natural Diversity Data Base at that time. The historical occurrences are from Lake and Sonoma Counties.

Typical *Navarretia leucocephala* ssp. *plieantha* was known historically only from Boggs Lake (A. Day *in litt.* 1993, *in litt.* 1997). The other reported occurrences include six sites with plants that are intermediate between *N. leucocephala* ssp. *plieantha* and other subspecies, and two sites where Dr. Day does not have access to specimens to confirm the identity of the plants (A. Day *in litt.* 1993, *in litt.* 1997). Three historical occurrences in Lake County (Loch Lomond, Mount Hannah Lodge, and Siegler Springs Road) have plants intermediate between *N. leucocephala* ssp. *pauciflora* and *N. leucocephala* ssp. *plieantha*. At least three occurrences in the Santa Rosa area, in Sonoma County, consist of plants intermediate between *N. leucocephala* ssp. *plieantha* and *N. leucocephala* ssp. *bakeri* (A. Day *in litt*. 1993, A. Day *in litt*. 1997). Dr. Day has not seen specimens from Stienhart Lake in Lake County and thus cannot confirm that *N. leucocephala* ssp. *plieantha* occurs there (A. Day *in litt.* 1997).

Current Distribution.——Of the nine occurrences the California Natural Diversity Data Base (2003) catalogued as *Navarretia leucocephala* ssp. *plieantha*, all are considered to be extant, except two occurrences within the Santa Rosa area which are considered to be "possibly extirpated" (Patterson in litt. 2000, California Natural Diversity Database 2003). Please refer to the Draft Santa Rosa Plains Recovery Plan (in development) for information regarding occurrences within the Santa Rosa vernal pool region identified by Keeler-Wolf *et.al*. (1998).

The five occurrences reported as extant in the final rule (U.S. Fish and Wildlife Service 1997*b*) were Boggs Lake, Loch Lomond, Mount Hannah Lodge, Siegler Springs Road, and Stienhart Lake, which are in the Lake-Napa Vernal Pool Region (Keeler-Wolf *et al.* 1998). These occurrences are still believed to be extant, although the only population that has been revisited since 1989 is that at Boggs Lake (California Natural Diversity Data Base 2003). The typical population of *Navarretia leucocephala* ssp. *plieantha* at Boggs Lake has not declined (Baldwin and Baldwin 1991, California Natural Diversity Data Base 2003).

3. Life History and Habitat

Reproduction and Demography.—The basic life history of *Navarretia leucocephala* ssp. *plieantha* presumably is similar to that of *N. leucocephala* ssp. *pauciflora*, although neither has been studied intensively. Three different measures of abundance collected annually from 1987 through 1991 at Boggs Lake revealed that the *N. leucocephala* ssp. *plieantha* population in the lakebed had

increased in abundance while that in the adjoining meadow had decreased. *Navarretia leucocephala* ssp. *plieantha* plants rarely had more than one flower head each during the monitoring period (Baldwin and Baldwin 1991). In certain years, competition from associated plants along the lake margin apparently caused the *N. leucocephala* ssp. *plieantha* plants to develop longer, less robust stems (Baldwin and Baldwin 1990).

Habitat and Community Associations.—Typical *Navarretia leucocephala* ssp. *plieantha* occurs only at Boggs Lake. The lake itself is classified as a Northern Volcanic Ashflow Vernal Pool (Sawyer and Keeler-Wolf 1995), which consists of a clay layer that is impervious to water and is buried under a layer of volcanic ash (California Department of Fish and Game 1987*b*). Mason (1946) noted that he collected the type specimen "In peaty soil of lake margin surrounded by a black oak, madrone [*Arbutus menziesii*], Douglas fir, and yellow pine [*Pinus ponderosa*] forest." More recent reports from Boggs Lake indicated that *N. leucocephala* ssp. *plieantha* also can grow in the center of the lake bed and in wet portions of the surrounding meadow (Baldwin and Baldwin 1989*a*, Baldwin and Baldwin 1991). The soil at Boggs Lake is in the Collayomi-Aiken-Whispering complex. Numerous plant species are associated with *N. leucocephala* ssp. *plieantha* at Boggs Lake, including *Eryngium aristulatum*, *Plagiobothrys stipitatus*, *Downingia* spp., and several other species of *Navarretia*. Rare plants that co-occur with typical *N. leucocephala* ssp. *plieantha* include *Orcuttia tenuis* and *Gratiola heterosepala* (Baldwin and Baldwin 1989*a*, California Natural Diversity Data Base 2003). The elevation of Boggs Lake is approximately 850 meters (2,800 feet) (California Natural Diversity Data Base 2003).

Elsewhere, *Navarretia leucocephala* ssp. *plieantha* occurs in vernal pools, vernal lakes, and swales (California Natural Diversity Data Base 2003). Occupied pools are classified as "Northern Vernal Pools" or Northern Volcanic Ashflow Vernal Pools (Sawyer and Keeler-Wolf 1995, California Natural Diversity Data Base 2003). *Pinus ponderosa* forest or mixed forests of *Quercus kelloggii*, *Pseudotsuga menziesii*, and *Pinus ponderosa* typically occur in the surrounding areas (California Department of Fish and Game 1987*b*, California Natural Diversity Data Base 2003).

Associates of *Navarretia leucocephala* ssp. *plieantha* throughout its range are similar to those at Boggs Lake (California Natural Diversity Data Base 2003). Other plants featured in this recovery plan that co-occur with *N. leucocephala* ssp. *plieantha* include *Eryngium constancei*, *Orcuttia tenuis*, *Gratiola heterosepala*, and *Legenere limosa* at one site each. In addition, the endangered plants *Blennosperma bakeri* (Sonoma sunshine) and *Lasthenia burkei* co-occur with

N. leucocephala ssp. *plieantha* in Sonoma County (California Natural Diversity Data Base 2003).

At three sites that support *Navarretia leucocephala* ssp. *plieantha*, the soils are mapped in the Collayomi-Aiken-Whispering complex, whereas the Stienhart Lake site has soils in the Konocti-Hambright complex. Soil types are not known for the other occurrences. At Loch Lomond, *N. leucocephala* ssp. *plieantha* is found in the deeper parts of the pool (California Department of Fish and Game 1994). Known sites range in elevation from 33 meters (110 feet) north of Santa Rosa to 853 meters (2,800 feet) at Loch Lomond (California Natural Diversity Data Base 2003).

4. Reasons for Decline and Threats to Survival

Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to *Navarretia leucocephala* ssp. *plieantha* are described below.

Unique to *Navarretia leucocephala* ssp. *plieantha* are three habitat impacts–feral pig rooting, horseback riding, and foot-use related to human recreational activity–not generally reported as important factors in the declines of the other vernal-pool-related species. Also, hybridization has been cited as a reason for the decline of *N. leucocephala* ssp. *plieantha* (Bittman 1989, California Department of Fish and Game 1990*a*), but the presence of intermediate forms is not evidence of any threat. The intermediates are not believed to be hybrids (A. Day *in litt.* 1997, pers. comm. 1997), and the fact that similar specimens were collected historically at all sites with intermediate plants indicates that the intergradation is not a recent phenomenon (A. Day *in litt.* 1993).

Other threats are also continuing. In particular, at Boggs Lake, competition from *Typha* spp. (cattail), *Centaurea solstitialis* (yellow star-thistle), and a native thistle (*Cirsium remotifolium*) threaten to crowd out *Navarretia leucocephala* ssp. *plieantha* (Baldwin and Baldwin 1991). Competition from non-native plants such as *Taeniatherum caput-medusae* and *Centaurea solstitialis* threatens *N. leucocephala* ssp. *plieantha* at the site east of Mount Hannah Lodge. Random events pose a threat to two small populations, one east of Mount Hannah Lodge and another in Sonoma County, which number only a few hundred individuals in even the most favorable years (California Natural Diversity Data Base 2003). Please refer to the Draft Santa Rosa Plains Recovery Plan (in development) for

information regarding threats facing *Navarretia leucocephala* ssp. *plieantha* in the Santa Rosa vernal pool region, as identified by Keeler-Wolf *et.al*. (1998).

5. Conservation Efforts

A final rule listing *Navarretia leucocephala* ssp. *plieantha* as an endangered species was published on June 18, 1997 (U.S. Fish and Wildlife Service 1997*b*). *Navarretia leucocephala* ssp. *plieantha* had previously been listed as endangered by the California Fish and Game Commission since 1979 (California Department of Fish and Game 1991). The California Native Plant Society has long recognized *N. leucocephala* ssp. *plieantha* as rare and endangered (Powell 1974); it is currently on List 1B and is ranked as "endangered in a portion of its range" (California Native Plant Society 2003).

Two localities for *Navarretia leucocephala* ssp. *plieantha* are protected as reserves. The Trust for Wildland Communities manages the Boggs Lake Preserve and the California Department of Fish and Game manages Loch Lomond Vernal Pool Ecological Reserve. Management activities at the two reserves include annual monitoring, protective measures such as fencing, and removal of competitors, and interpretive displays (Baldwin and Baldwin 1991; California Department of Fish and Game 1991, 1994).

Additional conservation efforts included a 1985 survey throughout the range of *Navarretia leucocephala* ssp. *plieantha* (California Department of Fish and Game 1987*b*) and a survey in the Santa Rosa area of Sonoma County in 1988 (Waaland and Vilms 1989). Please refer to the Draft Santa Rosa Plains Recovery Plan (in development) for specific information regarding *Navarretia leucocephala* ssp. *plieantha* conservation efforts.

H. *NEOSTAPFIA COLUSANA* (COLUSA GRASS)

1. Description and Taxonomy

Taxonomy.—Colusa grass is a member of the subfamily Chloridoideae in the grass family (Poaceae) and is in the Orcuttieae *tribe*, which also includes *Orcuttia* and *Tuctoria* (Reeder 1965, Keeley 1998). Davy (1898) first described Colusa grass, giving it the Latin name *Stapfia colusana.* He had collected the type specimen near the town of Princeton in Colusa County. Davy soon realized that the name *Stapfia* had already been assigned to a genus of green algae and therefore changed the scientific name of Colusa grass to *Neostapfia colusana* (Davy 1899). The name *Anthochloa colusana* was used for decades after Scribner (1899) published the combination in the mistaken belief that Colusa grass was

closely related to South American species of that genus. However, Hoover (1940) evaluated the many differences between *Anthochloa* and *Neostapfia* and concluded that the latter should be considered a distinct genus. Since that time, the accepted name for Colusa grass has been *Neostapfia colusana*. No other species of *Neostapfia* are known (Reeder 1982, Reeder 1993). *Neostapfia* is the most primitive member of the tribe (Keeley 1998).

Description and Identification.—All members of the Orcuttieae share several characteristics that differ from many other grasses. Most grasses have hollow stems, but the Orcuttieae have stems filled with pith. Another difference is that the Orcuttieae produce two or three different types of leaves during their life cycle, whereas most grasses have a single leaf type throughout their life span. The juvenile leaves of the Orcuttieae, which form underwater, are cylindrical and clustered into a basal rosette. After the pool dries, terrestrial leaves form in all species of the tribe; these leaves have flattened blades and are distributed along the stem (Keeley 1998). *Orcuttia* species have a third type of leaf that is not found in *Neostapfia* or *Tuctoria* (Reeder 1982, Keeley 1998). The terrestrial leaves of the Orcuttieae also differ from other grasses in other respects. Whereas grass leaves typically are differentiated into a narrow, tubular sheath that clasps the stem tightly and a broader blade that projects away from the stem, terrestrial leaves of the Orcuttieae are broad throughout and the lower portion enfolds the stem only loosely. The Orcuttieae also lack a ligule, which is a leaf appendage commonly found in other grasses (Reeder 1965, Reeder 1982, Keeley 1998). Another characteristic common to all Orcuttieae is the production of an aromatic exudate, which changes from clear to brown during the growing season (Reeder 1965, Reeder 1982). The exudate most likely helps to repel herbivores (Crampton 1976, Griggs 1981).

The Orcuttieae, however, are similar to other grasses in their flower structure. Grasses do not have petals and sepals like most other flowering plants, so their flowers are inconspicuous. Grass flowers are reduced to florets, which include several stamens (three in the Orcuttieae) and one pistil enclosed in two scales known as the lemma and palea. A spikelet consists of one or more florets and may have one or two glumes at its base. The grass inflorescence typically includes several to many spikelets, which are attached to a central stem known as the rachis. A grass fruit, which is known as a caryopsis or grain, consists of a single seed fused to the fruit wall. Each floret is capable of producing one grain.

Compared to other members of the Orcuttieae, *Neostapfia colusana* (**Figure II-12**) shows fewer adaptations to existence underwater, indicative of its relatively primitive evolutionary position and the shorter duration of underwater growth (Keeley 1998). The aquatic seedlings of *N. colusana* have only one or

Figure II-12. Illustration of *Neostapfia colusana* (Colusa grass). (Reprinted from the Jepson Manual, J. Hickman, Ed., 1993, with permission from the Jepson Herbarium. © Regents of the University of California)

two juvenile leaves (Keeley 1998). The terrestrial stage consists of multiple stems arising in clumps from a common root system. The stems are decumbent and have a characteristic zigzag growth form (Crampton 1976). Overall stem length ranges from 10 to 30 centimeters (3.9 to 11.8 inches). The entire plant is pale green when young (Davy 1898), but becomes brownish as the exudate darkens (Reeder 1982, Reeder 1993). Leaf length is 5 to 10 centimeters (2.0 to 3.9 inches) (Hitchcock and Chase 1971). Each stem produces one dense, cylindrical inflorescence that is 2 to 8 centimeters (0.8 to 3.1 inches) long and 8 to 12 millimeters (0.31 to 0.47 inch) broad. Within the inflorescence, the spikelets are densely packed in a spiral arrangement; the tip of the rachis projects beyond the spikelets. *Neostapfia colusana* has a diploid chromosome number of 40 (Reeder 1982, Reeder 1993).

Unlike terrestrial grasses, *Neostapfia colusana* has pith-filled stems, lacks distinct leaf sheaths and ligules, and produces exudate. *Neostapfia colusana* differs from other members of the Orcuttieae in that it has zigzag stems, cylindrical inflorescences, and fan-shaped lemmas and lacks glumes, whereas the other genera within the tribe have fairly straight stems and possess glumes. Moreover, *Orcuttia* species have distichous spikelets and narrow, five-toothed lemmas, and *Tuctoria* species have spikelets arranged in a loose spiral, and narrow, more-or-less entire lemmas. *Neostapfia colusana* is not likely to be confused with *Anthochloa*, despite their former taxonomic affiliation. The latter does not occur in North America, is perennial, does not have glands, the inflorescence is not cylindrical, and the spikelets have glumes (Hoover 1940).

2. Historical and Current Distribution

Historical Distribution.—In the 50 years after its initial discovery (Davy 1898), *Neostapfia colusana* was reported from only three sites other than the type locality; these sites were in Merced and Stanislaus Counties. By 1989, 51 occurrences were known, but 11 of those already had been extirpated (Stone *et al.* 1988, California Natural Diversity Data Base 2003). Through November 2003, the California Natural Diversity Data Base (2003) included 60 reported occurrences of *N. colusana* in Colusa, Merced, Solano, and Stanislaus Counties. Five each were reported from the San Joaquin Valley and Solano-Colusa Vernal Pool Regions, and the remainder were from the Southern Sierra Foothills Vernal Pool Region (**Figure II-13**).

Current Distribution.—Currently, no more than 45 occurrences of *Neostapfia colusana* remain extant (Hogle 2002, California Natural Diversity Data Base 2003). At least one population remains in each of the vernal pool regions from which *N. colusana* was known historically. The majority of extant

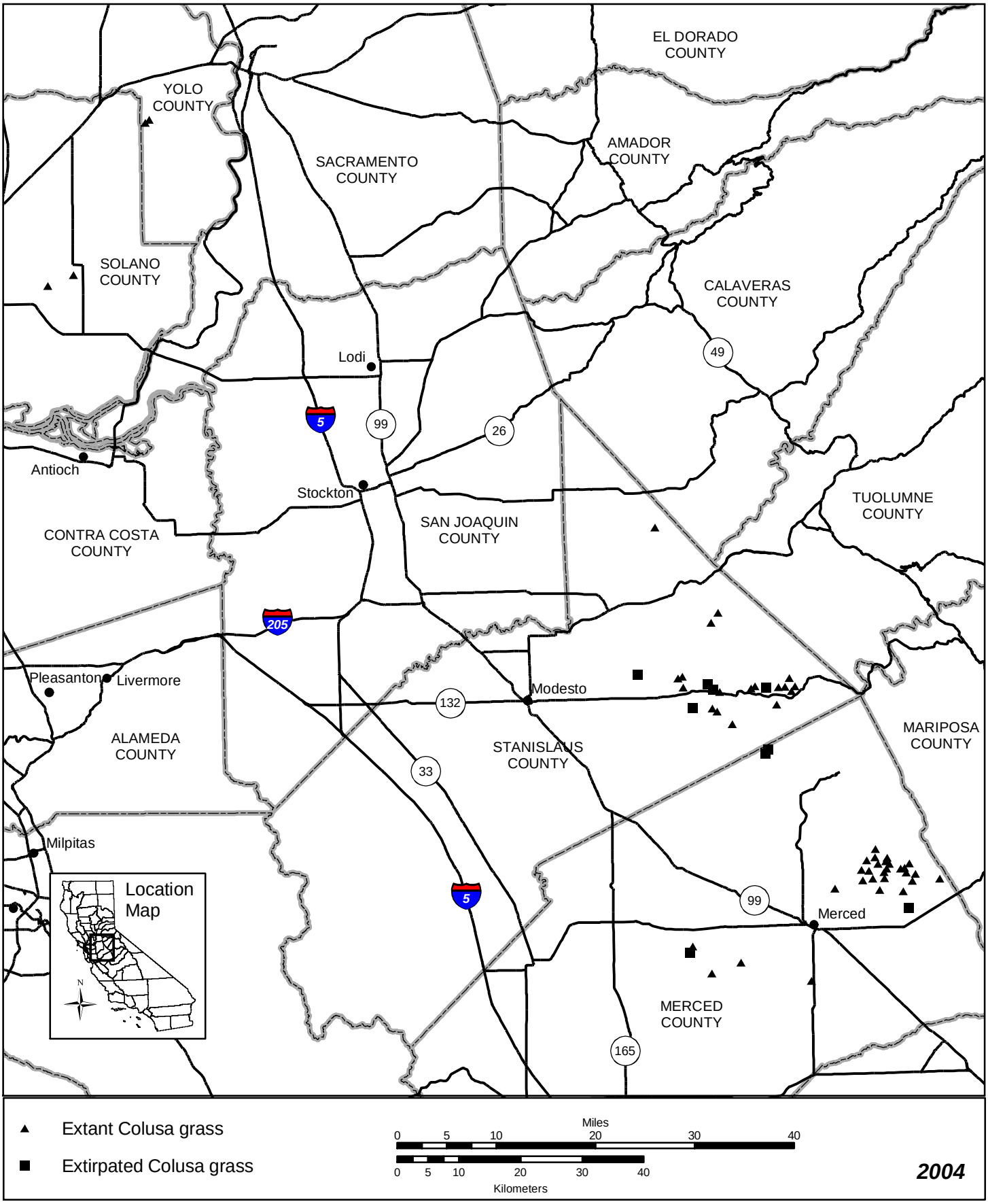

Figure II-13. Distribution of *Neostapfia colusana* (Colusa grass).

occurrences are in the Southern Sierra Foothills Vernal Pool Region, where they are concentrated northeast of the City of Merced in Merced County and east of Hickman in Stanislaus County. One or two occurrences remain in central Merced County, which is part of the San Joaquin Valley Vernal Pool Region. Four occurrences are extant in the Solano-Colusa Vernal Pool Region, with two each in southeastern Yolo and central Solano Counties (Stone *et al*. 1988 , Keeler-Wolf *et al.* 1998, California Natural Diversity Data Base 2003). This species has apparently been extirpated from Colusa County, however (California Natural Diversity Data Base 2003).

3. Life History and Habitat

Many life-history characteristics are common to all members of the Orcuttieae. In particular, they are all annuals (Griggs 1981). All are wind-pollinated, but pollen probably is not carried long distances between populations (Griggs 1980, Griggs and Jain 1983). Local seed (*i.e*., caryopsis) dispersal is by water, which breaks up the inflorescences (Reeder 1965, Crampton 1976, Griggs 1980, Griggs 1981). Long-distance dispersal is unlikely (U.S. Fish and Wildlife Service 1985*a*), but seed may have been carried occasionally by waterfowl (family Anatidae), tule elk (*Cervus elaphus nannoides*), or pronghorn (*Antilocapra americana*) in historical times (Griggs 1980). The seeds can remain dormant for an undetermined length of time (but at least 3- 4 years) and germinate underwater after they have been immersed for prolonged periods (Crampton 1976, Griggs 1980, Keeley 1998). Unlike typical terrestrial grasses that grow in the uplands surrounding vernal pools, members of Orcuttieae flower during the summer months (Keeley 1998).

Among all members of the Orcuttieae, the soil seed bank may be 50 times or more larger than the population in any given year. In general, years of above-average rainfall promote larger populations of Orcuttieae, but population responses vary by pool and by species (Griggs 1980, Griggs and Jain 1983). Population sizes have been observed to vary by one to four orders of magnitude among successive years and to return to previous levels even after 3 to 5 consecutive years when no mature plants were present (Griggs 1980, Griggs and Jain 1983, Holland 1987). Thus, many years of observation are necessary to determine whether a population is stable, declining, or extirpated. All members of the Orcuttieae are endemic to vernal pools. Although the various species have been found in pools ranging widely in size, the vast majority occur in pools of 0.01 hectare (0.025 acre) to 10 hectares (24.7 acres) (Stone *et al.* 1988). Large pools such as these retain water until May or June, creating optimal conditions for Orcuttieae (Crampton 1959, 1976; Griggs 1981; Griggs and Jain 1983). Within such pools, Orcuttieae occurs in patches that are essentially devoid of other plant species (Crampton 1959, 1976). Typically, plants near the center of a pool grow larger and produce

more spikelets than those near the margins, but patterns vary, depending on individual pool characteristics and seasonal weather conditions (Griggs 1980).

Reproduction and Demography.—In an experiment where *Neostapfia colusana* was grown along with *Tuctoria greenei* and two species of *Orcuttia* (Keeley 1998), seeds of *N. colusana* took about 3 months to germinate following inundation, longer than all other species. Hogle (2002) also provided evidence that long periods of inundation are necessary for germination of *N. colusana* seeds. Unlike *Orcuttia* species, *N. colusana* does not produce flattened, floating, juvenile leaves (Reeder 1982, Keeley 1998). Germination and seedling development have not been studied in the wild, but are assumed to be similar to those of *Tuctoria* species, which have similar seedlings. Thus, *N. colusana* seed would be expected to germinate in late spring when little standing water remains in the pool, and flowering would begin approximately 3 to 4 weeks later, as observed for *Tuctoria* (Griggs 1980). Flowering individuals of *N. colusana* have been collected as early as May throughout the range of the species (California Natural Diversity Data Base 2003). *Neostapfia colusana* spikelets break between the florets (Reeder 1993), quickly shattering as soon as the inflorescence matures (Crampton 1976).

Reproductive and survival rates have not been reported, but annual monitoring confirms that population sizes of *N. colusana* vary widely from year-to-year. Over a 6-year monitoring period, the population at the Bert Crane Ranch in Merced County dropped from 250 plants in 1987 to zero in 1989 and 1990, but rebounded to over 2,000 plants in 1992 (J. Silveira *in litt.* 2000). At Olcott Lake in Solano County, the lowest population of the decade was 1,000 in 1994; but this low point was followed by a high of over 1 million estimated plants the following year (California Natural Diversity Data Base 2003).

Habitat and Community Associations.—*Neostapfia colusana* has the broadest ecological range among the Orcuttieae. It occurs on the rim of alkaline basins in the Sacramento and San Joaquin Valleys, as well as on acidic soils of alluvial fans and stream terraces along the eastern margin of the San Joaquin Valley and into the adjacent foothills (Stone *et al.* 1988). Elevations range from 5 meters (18 feet) to about 105 meters (350 feet) at known sites (California Natural Diversity Data Base 2003). *Neostapfia colusana* has been found in Northern Claypan and Northern Hardpan vernal pool types (Sawyer and Keeler-Wolf 1995) within rolling grasslands (Crampton 1959). It grows in pools ranging from 0.01 to 250 hectares (0.02 to 617.5 acres), with a median size of 0.2 hectare (0.5 acre), and also occurs in the beds of intermittent streams and in artificial ponds (Stone *et al.* 1988, K. Fuller pers. comm. 1997, EIP Associates 1999). This species typically grows in the deepest portion of the pool or stream bed (Crampton 1959,

Stone *et al.* 1988), but also may occur on the margins (Hoover 1937, Stone *et al.* 1988). It appears that deeper pools and stock ponds are most likely to provide the long inundation period required for germination (EIP Associates 1999).

Several soil series are represented throughout the range of *Neostapfia colusana*. In the Solano-Colusa Vernal Pool Region, *N. colusana* grows on clay, silty clay, or silty clay loam soils in the Marvin, Pescadero, and Willows series. In the San Joaquin Valley Vernal Pool Region, soils are clay or silty clay loam in the Landlow and Lewis series (J. Silveira *in litt.* 2000). *Neostapfia colusana* habitat in the Southern Sierra Foothills Vernal Pool Region includes many soil series with textures ranging from clay to gravelly loam. For sites with known soil series, Bear Creek, Corning, Greenfield, Keyes, Meikle, Pentz, Peters, Raynor, Redding, and Whitney are represented (Stone *et al.* 1988, EIP Associates 1999, California Natural Diversity Data Base 2003). The type and composition of impermeable layers underlying occupied vernal pools also varies, ranging from claypan to lime-silica or iron-silica cemented hardpan and tuffaceous alluvium (Stone *et al.* 1988).

Neostapfia colusana usually grows in single-species stands, rather than intermixed with other plants. Thus, associated species in this case are plants that occur in different zones of the same pools, but are generally present in the same season. For example, Crampton (1959) observed that *N. colusana* dominated pool beds, with *Orcuttia pilosa* forming a band around the upper edge of the stand. In saline-alkaline sites, common associates of *N. colusana* are *Frankenia salina* and *Distichlis spicata*, whereas on acidic sites associates include *Eryngium* spp., *Eremocarpus setigerus* (turkey mullein), and *Plagiobothrys stipitatus* (Stone *et al.* 1988, EIP Associates 1999). Many of the other rare plants featured in this recovery plan grow in the same pools as *N. colusana*. Among these species, the most frequent associate is *Orcuttia inaequalis* (seven co-occurrences), followed by *O. pilosa* (four), *Tuctoria mucronata* (three), *Chamaesyce hooveri* and *Atriplex persistens* (two each), and *Astragalus tener* var. *tener* (one) (Stone *et al.* 1988, EIP Associates 1999, J. Silveira *in litt.* 2000, California Natural Diversity Data Base 2003). *Tuctoria greenei* formerly grew in one vernal pool with *N. colusana*, but the former no longer occurs there (Stone *et al.* 1988, California Natural Diversity Data Base 2003).

4. Reasons for Decline and Threats to Survival

Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the

Introduction section of this draft recovery plan. Additional, specific threats to *Neostapfia colusana* are described below.

Three additional potential reasons for site-specific declines have been reported relative to this species: inundation by poultry manure and, in Yolo County, damage by herbicide applications (C. Witham *in litt.* 2000*a*) and groundwater becoming contaminated by industrial chemicals (K. Fuller pers. comm. 1997).

The largest continuing threat is agricultural conversions, especially in Stanislaus County. Urbanization is the second greatest threat, especially at the proposed University of California campus and associated community development in eastern Merced County. Four occurrences are in the area expected to be developed within the next 15 years and two others are within the general "planning area" (EIP Associates 1999, California Natural Diversity Data Base 2003). Proposed construction of a new prison and a landfill also threaten other specific populations (U.S. Fish and Wildlife Service 1997*a*). A proposed flood-control project in eastern Merced County threatens four of the occurrences with inundation, and runoff alterations are a threat to the two Yolo County occurrences. Almost all of the extant occurrences of *Neostapfia colusana* are subject to livestock grazing, thus to the extent inappropriate grazing practices are still being followed at certain sites, these sites may be threatened. Competition from invasive native and non-native plants poses a problem at several sites, especially in combination with adverse hydrology changes and adverse grazing practices (Stone *et al.* 1988, C. Witham *in litt.* 2000*a*). One or two sites have also been reported as threatened by vandalism (*i.e.*, trampling near urban areas [U.S. Fish and Wildlife Service 1997*a*]) and foraging by grasshopper outbreaks (Stone *et al.* 1988). Small population size may be a threat at nine sites, which have never exceeded 100 plants in number. In addition, several other sites that were formerly larger than 100 plants each now appear to have declined to fewer than 100 plants (Hogle 2002, California Natural Diversity Data Base 2003).

5. Conservation Efforts

We listed *Neostapfia colusana* as a threatened species on March 26, 1997 (U.S. Fish and Wildlife Service 1997*a*). *Neostapfia colusana* has been State-listed as endangered since 1979 (California Department of Fish and Game 1991) and has been considered to be rare and endangered by the California Native Plant Society since 1974 (Powell 1974). The California Native Plant Society now includes *N. colusana* on List 1B and considers it to be "endangered throughout its range" (California Native Plant Society 2001). In 2003, critical habitat was designated for *N. colusana* and several other vernal pool species in *Final Designation of*

Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon (U.S. Fish and Wildlife Service 2003).

Most of the conservation efforts for *Neostapfia colusana* have been accomplished as part of the broader effort to survey and protect vernal pools in the Central Valley. Surveys conducted by Crampton (1959), Medeiros (1976), and Stone *et al.* (1988) contributed to distributional records and identification of threats. Four occurrences of *N. colusana*, comprising six occupied pools, have been protected by The Nature Conservancy. One is Olcott Lake on the Jepson Prairie Preserve in Solano County, where the *N. colusana* population has been monitored annually since 1989 (C. Witham *in litt.* 1992, California Natural Diversity Data Base 2003). The other five pools are on the Flying M Ranch conservation easement in eastern Merced County (Stone *et al.* 1988).

Three additional occurrences of *Neostapfia colusana* are on Federal land, which offers more options for conservation, but does not in itself constitute protection. Two are on a U.S. Department of Defense facility in Yolo County (Davis Communications Annex), which is in the process of being transferred to the ownership of Yolo County Parks (K. Fuller *in litt.* 2000). The other occurrence is on the Arena Plains Unit of the Merced National Wildlife Refuge in Merced County. Our National Wildlife Refuge system acquired the Arena Plains in 1992, and refuge personnel have been monitoring the *N. colusana* population annually since 1993. Although the refuge allowed grazing to continue on the Arena Plains after it was purchased, temporary electric fencing was placed around the *N. colusana* pool one year to exclude cattle, when the plant population was deemed to be particularly vulnerable (D. Woolington pers. comm. 1997, J. Silveira *in litt.* 2000).

I. *ORCUTTIA INAEQUALIS* (SAN JOAQUIN VALLEY ORCUTT GRASS)

1. Description and Taxonomy

Taxonomy.—Hoover (1936*b*) first published the scientific name *Orcuttia inaequalis* for San Joaquin Valley Orcutt grass. A 1935 collection from "Montpellier [sic], Stanislaus County" was cited as the type specimen (Hoover 1936*b*). Hoover (1941) subsequently reduced this taxon to a variety of California Orcutt grass (*Orcuttia californica*), using the combination *Orcuttia californica* var. *inaequalis*. Based on differences in morphology, seed size, and chromosome number, Reeder (1980) restored the taxon to species status, and the scientific name *Orcuttia inaequalis* is thus currently in use (Reeder 1993). *Orcuttia inaequalis* is a member of the grass family, subfamily Chloridoideae, and is in

the tribe Orcuttieae (Reeder 1965). The genus *Orcuttia* is the most evolutionarily advanced group within the tribe (Keeley 1998, L. Boykin *in litt.* 2000). Alternative common names for this species are San Joaquin Valley orcuttia (Smith *et al.* 1980) and San Joaquin Orcutt grass (U.S. Fish and Wildlife Service 1985*c*).

Description and Identification.—Characteristics common to all members of the Orcuttieae were described earlier in this document in the *Neostapfia colusana* species account. Species in the genus *Orcuttia* are characterized by an inflorescence consisting of narrow, flattened, distichous spikelets, each of which has two glumes at the base. *Orcuttia* species produce three different types of leaves during their life cycle: a submerged basal rosette of five to eight cylindrical, juvenile leaves; intermediate leaves in which the submerged portion is cylindrical but the upper portion has a flat, floating blade; and terrestrial leaves with a flattened blade and loosely sheathing base, which develop after the pools dry (Keeley 1998).

Mature plants of *Orcuttia inaequalis* (**Figure II-14**) grow in tufts of several erect stems, each of which ranges from 5 to 30 centimeters (2.0 to 11.8 inches) in length. The entire plant is grayish-green, due to the long hairs on the stem and leaves, and the plant produces exudate. Terrestrial leaves are 2 to 4 millimeters (0.08 to 0.16 inch) wide. The oval lemmas are 4 to 5 millimeters (0.16 to 0.20 inch) long and their tips are divided into five teeth approximately 2 millimeters (0.08 inch) long; the central tooth is longer than the others, hence the name *inaequalis* ("unequal"). Each spikelet is flattened and contains 4 to 30 florets. Both rows of spikelets grow towards one side. The spikelets are crowded near the top one-third of the stem, producing a head-like inflorescence 2-3.5 centimeters (0.8 to 1.4 inches) long. Each caryopsis is 1.3 to 1.5 millimeters (0.05 to 0.06 inch) long (Hoover 1941; Crampton 1976; Reeder 1982, 1993). The seeds averaged 0.28 milligram (1×10^{-5} ounce) in one population, although seed weight likely varies among sites (Griggs 1980). *Orcuttia inaequalis* has a diploid chromosome number of 24 (Reeder 1980, 1982).

The pith-filled stems, lack of both leaf sheaths and ligules, and presence of exudate distinguish *Orcuttia inaequalis* (and all members of the Orcuttieae) from grasses in other tribes. The elongate, distichous spikelets with oval lemmas and glumes differentiate *Orcuttia* species from *Neostapfia*, which has a cylindrical head with the spikelets arranged in a spiral, fan-shaped spikelets and lemmas, and no glumes. The unequal lemma teeth in *O. inaequalis* distinguish it from *O. pilosa* and *O. tenuis*. *Orcuttia californica* is similar to *O. inaequalis* but the former does not have a head-like inflorescence, has few hairs on the plant, and grows only near the California-Mexico border. *Orcuttia inaequalis* has shorter

Figure II-14. Illustration of *Orcuttia inaequalis* (San Joaquin Valley Orcutt grass). (Reprinted from the Jepson Manual, J. Hickman, Ed., 1993, with permission from the Jepson Herbarium. © Regents of the University of California)

lemmas, shorter bristles, and smaller seeds than *O. viscida*. Furthermore, each species of *Orcuttia* has a unique chromosome number (Reeder 1982).

2. Historical and Current Distribution

Historical Distribution.—*Orcuttia inaequalis* always has been restricted to the Southern Sierra Foothills Vernal Pool Region (Keeler-Wolf *et al.* 1998) (**Figure II-15**). The earliest collection was made in 1927 from the Fresno-Madera county border near Lanes Bridge (California Natural Diversity Data Base 2003). Hoover (1941) mentioned collections from eight sites in Fresno, Madera, Merced, Stanislaus, and Tulare Counties. A total of 20 occurrences had been reported by the mid-1970's, all in the same five counties (Crampton 1959, California Natural Diversity Data Base 2003), but none remained as of the late 1970's (Griggs 1980, Griggs and Jain 1983). However, 20 new occurrences were discovered within the following decade, including 16 in Merced County, 3 in Madera County, and 1 in Fresno County (Stone *et al.* 1988, California Natural Diversity Data Base 2003).

Current Distribution.—Since 1990, six additional occurrences of *Orcuttia inaequalis* have been found, including one in Tulare County (EIP Associates 1999, C. Witham *in litt.* 2000*b*, California Natural Diversity Data Base 2003) and five on ranches in Merced County (California Natural Diversity Data Base 2003), with another one that has been established artificially (Stebbins *et al.* 1995). Of the 50 occurrences of *O. inaequalis* catalogued in the data base, 30 are presumed to be extant; 17 are extirpated and 3 others are possibly extirpated because the habitat has been modified (California Natural Diversity Data Base 2003). However, only 12 of the occurrences presumed extant have been revisited within the past decade, so even the most recent information is outdated. This species has apparently been extirpated from Stanislaus County but remains in Fresno, Madera, Merced, and Tulare Counties (Stone *et al.* 1988, Skinner and Pavlik 1994, California Natural Diversity Data Base 2003). *Orcuttia inaequalis* does not occur outside of the Southern Sierra Foothills Vernal Pool Region (Keeler-Wolf *et al.* 1998). The primary area of concentration is northeast of Merced in Merced County, with 14 occurrences (52 percent) on the Flying M Ranch and adjacent lands (EIP Associates 1999, C. Witham *in litt.* 2000*b*, California Natural Diversity Data Base 2003). Eastern Merced County is considered a critical region for the conservation of this species from the perspective of being located near the historic geographic center, for harboring a large majority of extant occurrences, and for harboring one of the largest incompletely surveyed blocks of quality habitat within the species' range (Vollmar 2002).

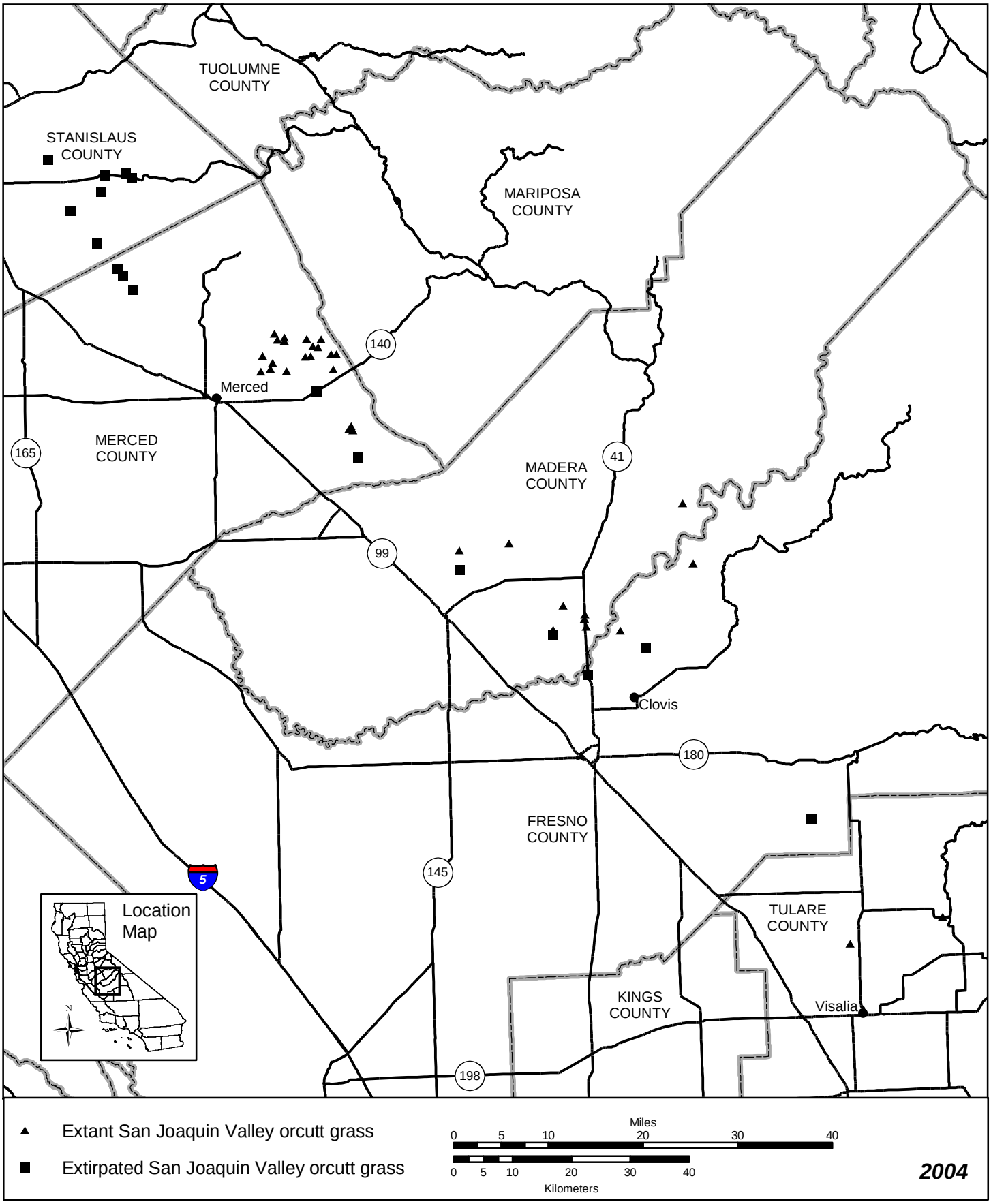

Figure II-15. Distribution of *Orcuttia inaequalis* (San Joaquin Valley Orcutt grass).

The Lanes Bridge area of Madera and Fresno Counties has the second highest concentration, with seven occurrences (26 percent), including the introduced population. The remaining six occurrences include three in the Le Grand area of Merced County, two on the tabletops near the San Joaquin River in Madera and Fresno Counties, and one in northwestern Tulare County (Stone *et al.* 1988, Stebbins *et al.* 1995, California Natural Diversity Data Base 2003).

3. Life History and Habitat

Many life-history characteristics for *Orcuttia inaequalis* are common to the entire tribe and have been discussed earlier in this document. Certain other aspects of the life history are shared by *Orcuttia* and *Tuctoria* species, but not by *Neostapfia*. One of these aspects is the pattern of flowering. The first two flowers on a given plant open simultaneously and do not produce pollen until the ovaries are no longer receptive. Thus, if they are fertilized it must be with pollen from another plant. Flowers that open subsequently may receive pollen from the same plant or others (Griggs 1980). *Orcuttia* and *Tuctoria* species are believed to be outcrossers based on estimates of genetic diversity (Griggs 1980, Griggs and Jain 1983). Seed production in *Orcuttia* and *Tuctoria* species can vary two- to three-fold among years (Griggs 1980, Griggs and Jain 1983).

Another suite of life-history characteristics is shared among all Orcutt grasses (*Orcuttia* species), but not other genera in the Orcuttieae. In particular, seeds of *Orcuttia* species germinate underwater in January and February (Griggs 1980, Griggs and Jain 1983, Keeley 1998), after being colonized by aquatic fungi (Griggs 1980, 1981). This observation was supported by Keeley's (1988) research, which indicated that fungicide inhibited germination of *O. californica* seeds, but did not affect *Tuctoria greenei* seeds. Detailed germination studies have not been conducted on all species, but cold treatment and other forms of stratification promoted germination in *O. californica* (Keeley 1988), *O. pilosa*, and *O. tenuis* (Griggs 1974, as cited in Stone *et al.* 1988) and most likely benefit other *Orcuttia* species as well. In an experimental study of *O. californica* (Keeley 1988), seeds germinated equally well in the light or the dark and could germinate whether exposed to air or *anaerobic* conditions; maximum germination was achieved in anaerobic conditions following cold stratification.

Orcuttia plants grow underwater for 3 months or more and have evolved specific adaptations for aquatic growth (Keeley 1998). Among these adaptations is the formation of the three different leaf types. The well-developed rosette of juvenile leaves is more specialized than those in *Neostapfia* or *Tuctoria* species (Keeley 1998), however. The floating-leaf stage is unique to *Orcuttia* species; these leaves form as water in the pool warms and remain as long as the standing water

lasts (Hoover 1941, Griggs 1980, Griggs 1981, Reeder 1982, Keeley 1998). Aquatic leaves of *Orcuttia* species also lack stomates, even though they are present on the juvenile leaves of both *Neostapfia* and *Tuctoria* (Keeley 1998).

As soon as the pools dry, normally in June or July, Orcutt grasses begin producing their typical terrestrial leaves (Hoover 1941, Griggs 1980, Griggs 1981, Reeder 1982, Keeley 1998). Inflorescences appear within a few days after the water evaporates. June and July are the peak months of flower production for most species, although flowering may continue into August and September in years of above-normal precipitation (Griggs 1980, Griggs 1981). Late-spring rains may prolong the flowering season (Griggs 1981, Griggs and Jain 1983), but inundation is more likely to kill flowering individuals (J. Silveira *in litt.* 1997). Spikelets break apart and scatter their seeds when autumn rains arrive (Reeder 1965, Crampton 1976, Griggs 1980, Griggs 1981).

Reproduction and Demography.—Griggs (1980) conducted demographic and genetic studies of one Fresno County population of *Orcuttia inaequalis* during spring 1976. In that year, each plant in the population produced an average of approximately 8 stems, 1,783 florets, and 254 seeds. The floret-to-seed ratio indicated a relatively good rate of pollination. Survival rates were not determined. Annual population estimates indicated that 1976 and 1978 were favorable years for the Fresno County population. Genetic diversity was high, even among plants grown from seeds collected from the same plant; among-population diversity was not evaluated for this species. The enzyme systems of *O. inaequalis* were most similar to those of *O. tenuis* (Griggs 1980, Griggs and Jain 1983).

Habitat and Community Associations.—Typical habitat requirements for all members of the Orcuttieae were described above under *Neostapfia colusana*. *Orcuttia inaequalis* occurs on alluvial fans, high and low stream terraces (Stone *et al.* 1988), and tabletop lava flows (Stebbins *et al.* 1995, California Natural Diversity Data Base 2003). This species grows in Northern Claypan, Northern Hardpan, and Northern Basalt Flow vernal pools (Sawyer and Keeler-Wolf 1995) within rolling grassland (Crampton 1959). Occupied pools range in surface area from 0.014 to 4.9 hectares (0.05 to 12.1 acres), with a median area of 0.62 hectare (1.54 acres) (Stone *et al.* 1988). *Orcuttia inaequalis* has been reported from elevations of 30 to 755 meters (100 to 2,475 feet); the highest-elevation sites are those on the tabletops of Fresno and Madera Counties (Stebbins *et al.* 1995, California Natural Diversity Data Base 2003).

Soils underlying *Orcuttia inaequalis* pools are acidic and vary in texture from clay to sandy loam. Soil series represented include the Hideaway series on

Fresno-Madera county tabletops, and Amador, Cometa, Corning, Greenfield, Los Robles, Madera, Peters, Pollasky-Montpellier complex, Raynor, Redding, and San Joaquin soil series elsewhere in the range. Underlying layers at historical or extant occurrences included iron-silica cemented hardpan, tuffaceous alluvium, and basaltic rock from ancient volcanic flows (Stone *et al.* 1988, Stebbins *et al.* 1995, EIP Associates 1999, California Natural Diversity Data Base 2003).

The plants most commonly associated with *Orcuttia inaequalis* are *Eryngium* spp., *Plagiobothrys stipitatus*, *Neostapfia colusana*, *Psilocarphus brevissimus* (dwarf woolly-heads), and *Eremocarpus setigerus*. Among the rare plants featured in this recovery plan, five currently co-occur or historically co-occurred with *O. inaequalis*. In descending order by number of co-occurrences, these are: *N. colusana* (nine), *Castilleja campestris* ssp. *succulenta* (five), *Gratiola heterosepala* (three), *O. pilosa* (two), and *Chamaesyce hooveri* (one) (EIP Associates 1999, C. Witham *in litt.* 2000*b*, California Natural Diversity Data Base 2003).

4. Reasons for Decline and Threats to Survival

Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to *Orcuttia inaequalis* are described below.

A potential reason for some site-specific declines of this species may be foraging by grasshopper outbreaks, which can decimate entire plant populations of *Orcuttia inaequalis* before they set seed (Griggs and Jain 1983, Stone *et al.* 1988).

At least ten of the extant occurrences are threatened with habitat loss due to urbanization. Four of these are in the path of the proposed extension of State Highway 41 in Madera County (R. Stone *in litt.* 1992). Three others are threatened by a proposed residential development in Madera and Fresno Counties (Stone *et al.* 1988, Stebbins *et al.* 1995, California Natural Diversity Data Base 2003), and three more could be destroyed by construction of the proposed University of California campus and associated community in Merced County (EIP Associates 1999, California Natural Diversity Data Base 2003). Most extant populations are still being grazed; thus to the extent inappropriate grazing practices are still being followed, certain sites may be threatened. At least six occurrences are threatened by small population size. Among the *Orcuttia inaequalis* occurrences for which population size has been estimated, six numbered fewer than 100 plants each, even in favorable years. Ten others are of

unknown size (R. Stone *in litt.* 1992, Stebbins *et al.* 1995, California Natural Diversity Data Base 2003).

5. Conservation Efforts

Orcuttia inaequalis was federally-listed as a threatened species on March 26, 1997 (U.S. Fish and Wildlife Service 1997*a*). The State of California had previously listed this grass as endangered in 1979 (California Department of Fish and Game 1991). The California Native Plant Society has considered this species to be rare and endangered for even longer (Powell 1974). Currently, *O. inaequalis* is on the California Native Plant Society's List 1B and is rated as "endangered throughout its range" (California Native Plant Society 2001). In 2003, critical habitat was designated for *O. inaequalis* and several other vernal pool species in *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon* (U.S. Fish and Wildlife Service 2003).

Currently, few occurrences of *Orcuttia inaequalis* are protected permanently. Two occurrences are on the Flying M Ranch in Merced County, which is protected under a conservation easement with The Nature Conservancy. Within those two occurrences, four pools supported *O. inaequalis* populations in excess of 5,000 individuals each in 1986 (Stone *et al.* 1988). The extant Tulare County occurrence of *O. inaequalis* is on a California Department of Fish and Game Ecological Reserve; it contained 250 plants in 1997 (California Natural Diversity Data Base 2003).

Three other occurrences are wholly or partially on public land, which does not necessarily confer protection. One occurrence in Fresno County consists of a pool that is partially on public land administered by the U.S. Bureau of Land Management. The pool supports the second-largest existing population of the species. The U.S. Bureau of Land Management and conservation groups are targeting acquisition of adjacent land to protect the entire pool (California Natural Diversity Data Base 2003). Another occurrence is within an 81-hectare (200-acre) vernal pool complex in Madera County, where one pool contains a small population of *Orcuttia inaequalis* (Stebbins *et al.* 1995); the California Department of Transportation recently acquired this complex. Although the proposed Highway 41 extension would cross this property, alignment to avoid affecting the plant is possible (D. York pers. comm. 1996).

The third occurrence on public land is the result of a vernal pool re-creation program coupled with seeding of various plant species. The California Department of Transportation funded the creation of artificial vernal pools in

Madera County by staff and students from California State University, Fresno (D. York pers. comm. 1996). *Orcuttia inaequalis* was introduced into six of the created pools; it germinated and flowered in five pools during the 2 years following its introduction (Durgarian 1995, Stebbins *et al.* 1995) and was still present in 2000 (R. Faubion *in litt.* 2000). This site is now recorded in California Natural Diversity Data Base occurrences (California Natural Diversity Data Base (2003). The Madera Irrigation District manages this property, which is owned by the U.S. Bureau of Reclamation (Stebbins *et al.* 1995).

J. *ORCUTTIA PILOSA* (HAIRY ORCUTT GRASS)

1. Description and Taxonomy

Taxonomy.—Hairy Orcutt grass is in the tribe Orcuttieae of the grass family (Reeder 1965). Hoover (1941) published the original scientific name *Orcuttia pilosa* for hairy Orcutt grass, which has remained unchanged since. He collected the type specimen in Stanislaus County, "12 miles east of Waterford" (Hoover 1941) in 1937. Hoover (1937) initially identified that specimen as *Orcuttia tenuis*, but later recognized that it represented a new species (Hoover 1941). This species also has been known by the common names hairy Orcuttia (Smith *et al.* 1980) and pilose Orcutt grass (U.S. Fish and Wildlife Service 1985*c*).

Description and Identification.—Characteristics shared among all members of the tribe or among species in the genus *Orcuttia* are described above in the *Neostapfia colusana* and *O. inaequalis* species accounts. *Orcuttia pilosa* (**Figure II-16**) grows in tufts consisting of numerous stems. The stems are decumbent or erect and branch from only the lower nodes. Stems are 5 to 20 centimeters (2.0 to 7.9 inches) long and 1 to 2 millimeters (0.04 to 0.08 inch) in diameter (Stone *et al.* 1988). Almost the entire plant is pilose, giving it a grayish appearance. The terrestrial leaves are 3 to 6 millimeters (0.12 to 0.24 inch) wide. The inflorescence is 5 to 10 centimeters (2.0 to 3.9 inches) long and contains between 8 and 18 flattened spikelets. The spikelets near the tip of the inflorescence are crowded together, whereas those near the base are more widely spaced. Each spikelet consists of 10 to 40 florets and two tiny (3 millimeters [0.12 inch]) glumes. The lemmas are 4 to 5 millimeters (0.16 to 0.20 inch) long, with five teeth of equal size. Each caryopsis is 1.75 to 2 millimeters (0.07 to 0.08 inch) long (Hoover 1941; Reeder 1982, 1993) and weighs 0.46-0.95 milligram (1.6 to 3.4 x 10^{-5} ounce) (Griggs 1980). *Orcuttia pilosa* has a diploid chromosome number of 30 (Reeder 1982).

Figure II-16. Illustration of *Orcuttia pilosa* (hairy Orcutt grass). (Reprinted from the Jepson Manual, J. Hickman, Ed., 1993, with permission from the Jepson Herbarium. © Regents of the University of California)

Orcuttia pilosa is most likely to be confused with *O. tenuis*. However, *O. pilosa* has broader stems and leaves, branches originating from the lower nodes, smaller spikelets that are crowded near the rachis tip, smaller grains, a later flowering period, and a different chromosome number (Reeder 1982). Other *Orcuttia* species typically have unequal lemma teeth and differ in seed size and chromosome number from *O. pilosa* and *O. tenuis* (Reeder 1982).

2. Historical and Current Distribution

Historical Distribution.—Prior to the surveys by Stone *et al.* (1988), *Orcuttia pilosa* had been reported from 25 sites, primarily in the Northeastern Sacramento Valley and Southern Sierra Foothills vernal pool regions (Keeler-Wolf *et al.* 1998) (**Figure II-17**). These included eight occurrences each in Tehama and Stanislaus Counties, six in Madera County, and two in Merced County (Hoover 1941, Crampton 1959, Reeder 1982, Stone *et al.* 1988, California Natural Diversity Data Base 2003). *Orcuttia pilosa* also was collected in the Solano-Colusa Vernal Pool Region, Glenn County, in 1937 (California Natural Diversity Data Base 2003); the specimen has since been lost, but may have originally been misidentified as California Orcutt grass (Oswald and Silveira 1995, J. Silveira pers. comm. 1997, J. Silveira *in litt.* 2000). During the late 1980's, Stone *et al.* (1988) determined that 12 historical occurrences had been extirpated, but they and others discovered three additional populations in Madera, Stanislaus, and Tehama Counties. One other occurrence from Madera County (California Natural Diversity Data Base Element Occurrence 29) was previously considered to be *O. pilosa* and is listed as such in the California Natural Diversity Data Base (2003); however, this population since has been identified as *O. inaequalis* (R. Stone *in litt.* 1992).

Current Distribution.—Within about the last decade, 10 new natural occurrences of *Orcuttia pilosa* has been discovered: five in Glenn County, three in Madera County, and one each in Merced and Tehama Counties (California Natural Diversity Data Base 2003). *Orcuttia pilosa* also has been discovered in another pool at the Vina Plains Preserve in Tehama County (Alexander and Schlising 1997); this pool may represent a separate occurrence or it may be an extension of California Natural Diversity Data Base Element Occurrence 25. In addition, this species has been introduced into a re-created pool in Madera County (Durgarian 1995, Stebbins *et al.* 1995, California Natural Diversity Data Base 2003).

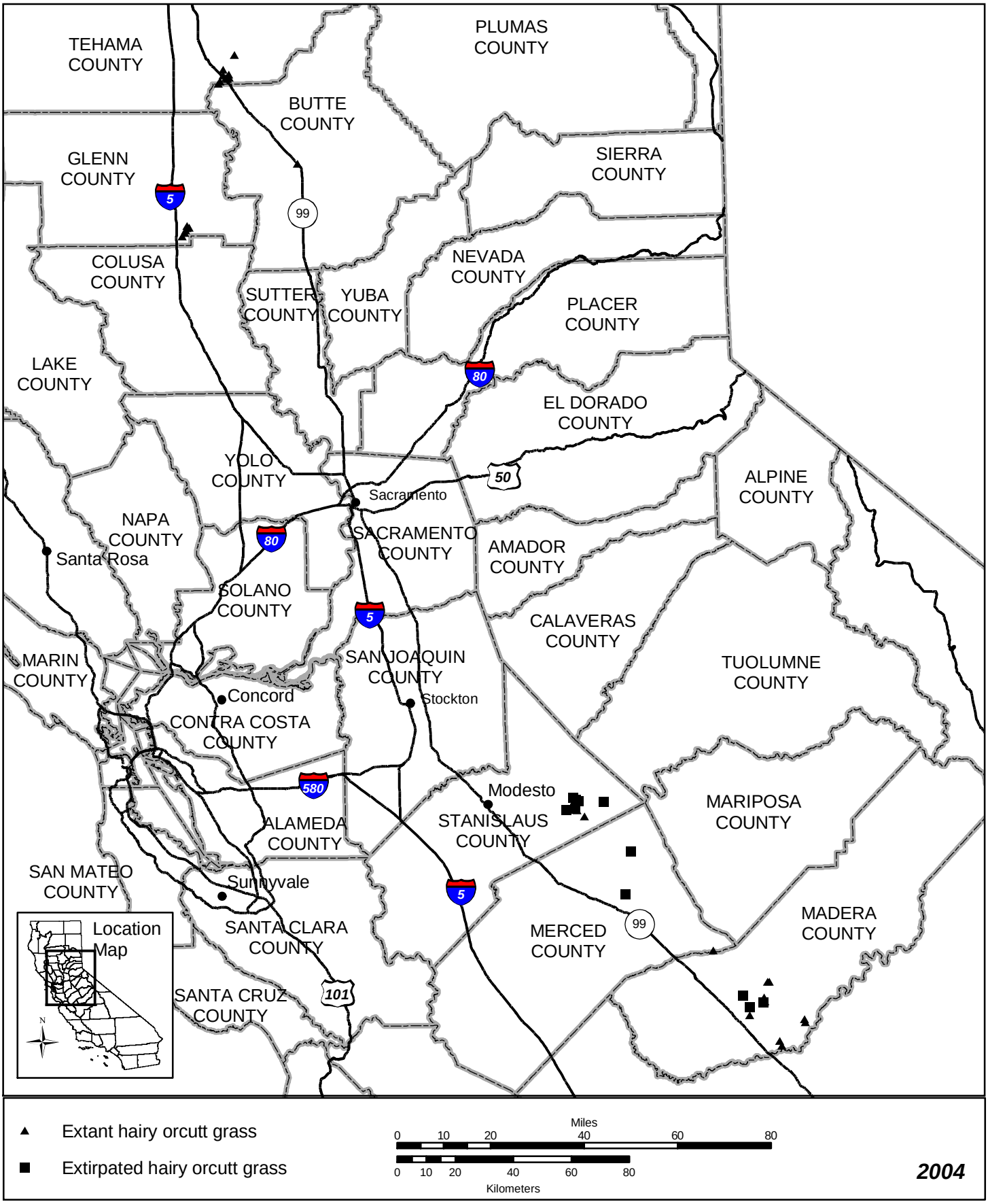

Figure II-17. Distribution of *Orcuttia pilosa* (hairy Orcutt grass).

Of the 37 Element Occurrences listed by the California Natural Diversity Data Base (2003), not counting the misidentified population of *Orcuttia inaequalis*, 26 natural occurrences and the introduced population are presumed to be extant (California Natural Diversity Data Base 2003).

Currently, the main area of concentration for *Orcuttia pilosa* (10 extant occurrences and one that is possibly extirpated) is the Vina Plains in Tehama County, which is in the Northeastern Sacramento Valley Vernal Pool Region. An isolated occurrence in southern Butte County is in the same region. Twelve occurrences are in the Southern Sierra Foothills Vernal Pool Region, including eight in Madera County between the City of Madera and Millerton Lake, three in eastern Stanislaus County, and one in Merced County. All five extant occurrences in the Solano-Colusa Vernal Pool Region are on the Sacramento National Wildlife Refuge in Glenn County (Stone *et al.* 1988, Keeler-Wolf *et al.* 1998, California Natural Diversity Data Base 2003).

3. Life History and Habitat

The life-history characteristics common to all members of the Orcuttieae were presented above within the *Neostapfia colusana* discussion, and others shared by all *Orcuttia* species were described under the *O. inaequalis* discussion.

Reproduction and Demography.— Griggs (1974, as cited in Stone *et al.* 1988) found that stratification followed by temperatures of 15 to 32 degrees Celsius (59 to 90 degrees Fahrenheit) was necessary for seed germination in *Orcuttia pilosa*. Flowering individuals have been observed as early as mid-April in Madera County (Durgarian 1995). Populations observed in Glenn County began flowering at the beginning of May 1993. However, heavy rains in late May and early June of that year refilled the five pools that were being monitored, causing 80 percent to 100 percent of the plants to die before they set seed (J. Silveira *in litt.* 1997). Seed production has not been studied extensively in *O. pilosa*, but Griggs and Jain (1983) did note that one individual plant produced more than 10,000 seeds. Although the predominant pollination agent for all Orcutt grasses is wind, native bees (Halictidae) have been observed visiting the inflorescences of *O. pilosa* to gather pollen (Griggs 1974, as cited in Stone *et al.* 1988).

Like other vernal pool annuals, the size of *Orcuttia pilosa* populations fluctuates dramatically from year-to-year. Population sizes have varied by as much as four orders of magnitude over time (Griggs 1980, Griggs and Jain 1983, Alexander and Schlising 1997). In fact, two populations that had no visible plants for 3 years in succession exceeded 10,000 plants in the 4th year (Griggs 1980, Griggs

and Jain 1983). However, populations that number fewer than 100 plants in even the most favorable years are not likely to persist. They probably begin with chance dispersal events which never build up enough of a soil seed bank to become established. This phenomenon was noted at the Sacramento National Wildlife Refuge, the Vina Plains, and an unspecified location where the population consisted of six plants in 1973, dropped to zero the following year, and was considered to be extirpated when no plants reappeared by 1978 (Griggs 1980, Griggs and Jain 1983).

Densities of *Orcuttia pilosa* were determined at the Vina Plains Preserve in 1995. Among four pools where this species grew, densities ranged from 45 to 474 plants per square meter (4.2 to 44.0 per square foot) (Alexander and Schlising 1997). The high densities illustrate that although the total population size seems large, the individuals grow in close proximity.

Habitat and Community Associations.— This species is found on high or low stream terraces and alluvial fans (Stone *et al.* 1988). *Orcuttia pilosa* occurs in Northern Basalt Flow, Northern Claypan, and Northern Hardpan vernal pools (Sawyer and Keeler-Wolf 1995) within annual grassland (California Natural Diversity Data Base 2003). The median size of occupied pools measured in the late 1980's was 1.7 hectares (4.2 acres), with a range of 0.34 to 250 hectares (0.8 to 617.5 acres) (Stone *et al.* 1988). At the Vina Plains, *O. pilosa* was found growing only in pools that held water until May, June, or July in 1995, and not in those that dried in April (Alexander and Schlising 1997). This species is known from elevations of 26 meters (85 feet) in Glenn County to 123 meters (405 feet) in Madera County (California Natural Diversity Data Base 2003). *Orcuttia pilosa* is found on both acidic and saline-alkaline soils, in pools with an iron-silica cemented hardpan or claypan. In the Northeastern Sacramento Valley Vernal Pool Region, pools supporting *O. pilosa* occur on the Anita and Tuscan soil series (Stone *et al.* 1988, California Natural Diversity Data Base 2003). At one pool in the Vina Plains that spans both Anita clay and Tuscan loam soils, *O. pilosa* was found growing primarily on the Anita clay type (Alexander and Schlising 1997). In the Solano-Colusa Vernal Pool Region, *O. pilosa* occurs on the Willows and Riz soil series (J. Silveira *in litt.* 2000), whereas in the Southern Sierra Foothills Vernal Pool Region, it occurs on the Cometa, Greenfield, Hanford, Meikle, and Whitney soil series (Stone *et al.* 1988).

Common associates of *Orcuttia pilosa* throughout its range include *Eryngium* spp. and *Plagiobothrys stipitatus*. *Orcuttia pilosa* also co-occurs at numerous sites with other rare plants addressed in this recovery plan, including *Neostapfia colusana* in the San Joaquin Valley and *Chamaesyce hooveri* and *Tuctoria greenei* in the Sacramento Valley (Stone *et al.* 1988, Alexander and Schlising

1997, California Natural Diversity Data Base 2003). Additional associates in the San Joaquin Valley include *Trichostema lanceolatum* (vinegar weed) and *Anthemis cotula* (mayweed) (Stone *et al.* 1988). *Orcuttia pilosa* formerly occurred in one pool with *O. inaequalis* (Crampton 1959), a habitat that has since been converted to almond orchards (California Natural Diversity Data Base 2003). In the Vina Plains, other common associates of *O. pilosa* are *Marsilea vestita*, *Convolvulus arvensis*, and *Amaranthus albus* (Alexander and Schlising 1997). Both *O. pilosa* and *O. tenuis* grow on the Vina Plains, but do not occur in the same pools (Stone *et al.* 1988, Alexander and Schlising 1997). At least in 1995, the Vina Plains pools where *O. pilosa* grew had few spring-flowering annuals (Alexander and Schlising 1997).

4. Reasons for Decline and Threats to Survival

Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to *Orcuttia pilosa* are described below.

Some indications of decline (*i.e.*, California Natural Diversity Data Base description as "possibly extirpated") for this species may have, in fact, been only artifacts of random dispersal events in which the "extirpated" populations were not established. In particular, two such occurrences on the Vina Plains Preserve apparently died out because the populations were too small to be viable. These occurrences involved only 2 plants at one site and fewer than 100 at the other site, and thus may have not represented truly established populations.

Nevertheless, the primary threats are continuing. In particular, agricultural and residential developments, and planning for such, are proceeding in the vicinity of the remaining Stanislaus and Madera County occurrences and may lead to the destruction of additional populations in the foreseeable future (Stone *et al.* 1988). Construction of a landfill threatens one occurrence (U.S. Fish and Wildlife Service 1997*a*). Cattle grazing was an ongoing land use at 20 occurrences when they were last visited, including six where this species may already be extirpated (California Natural Diversity Data Base 2003). Also, competition from invasive plants is believed to be an increasing problem throughout the range of *Orcuttia pilosa* (Stone *et al.* 1988). Several researchers (Stone *et al.* 1988, Alexander and Schlising 1997) have suggested that cattle may have carried in seeds of non-native plants, and disturbance from trampling may have then facilitated their establishment. *Convolvulus arvensis* has increased in frequency in the Vina Plains since 1984, and *Xanthium strumarium* is still present. In addition, small

population size continues to be a threat to *O. pilosa*. Six of the presumably extant populations have had fewer than 100 plants at their peak (California Natural Diversity Data Base 2003).

5. Conservation Efforts

We listed *Orcuttia pilosa* as an endangered species on March 26, 1997 (U.S. Fish and Wildlife Service 1997*a*). *Orcuttia pilosa* had previously been State-listed as endangered in 1979 (California Department of Fish and Game 1991) and was identified as rare and endangered by the California Native Plant Society 5 years before that (Powell 1974). The California Native Plant Society still considers this species to be "endangered throughout its range" and includes it on List 1B (California Native Plant Society 2001). In 2003, critical habitat was designated for *O. pilosa* and several other vernal pool species in *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon* (U.S. Fish and Wildlife Service 2003).

Relatively large populations of *Orcuttia pilosa* are protected at The Nature Conservancy's Vina Plains Preserve in Tehama County (Broyles 1987, Alexander and Schlising 1997, California Natural Diversity Data Base 2003) and at our Sacramento National Wildlife Refuge in Glenn County (J. Silveira *in litt.* 1997, J. Silveira *in litt.* 2000). A small population is now protected at a California Department of Transportation mitigation site in Madera County, although that site has, at times, been degraded due to discing by the former landowner (Stebbins *et al.* 1995). The Vina Plains populations have been monitored sporadically since 1983 (Alexander and Schlising 1997) and the Sacramento National Wildlife Refuge populations since 1993 (J. Silveira *in litt.* 2000). *Xanthium strumarium*, an aggressive native plant, has been removed by hand from some of the Vina Plains pools (Alexander and Schlising 1997), an effort that began in 1991 using funds from the California Endangered Species Tax Check-Off Fund (California Department of Fish and Game 1991).

Orcuttia pilosa was one component of an interagency vernal pool re-creation program in Madera County. The experiment was funded by the California Department of Transportation, carried out on U.S. Bureau of Reclamation property, and conducted by personnel from California State University, Fresno, and the University of California, Davis (Stebbins *et al.* 1996). *Orcuttia pilosa* was seeded into nine of the re-created pools in fall 1993. Flowering individuals were found in eight of the pools the following year, six in 1995, and eight in 1996 (Durgarian 1995, Stebbins *et al.* 1996), and the species was also observed in the re-created pools in 2000 (R. Faubion *in litt.* 2000).

K. *ORCUTTIA TENUIS* (SLENDER ORCUTT GRASS)

1. Description and Taxonomy

Taxonomy.—Slender Orcutt grass is a member of the tribe Orcuttieae in the grass family (Reeder 1965). Hitchcock (1934) first published the name *Orcuttia tenuis* for slender Orcutt grass, and this name has remained unchanged. Nonetheless, some confusion surrounds the taxonomy of the species. The type specimen of *Orcuttia tenuis* was collected in Goose Valley, Shasta County, in 1912. Before the initial collections had been recognized as a new species, they were mistakenly identified as *Orcuttia californica* and were used as the basis for illustrating the latter species in a 1920 publication (Hitchcock 1934). Another common name is slender orcuttia (Smith *et al.* 1980).

***Description* and Identification.**—The *Neostapfia colusana* account provided above describes characteristics common to all members of the tribe, and the *Orcuttia inaequalis* account describes features shared among *Orcuttia* species. *Orcuttia tenuis* (**Figure II-18**) grows as single stems or in small tufts consisting of a few stems. The plants are sparsely hairy and branch only from the upper half of the stem. Although the stems typically are erect, they may become decumbent if many branches form near the stem tip (Reeder 1982). The stems range from 5 to 20 centimeters (2.0 to 7.9 inches) in height (G. Schoolcraft *in litt.* 2000) and are about 0.5 millimeter (0.02 inch) in diameter. The terrestrial leaves are 1.5 to 2 millimeters (0.06 to 0.08 inch) wide. In *O. tenuis*, the inflorescence comprises more than half of the plant's height, and the spikelets are more or less evenly spaced throughout the inflorescence. Each spikelet contains from 5 to 20 florets. The grains are about 3 millimeters (0.12 inch) long (Hitchcock 1934, Reeder 1982, Stone *et al.* 1988, Reeder 1993). In one study, seed weight ranged from 0.32 to 0.81 milligram (1.1 to 2.8 x 10^{-5} ounce) (Griggs 1980). The diploid chromosome number of *O. tenuis* is 26 (Reeder 1982).

Orcuttia tenuis is most similar to *O. pilosa*, but the former has narrower stems and leaves, branches at the upper nodes, larger spikelets that are not crowded on the rachis, larger seeds, a different chromosome number, and it flowers earlier (Reeder 1982). Other *Orcuttia* species have unequal lemma teeth and also differ in seed size and chromosome number (Reeder 1982).

2. Historical and Current Distribution

Historical Distribution.—By the mid-1980's, *Orcuttia tenuis* was known from only 18 localities in Lake, Sacramento, Shasta, and Tehama Counties (Reeder 1982, Stone *et al.* 1988) (**Figure II-19**). During the late 1980's, Stone *et*

Figure II-18. Illustration of *Orcuttia tenuis* (slender Orcutt grass). (Reprinted from the Jepson Manual, J. Hickman, Ed., 1993, with permission from the Jepson Herbarium. © Regents of the University of California)

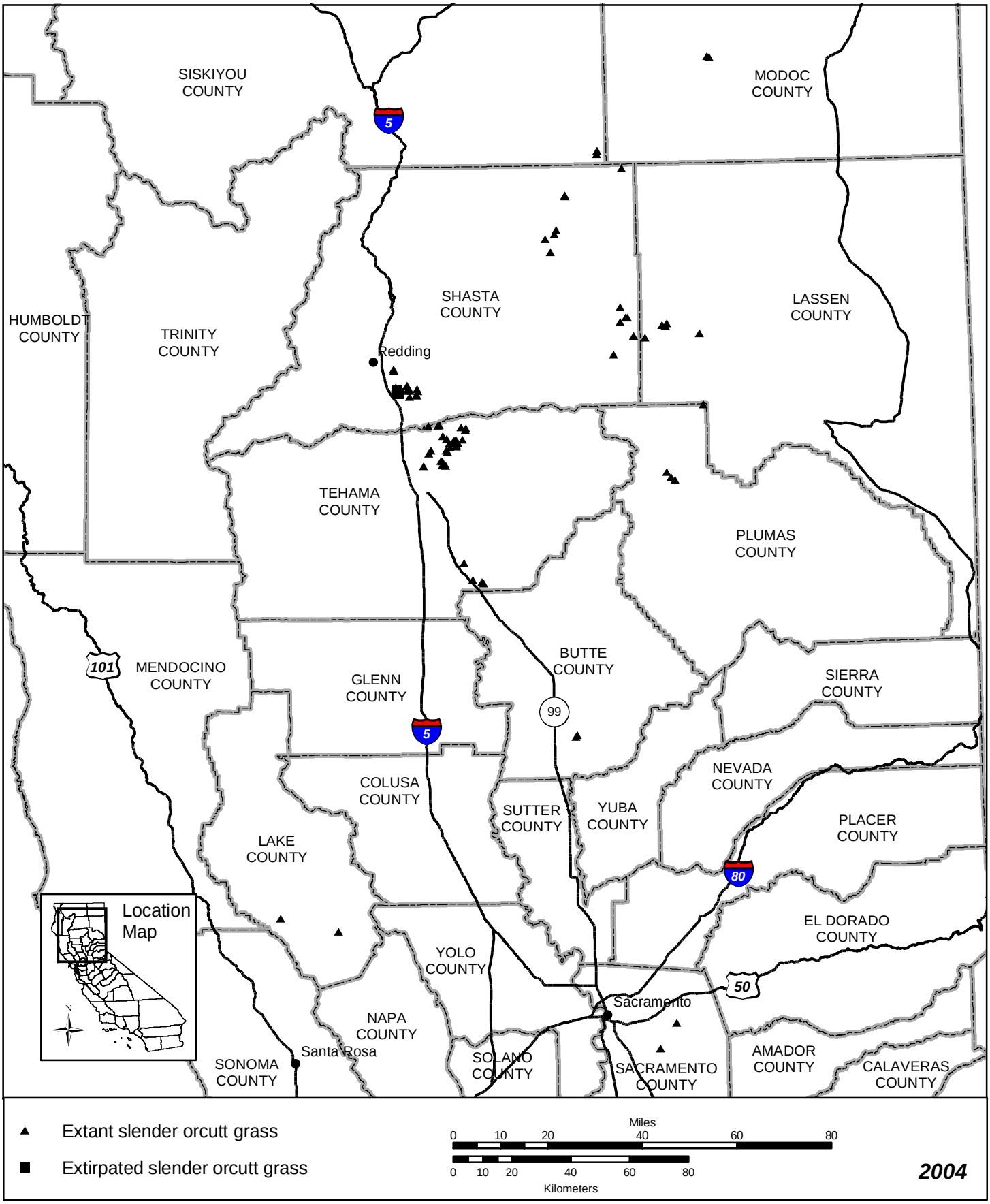

Figure II-19. Distribution of *Orcuttia tenuis* (slender Orcutt grass)

al. (1988) and others (California Natural Diversity Data Base 2003) discovered 34 additional occurrences of *O. tenuis*. Of the 52 occurrences reported prior to 1990, the majority (29 occurrences, 55.8 percent) were in the Northeastern Sacramento Valley Vernal Pool Region of Tehama County, mostly in the vicinity of Dales, except for 4 occurrences on the Vina Plains. Another 14 occurrences (26.9 percent) were in the Northwestern Sacramento Valley Vernal Pool Region, on the Stillwater and Millville Plains of Shasta County. The Modoc Plateau Vernal Pool Region accounted for another six occurrences (11.5 percent), including four in Shasta County and two in Siskiyou County. The remaining three occurrences included two in Lake County, which was in the Lake-Napa Vernal Pool Region, and one in Sacramento County, in the Southeastern Sacramento Valley Vernal Pool Region (Griggs and Jain 1983, Stone *et al.* 1988, California Natural Diversity Data Base 2003).

Current Distribution.—During the past decade, 27 new occurrences of *Orcuttia tenuis* have been reported, including three that were introduced into created pools. Thus, a total of 79 occurrences are known, of which 73 are presumed to be extant (B. Corbin *in litt.* 1999, California Natural Diversity Data Base 2003); occurrences are presumed to be extant until the California Natural Diversity Data Base receives documentation that they have been extirpated. In addition to the counties where it was reported historically, *O. tenuis* is now also known from Lassen and Plumas Counties. The primary area of concentration for *O. tenuis* is still in the vicinity of Dales, Tehama County, where 28 natural occurrences and the three introduced populations apparently remain extant (42.5 percent of occurrences). Those 31 occurrences and the four in the Vina Plains of Tehama County are all in the Northeastern Sacramento Valley Vernal Pool Region (Keeler-Wolf *et al.* 1998). A secondary area of concentration is the Modoc Plateau Vernal Pool Region in Lassen, Plumas, Shasta, and Siskiyou Counties, with 21 extant occurrences (28.8 percent). The portion of Shasta County that is in the Northwestern Sacramento Valley Vernal Pool Region has 12 extant occurrences (16.4 percent). The Lake-Napa Vernal Pool Region accounts for two extant occurrences, both in Lake County; two occurrences are in Sacramento County, in the Southeastern Sacramento Valley Vernal Pool Region; and the one remaining occurrence, in Shasta County (California Natural Diversity Data Base Element Occurrence 69), is outside of mapped vernal pool regions (Stone *et al.* 1988, Corbin and Schoolcraft 1989, B. Corbin *in litt.* 1999, California Natural Diversity Data Base 2003).

3. Life History and Habitat

The general life history of *Orcuttia tenuis* is similar to that of *O. inaequalis* and *Neostapfia colusana*, as discussed previously in this recovery plan.

Reproduction and Demography.—Optimal germination of *Orcuttia tenuis* is achieved through stratification followed by warm days and mild nights (Griggs 1974 as cited in Stone *et al.* 1988). Peak flowering of this species typically occurs in May in the Central Valley (Griggs 1981, Reeder 1982), but not until June or July on the Modoc Plateau (B. Corbin *in litt.* 2000, G. Schoolcraft *in litt.* 2000). Unlike *O. pilosa* and *Tuctoria greenei*, *O. tenuis* is not likely to die when pools are flooded by late spring or summer rains. At two sites near Dales that were inundated by rains in May 1977, *O. tenuis* plants dropped their existing inflorescences, but resprouted and flowered again within 1 month (Griggs 1980, Griggs and Jain 1983). Moreover, the population at the Vina Plains Preserve in Tehama County experienced a second pulse of germination after summer rains in 1982 (Broyles 1983, cited in Alexander and Schlising 1997). Conversely, drought has been known to cause 100 percent mortality of local populations (Griggs 1980, Griggs and Jain 1983).

Similar to other vernal pool annuals, *Orcuttia tenuis* populations can vary greatly in size from year- to-year. Fluctuations of up to four orders of magnitude have been documented in Lake and Shasta Counties (Griggs 1980, Griggs and Jain 1983). At the Vina Plains Preserve, the single population ranged in size from 1,000 to 147,700 estimated individuals during the five times it was reported over a 13-year period (Stone *et al.* 1988, Alexander and Schlising 1997). However, *O. tenuis* populations do not always fluctuate in size. Among five populations of *O. tenuis* that Griggs tracked from 1973 to 1979, two remained at the same order of magnitude for the entire period. Both were in the Dales area. None of the other five species of Orcuttieae included in the study remained stable for the full 7 years (Griggs 1980, Griggs and Jain 1983).

Seeds of *Orcuttia tenuis* germinate even in dry years, but the proportion of plants surviving to maturity varies. In a 1977 demographic study of two *O. tenuis* populations near Dales and a third near Redding (Griggs 1980, Griggs and Jain 1983), survivorship ranged from 0 to 75 percent, averaging 40 percent. At the two sites near Dales, densities of *O. tenuis* were 694 and 1,530 plants per square meter (64.5 and 142.1 per square foot, respectively) in 1977 (Griggs 1980, Griggs and Jain 1983). At the Vina Plains Preserve, the single occupied pool had a density of 71 plants per square meter (6.6 per square foot) in 1995 (Alexander and Schlising 1997). *Orcuttia tenuis* produced an average of 58 seeds per plant in 1977, ranging from 11.3 to 163.9 among the populations studied. At one Dales-area site, the soil seed bank was estimated to be more than 14 times greater than the population of growing plants in 1977 (Griggs 1980, Griggs and Jain 1983).

Griggs (1980, Griggs and Jain 1983) reported that most of the genetic diversity in *Orcuttia tenuis* occurred among individuals with the same seed parent. He found nearly as much genetic diversity within a single population, but little difference between populations. However, his study included only two populations from Tehama County, which were in close proximity. One of the Sacramento County populations differs considerably from other occurrences in outward appearance, suggesting that it may differ in genetic makeup (S. Cochrane *in litt.* 1995*a*).

Habitat and Community Associations.—*Orcuttia tenuis* is found primarily on substrates of volcanic origin (Crampton 1959, Corbin and Schoolcraft 1989). Natural pools in which *O. tenuis* grows are classified as Northern Volcanic Ashflow and Northern Volcanic Mudflow vernal pools (Sawyer and Keeler-Wolf 1995). However, this species also has been reported from other natural and artificially-created seasonal wetlands such as creek floodplains, stock ponds, and borrow pits. Impervious layers range from iron-silica hardpan to bedrock (Stone *et al.* 1988, Corbin and Schoolcraft 1989, California Natural Diversity Data Base 2003). Among the populations studied by Stone *et al.* (1988), the median area of pools occupied by *O. tenuis* was 0.65 hectare (1.6 acres) and ranged from 0.08 to 45 hectares (0.2 to 111 acres). On the Modoc Plateau, occupied pools known as of 1989 ranged in size from 2 to 40 hectares (5 to 100 acres) and were typically at least 30 centimeters (11.8 inches) deep; this species was restricted to the deepest areas of these pools (Corbin and Schoolcraft 1989). *Orcuttia tenuis* occurs through a wide range of elevations corresponding to its broad geographical range. The lowest reported elevation was 27 meters (90 feet) in Sacramento County (Stone *et al.* 1988) and the highest was 1,756 meters (5,761 feet) in Plumas County (B. Corbin *in litt.* 1999).

Soil types supporting *Orcuttia tenuis* are similarly diverse, ranging from slightly to strongly acidic (Stone *et al.* 1988) and from clay to sandy, silty, or cobbly loam (Corbin and Schoolcraft 1989, California Natural Diversity Data Base 2003 and unprocessed data). The soil series has not been reported for all *O. tenuis* sites, but includes at least the following, by region: In the Lake-Napa Vernal Pool Region, this species occurs on the Collayomi-Aiken-Whispering complex and the Konocti-Hambright complex; Modoc Plateau populations occur on the Gooval, Lasvar, Lasvar-Pitvar complex, and Nosoni soil series; and those in the Northeastern Sacramento Valley are on the Anita, Guenon, Inks, Inskip, Laniger, Moda, Redding, Toomes, and Tuscan soil series. The Redding soil series also supports *O. tenuis* in the Southeastern Sacramento Valley Vernal Pool Region (Stone *et al.* 1988, California Natural Diversity Data Base 2003).

Vegetation types in which the occupied pools occur are diverse, ranging from grassland and oak woodland to mixed conifer forest, *Artemisia cana* (silver

sagebrush) flats, and sedge meadows (Crampton 1959, California Natural Diversity Data Base 2003). Associated species vary throughout the range of *Orcuttia tenuis*. Among the most common associates in the Sacramento Valley are *Plagiobothrys stipitatus*, *Eleocharis macrostachya* (pale spikerush), *Eryngium* spp., *Navarretia leucocephala*, and *Marsilea vestita*. At other locations throughout northern California, *O. tenuis* occurs with a wide variety of plants, including various species of *Downingia*, *Eryngium*, and *Navarretia* (Stone *et al.* 1988, Corbin and Schoolcraft 1989, Alexander and Schlising 1997, California Natural Diversity Data Base 2003). *Orcuttia tenuis* also co-occurs with several of the other species addressed in this recovery plan, including *Navarretia leucocephala* ssp. *plieantha* and *Gratiola heterosepala* at Boggs Lake in Lake County (California Natural Diversity Data Base 2003), *G. heterosepala* and *Legenere limosa* at Dales Lake Ecological Reserve and Hog Lake in Tehama County (C. Witham *in litt.* 2000*a*), *Tuctoria greenei* at Laniger Lakes in Tehama County, and with *G. heterosepala* at nine other sites in Tehama County and four sites in Shasta County (Stone *et al.* 1988, B. Corbin *in litt.* 2000, California Natural Diversity Data Base 2003). Although *O. tenuis* grows in the same vernal pool complexes as *O. pilosa* in Tehama County (including the Vina Plains Preserve) and *O. viscida* in Sacramento County, it has not been found to share any pools with either of these two species (Stone *et al.* 1988, S. Cochrane *in litt.* 1995*a*, Alexander and Schlising 1997, California Natural Diversity Data Base 2003).

4. Reasons for Decline and Threats to Survival

Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to *Orcuttia tenuis* are described below.

A number of specific threats are also continuing. In particular, urbanization is a continuing threat to *Orcuttia tenuis* populations in the vicinity of Redding and Sacramento. Off-road vehicle use is a particular problem near Redding and in forested areas of the Modoc Plateau. And despite the comparatively wide range of *O. tenuis*, small population size is of concern in the Lake-Napa Vernal Pool Region and the Millville Plains-Stillwater Plains area of the Northeastern and Northwestern Sacramento Valley Vernal Pool Regions.

5. Conservation Efforts

Orcuttia tenuis was federally listed as threatened on March 26, 1997 (U.S. Fish and Wildlife Service 1997*a*) and has been State listed as endangered since 1979 (California Department of Fish and Game 1991). This species was recognized as rare and endangered by the California Native Plant Society as early as 1974 (Powell 1974) and is now included on List 1B and is considered to be "endangered throughout its range" (California Native Plant Society 2001). In 2003, critical habitat was designated for *O. tenuis* and several other vernal pool species in *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon* (U.S. Fish and Wildlife Service 2003).

Four natural occurrences of *Orcuttia tenuis* are in designated preserves. These include the Trust for Wildland Communities' Boggs Lake Preserve in Lake County, The Nature Conservancy's Vina Plains Preserve in Tehama County, and two occurrences on the California Department of Fish and Game's Dales Lake Ecological Reserve in Tehama County (Broyles 1987, Stone *et al.* 1988, California Natural Diversity Data Base 2003). All four populations are monitored annually (Baldwin and Baldwin 1989*a*, 1989*b*, 1991; D. Alexander pers. comm. 1997; California Natural Diversity Data Base 2003). Also, a conservation area containing a population of *O. tenuis* was recently established in Sacramento County to compensate for impacts to vernal pools (K. Fuller *in litt.* 2000). An unknown number of additional occurrences are protected from development by conservation easements; one is in Shasta County (California Natural Diversity Data Base 2003), and the others are in the Dales Lake area of Tehama County, where a private landowner put more than 16,188 hectares (40,000 acres) of ranch land into a conservation easement in cooperation with The Nature Conservancy (C. Witham *in litt.* 2000*a*).

Introductions of *Orcuttia tenuis* have been attempted at two privately-owned sites. In 1978, *O. tenuis* was seeded into two adjacent "ponds" in Chico, Butte County. Fewer than 100 plants grew in the two ponds that year or in 1979 (Griggs 1980), which was the last time the population size was reported. The other introduction was in 1982, when *O. tenuis* was seeded into an artificial pool in Shasta County. As of 1987, the population was thriving (California Natural Diversity Data Base 2003), but its current size is not known. An unintentional introduction may have taken place at the Dales Lake Ecological Reserve. In 1995, *O. tenuis* appeared in 11 of 21 artificially-created vernal pools there, possibly because its seeds were contained in plant litter from nearby natural pools that was spread on the surface of the created pool (C. Witham *in litt.* 2000*a*). The California Natural Diversity Data Base (2003) considers those 11 pools to

comprise three Element Occurrences, but the populations may not be viable; very few plants were found in 1995 and only one of the pools still supported *O. tenuis* in 1999 (C. Witham *in litt.* 2000*a*).

Twenty-seven of the 73 (37.0 percent) extant occurrences of *Orcuttia tenuis* are wholly or partially on Federal land. Seventeen of these are managed by the U.S. Forest Service, primarily the Lassen National Forest, although one is on the Shasta-Trinity National Forest. The other ten are on lands controlled by the U.S. Bureau of Land Management; nine of these are in the Redding Resource Area and the other is in the Alturas Resource Area. Two of the occurrences on the Lassen National Forest, Adobe North and South Vernal Pools, are within an area that has been proposed as a Research Natural Area (B. Corbin *in litt.* 2000). The Green Place Reservoir occurrence in Shasta County is within a Wilderness Study Area and has been jointly proposed by the U.S. Bureau of Land Management and the Lassen National Forest as a Research Natural Area (G. Schoolcraft *in litt.* 2000).

The Lassen National Forest and Susanville District of the U.S. Bureau of Land Management jointly prepared a management plan for *Orcuttia tenuis* sites under their administration (including those in the Shasta-Trinity National Forest) in order to ensure the long-term survival of the species (Corbin and Schoolcraft 1989). Actions identified in that plan included avoidance of known populations, maintenance of natural hydrology, monitoring selected populations, and surveys in suitable habitats. As a result of the plan, several areas have been fenced to exclude livestock and a considerable number of additional populations have been discovered (B. Corbin *in litt.* 1999, B. Corbin *in litt.* 2000, G. Schoolcraft *in litt.* 2000, California Natural Diversity Data Base 2003).

Substantial information on the demography, ecology, and genetics of *Orcuttia tenuis* was provided by Griggs (1980) through his doctoral research. Also, a status survey funded by us led to the discovery of 18 new *O. tenuis* occurrences (Stone *et al.* 1988). In addition, U.S. Forest Service personnel subsequently discovered 16 additional occurrences on public land (California Natural Diversity Data Base 2003). In 1995, the California Department of Fish and Game sponsored a workshop focusing on recovery strategies for *Orcuttia* species in Sacramento County (S. Cochrane *in litt.* 1995*a*, *in litt.* 1995*b*). A study of vernal pools on the Vina Plains preserve that was conducted in 1995 provided additional ecological information and management recommendations; we supported this research through section 6 funding (Alexander and Schlising 1997).

L. *ORCUTTIA VISCIDA* (SACRAMENTO ORCUTT GRASS)

1. Description and Taxonomy

Taxonomy.—Sacramento Orcutt grass is in the tribe Orcuttieae of the grass family (Reeder 1965). Hoover (1941) first published the scientific name *Orcuttia californica* var. *viscida* for Sacramento Orcutt grass. He had collected the type specimen from "7 miles south of Folsom" in Sacramento County (Hoover 1941). Although Hoover recognized that Sacramento Orcutt grass differed from California Orcutt grass in several respects, he did not consider the former to represent a distinct species. However, Reeder (1980) determined that the differences in morphology, seed size, and chromosome number were sufficient grounds to elevate Sacramento Orcutt grass to the species level as *Orcuttia viscida*. Reeder's taxonomy has been accepted since that time. Other common names for this species include Sacramento orcuttia (Smith *et al.* 1980) and sticky Orcutt grass (California Department of Fish and Game 1987*c*).

Description and Identification.—In basic form, *Orcuttia viscida* (**Figure II-20**) resembles other members of the tribe and genus. Although all members of the Orcuttieae produce exudate, *O. viscida* is particularly viscid even when young, hence the scientific name. The plants are densely tufted, bluish-green, and covered with hairs. The stems are erect or spreading, 3 to 10 centimeters (1.2 to 3.9 inches) long, and do not branch. Leaf width is 2 to 4 millimeters (0.08 to 0.16 inch). The inflorescence occupies the upper one-third to one-half of the stem and consists of between 5 and 15 spikelets. The spikelets are closely spaced, and although distichous, are oriented towards one side of the stem. Each spikelet contains 6 to 20 florets. The lemmas are 6 to 7 millimeters (0.24 to 0.28 inch) long and divided about halfway into teeth; the central tooth is longer than the others. The teeth are tipped with bristles 1 millimeter (0.04 inch) or more in length. The tips of the lemma teeth bend downward slightly, giving the inflorescence a bristly appearance. Seeds of *O. viscida* are about 2.5 millimeters (0.10 inch) long (Hoover 1941; Griggs 1977a; Reeder 1982, 1993; Stone *et al.* 1988) and weigh about 0.45 milligram (1.6×10^{-5} ounce) (Griggs 1980, Griggs and Jain 1983). The diploid chromosome number is 28 (Reeder 1980).

Orcuttia viscida has unequal lemma teeth, unlike *O. pilosa* and *O. tenuis*. Both *O. californica* and *O. inaequalis* have unequal lemma teeth but can be distinguished from *O. viscida* by the length of the lemma and its teeth and

Figure II-20. Illustration of *Orcuttia viscida* (Sacramento Orcutt grass). (Reprinted from the Jepson Manual, J. Hickman, Ed., 1993, with permission from the Jepson Herbarium. © Regents of the University of California)

bristles, the size and density of the inflorescence, and the size of the seeds. Moreover, the chromosome number of *O. viscida* differs from all other *Orcuttia* species (Reeder 1982).

2. Historical and Current Distribution

Historical Distribution.—*Orcuttia viscida* is endemic to the Southeastern Sacramento Valley Vernal Pool Region (Keeler-Wolf *et al.* 1998) and always has been restricted to Sacramento County (**Figure II-21**). The earliest collection was from 1936 near Phoenix Field. Three other occurrences documented in 1941 and 1958 extended the range north to Orangevale and south to near Sloughhouse. *Orcuttia viscida* was introduced to Phoenix Park, in Sacramento County, in 1978. Three additional natural occurrences were discovered in the late 1980's, including one in extreme southeastern Sacramento County near Route 104. Thus, by 1990, this species was known from a total of seven natural occurrences and one introduction (Stone *et al.* 1988, California Natural Diversity Data Base 2003).

Current Distribution.—Within the past decade, *Orcuttia viscida* has been discovered at one new site in Sacramento County, within the previously known range. However, one entire occurrence and a portion of another have been extirpated. Thus, eight of the nine occurrences are extant. Five occurrences, comprising more than 70 percent of the occupied habitat, are concentrated into a single area of about 6 square kilometers (2.3 square miles) in the Rancho Cordova area east of Mather Field. Two other occurrences are adjacent to each other: Phoenix Field Ecological Reserve and the introduced population at Phoenix Park. The eighth extant occurrence is near Rancho Seco Lake (Stone *et al.* 1988, S. Cochrane *in litt.*1995*a*, S. Morey *in litt.* 1996, California Natural Diversity Data Base 2003). All occurrences are in the Southeastern Sacramento Valley Vernal Pool Region (Keeler-Wolf *et al.* 1998).

3. Life History and Habitat

Basic life history and habitat requirements of this plant are likely similar to those described above in the species accounts for *Orcuttia inaequalis* and *Neostapfia colusana*.

Reproduction and Demography.—*Orcuttia viscida* flowers in May and June (Griggs 1977a, Skinner and Pavlik 1994, S. Cochrane *in litt.* 1995*a*) and sets seed in June and July (Holland 1987). The plants are adapted for wind pollination, but do provide a source of pollen for native bees (Griggs 1974 as

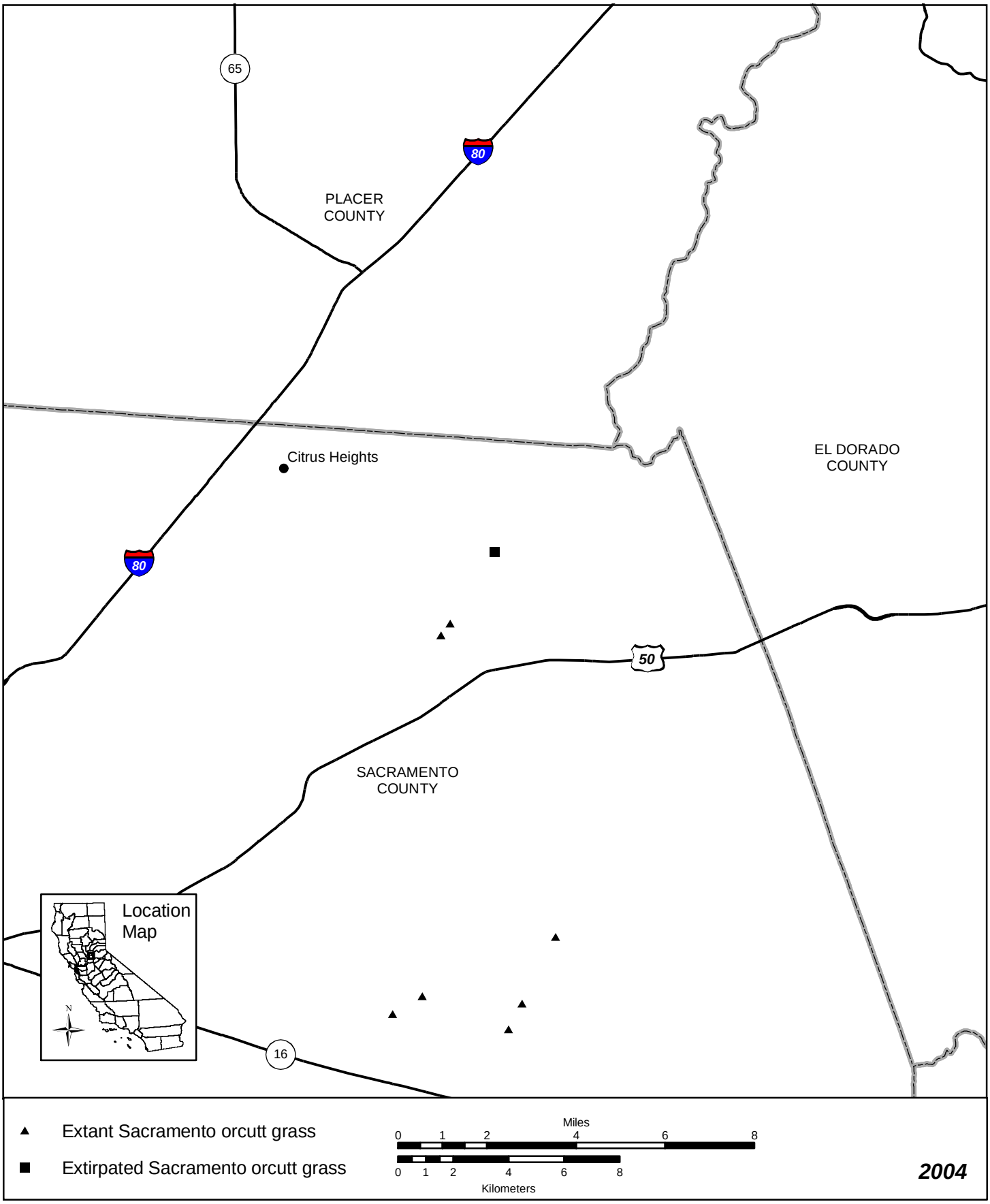

Figure II-21. Distribution of *Orcuttia viscida* (Sacramento Orcutt grass)

cited in Stone *et al.* 1988). Seeds likely do not disperse far under natural conditions. In a 6-year period, an experimental population spread at most 3 meters (10 feet) from the seed source, and 95 percent of plants were within 30 centimeters (11.8 inches) of the source (R. Holland *in litt.* 1986). A demographic study conducted from 1974 to 1978 (Griggs 1980, Griggs and Jain 1983) indicated that *O. viscida* produced an average of 500 seeds per plant. At one site in 1978, 88 percent of plants survived to maturity. The size of the seed bank stored in the soil was about 44 times as great as the population of growing plants (Griggs 1980, Griggs and Jain 1983). The number of plants varies with rainfall. Large numbers of plants grow only in years when seasonal rainfall exceeds 40 centimeters (15.7 inches), particularly when heavy rains begin in November and continue through the end of April (Holland 1987). This species is apparently less likely to germinate in years of below-normal precipitation than are other members of the tribe (Griggs 1980, Griggs and Jain 1983). In studies of enzyme systems, genetic diversity between populations of *O. viscida* was low. However, plants from the primary area of concentration had alleles that did not occur in other areas. The amount of genetic variation occurring among related individuals was about equal to that within populations (Griggs 1980, Griggs and Jain 1983).

Habitat and Community Associations.—*Orcuttia viscida* has been found in Northern Hardpan and Northern Volcanic Mudflow vernal pools (Sawyer and Keeler-Wolf 1995). It occurs on high-terrace sites (Stone *et al.* 1988) at elevations of 46 to 82 meters (150 to 270 feet) (California Natural Diversity Data Base 2003). Occupied pools occur in *Quercus douglasii* woodland and annual grassland (Crampton 1959, Griggs 1977a, California Natural Diversity Data Base 2003). Among occupied pools discovered prior to 1988, the median area was 0.28 hectare (0.69 acre) and ranged from 0.1 hectare (0.25 acre) to 0.82 hectare (2.03 acres). Soils underlying pools where *O. viscida* grows are acidic with an iron-silica hardpan (Stone *et al.* 1988), and the pools contain numerous cobbles (Crampton 1959, Stone *et al.* 1988). Four of the known occurrences are on soils in the Redding series, two are on Red Bluff-Redding complex soils, two are (or were) on Xerarents-urban land-San Joaquin complex, and one is on Corning complex soils. The most common associates of *Orcuttia viscida* are *Plagiobothrys stipitatus*, *Eryngium* spp., *Eleocharis macrostachya*, and *Psilocarphus brevissimus* (Stone *et al.* 1988). *Gratiola heterosepala* co-occurs with *O. viscida* in one pool (Stone *et al.* 1988, California Natural Diversity Data Base 2003). One population of *O. tenuis* grows in the same vicinity as *O. viscida*, but the two species have not been found together (Cochrane *in litt.* 1995*a*).

4. Reasons for Decline and Threats to Survival

Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to *Orcuttia viscida* are described below.

Urbanization is a continuing threat particularly in the Rancho Cordova area, and another occurrence in that area could be destroyed by expansion of the Sacramento County landfill (S. Cochrane *in litt.* 1995*a*). At present, trash from the landfill frequently blows into the pools (S. Cochrane *in litt.* 1995*b*). An industrial park and road widening are other urban-related factors that threaten *Orcuttia viscida* (Stone *et al.* 1988, S. Cochrane *in litt.* 1995*a*). The Phoenix Field Ecological Reserve and Phoenix Park occurrences are in an urban landscape. They are affected by excess runoff from lawns, ball fields, and roads; by herbicide and fertilizer applied in adjacent areas (Griggs and Jain 1983, R. Holland *in litt.* 1986, Stone *et al.* 1988, S. Cochrane *in litt.* 1995*a*, S. Morey *in litt.* 1996, Clark *et al.* 1998); and by dumping of landscape waste (Clark *et al.* 1998). Another threat at the Phoenix Field Ecological Reserve is invasion of garden plants (Clark *et al.* 1998, California Natural Diversity Data Base 2003). Recreational activities such as rollerblading (C. Witham *in litt.* 2000*a*), biking, and horseback riding (S. Cochrane *in litt.* 1995*a*, *in litt.* 1995*b*; Clark *et al.* 1998) also pose continuing threats of damage to the Phoenix Park occurrence of this plant. In addition, competition from other native plants, such as *Eleocharis macrostachya* and non-native plants such as *Glyceria* spp. (mannagrass) could displace *O. viscida* (Stone *et al.* 1988, S. Cochrane *in litt.* 1995*a*, S. Cochrane *in litt.* 1995*b*, Clark *et al.* 1998). Mining, off-road vehicle use, and vandalism also threaten one or more specific occurrences (U.S. Fish and Wildlife Service 1997*a*). Although the individual populations of *O. viscida* are sufficiently large that they are not subject to random fluctuations such as genetic drift, the very restricted range of the species as a whole puts it in continued danger of extinction from random, catastrophic events.

5. Conservation Efforts

Orcuttia viscida was federally listed as an endangered species on March 26, 1997 (U.S. Fish and Wildlife Service 1997*a*) and had been previously State-listed as endangered in 1979 (California Department of Fish and Game 1991). The California Native Plant Society has included it on lists of very rare and endangered plants for over 2 decades (Powell 1974); *O. viscida* is currently on List 1B, with the highest endangerment rating possible (California Native Plant

Society 2001). In 2003, critical habitat was designated for *O. viscida* and several other vernal pool species in *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon* (U.S. Fish and Wildlife Service 2003).

Two reserves have been set aside to protect *Orcuttia viscida*. The Phoenix Field Ecological Reserve encompasses 3.2 hectares (8 acres) and is managed by the California Department of Fish and Game. The site has been fenced, and only authorized persons have access. The California Department of Fish and Game plans to install a drain to prevent urban and landscape runoff from entering the pools. Volunteers and agency personnel monitor the *O. viscida* population periodically (S. Morey *in litt.* 1996, Clark *et al.* 1998). The nearby Phoenix Park Vernal Pool Preserve encompasses 5.7 hectares (14 acres) and is managed by the Fair Oaks Recreation and Park District. A low fence excludes motorized vehicles, but allows foot traffic. Interpretive signs and a footbridge also have been installed (Clark *et al.* 1998).

Griggs (1980) studied the ecology, demography, and genetics of several species in the Orcuttieae tribe, including *Orcuttia viscida*. In the course of his research, he introduced local seeds into an unoccupied, natural pool in Phoenix Park. The introduction apparently was successful because the population has persisted and remained stable since 1978 (S. Cochrane *in litt.* 1995*a*, California Natural Diversity Data Base 2003).

We funded a status survey for members of the Orcuttieae in the 1980's, which led to the discovery of several new populations (Stone *et al.* 1988). The California Department of Fish and Game sponsored a native plant recovery workshop in 1995 to develop recovery strategies for *Orcuttia viscida* (S. Cochrane *in litt.* 1995*a*). Workshop participants have since conducted several tasks contributing to the species' recovery, including monitoring populations, assessing threats, and providing public education (S. Cochrane *in litt.* 1995*b*, S. Morey *in litt.* 1996).

M. *PARVISEDUM LEIOCARPUM* (LAKE COUNTY STONECROP)

1. Description and Taxonomy

Taxonomy.—Lake County stonecrop is in the stonecrop family (Crassulaceae) and is one of only three (Moran 1997) or four (Clausen 1946, Denton 1993) species in the genus *Parvisedum*, depending on individual interpretations by taxonomists. The original scientific name for Lake County stonecrop was *Sedella leiocarpa* (Sharsmith 1940). The type locality was cited as "6.5 miles north of Lower Lake, Lake County, California" (Sharsmith 1940, p.

193). Clausen (1946) changed the name of this species to *Parvisedum leiocarpum* because the genus name *Sedella* already had been applied to another group of plants. However, Moran (1997) returned to using the name *Sedella leiocarpa* for Lake County stonecrop, after another taxonomist determined that the genus name *Sedella* had been used improperly for the other group of plants. We originally listed the species as endangered under the name *Parvisedum leiocarpum* (U.S. Fish and Wildlife Service 1997b) and we have not yet formally changed our nomenclature for the species, so in this recovery plan we continue to refer to it by the scientific name *Parvisedum leiocarpum*.

Description and Identification.—*Parvisedum leiocarpum* (**Figure II-22**) is a tiny, fleshy, annual herb. The reddish, hairless stems are at most 5 centimeters (2.0 inches) tall and may or may not be branched. Leaf arrangement is opposite at the base of the plant and alternate on the upper stem. The 2 to 5 millimeter-long (0.08 to 0.20 inch-long) leaves are entire, fleshy, and green with red streaks; the bracts are similar but smaller. The leaves fall off the stem before the flowers open, but the bracts persist. On each branch of the inflorescence, the flowers are crowded together in two rows, which are both on the same side of the branch. The individual flowers are 3 to 4 millimeters (0.12 to 0.16 inch) wide and about the same length. Flowers typically have five petals and other parts (sepals, pistils, and stamens), but occasionally have four of each flower part. The petals range in color from pale yellow to chartreuse, have reddish streaks on the back, and are about 2.6 to 3.8 millimeters (0.10 to 0.15 inch) long with light fusing at the base. Each petal has a flattened, reddish nectar-producing gland at its base; the glands are 0.5 to 0.8 millimeter (0.02 to 0.03 inch) in length. Each pistil develops into a dry, hairless fruit 1.5 to 2.5 millimeters (0.06 to 0.10 inch) long, which contains a single seed. The narrow seeds are light brown and 1 to 1.5 millimeters (0.04 to 0.06 inch) long (Sharsmith 1940, Clausen 1975, Denton 1993, Moran 1997). *Parvisedum leiocarpum* has a diploid chromosome number of 18 (Moran 1997), as do all other species in the genus (Clausen 1975, Denton 1993). The species most likely to be confused with *P. leiocarpum* is *P. pentandrum* (Mt. Hamilton stonecrop), which overlaps in range. However, the latter is a taller plant with smaller flowers, nectaries, fruits, and seeds; the petals do not have red streaks on the back; and the fruits are glandular-hairy.

Other species of *Parvisedum* have 10 stamens. *Crassula connata* (pygmy stonecrop), another inconspicuous annual species in the same family, has strictly opposite leaves that are fused at the base and very tiny flowers in the leaf axils. Other genera in the family are perennial or have more seeds per pistil (Sharsmith 1940, Clausen 1975, Denton 1993).

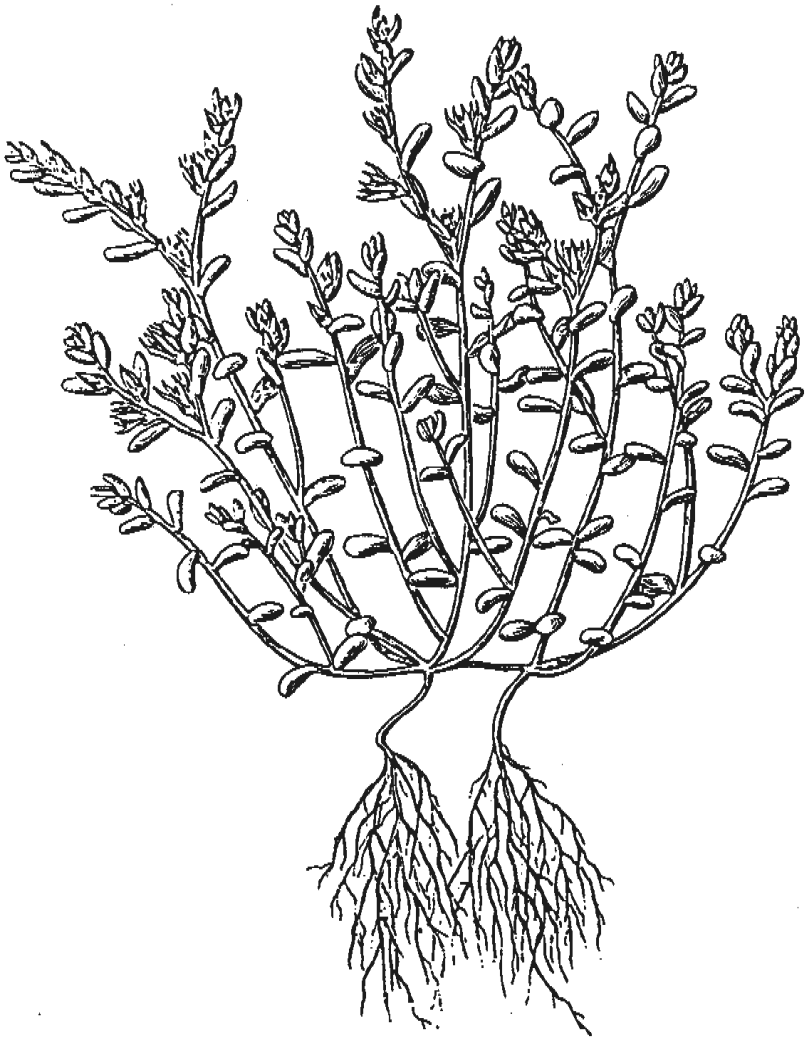

Figure II-22. Illustration of *Parvisedum leiocarpum* (Lake County stonecrop) (Drawing by Elfriede Abbe, reprinted from R.T. Clausen, *Sedum of North America North of the Mexican Plateau.* Copyright © 1975 by Cornell University. Used by permission of the publisher, Cornell University Press)

2. Historical and Current Distribution

Historical Distribution.—Current evidence indicates that this species always has been restricted to southeastern Lake County, and to the Lake-Napa Vernal Pool Region (Keeler-Wolf *et al.* 1998) (**Figure II-6**). *Parvisedum leiocarpum* was known historically from six to eight occurrences west and south of Clear Lake, where it was collected repeatedly between 1936 and 1961. The exact number of sites is uncertain because several vague location descriptions may or may not refer to the same site. All collections were from the area roughly bounded by Kelseyville, Lower Lake, and Middletown (Patterson 1986). Manning Flat, which is along Highway 29 west of Lower Lake, apparently represents the type locality (Moran 1997). Although it is west rather than north of Lower Lake, Clausen (1975) noted that the type specimen was collected "on Kelseyville Highway", which apparently refers to Highway 29. *Parvisedum leiocarpum* was not observed between 1963 (Clausen 1975) and the late 1980's, when it was rediscovered at three of the historical localities (Patterson 1986, 1988; California Natural Diversity Data Base 2003). A sixth population was discovered in 1995 near Snows Lake in Lake County (Moran 1997), but is not catalogued by the California Natural Diversity Data Base (2003).

Current Distribution.—The four occurrences of *Parvisedum leiocarpum* seen in the 1980's and 1990's are assumed to be extant, although they have not been revisited. Two others not seen since the 1940's also are assumed to remain extant because suitable habitat remained in the vicinity of those collections as of 1986. Three of those six occurrences, including Manning Flat, are along Highway 29. The other three occurrences include one farther south near Whispering Pines, one southeast of Lower Lake in Little High Valley (Patterson 1986, Patterson 1988, California Natural Diversity Data Base 2003), and one at Snows Lake (Moran 1997). All known occurrences are in the Boggs Lake-Clear Lake Core Area in the Lake-Napa Vernal Pool Region.

3. Life History and Habitat

Reproduction and Demography.—Relatively little is known about the life history and demography of *Parvisedum leiocarpum*. It is an annual that flowers in April and May (Clausen 1975, California Department of Fish and Game 1990*b*, Skinner and Pavlik 1994, Moran 1997). The presence of conspicuous nectaries suggests that the flowers are insect-pollinated. Seed dispersal is likely very limited in extent. The seeds normally remain inside the fruits and the fruits remain on the plants even after the growing season (Moran 1997). Water is one possible dispersal mechanism because the fruits can float if detached (Moran 1997). *Parvisedum leiocarpum* typically occurs in dense patches with few other

plants (Clausen 1975), although Patterson (1988) found one colony that was very sparse. The number of individual plants in a population can be high, even when it occupies a very small area due to the high density and the small size of each plant.

Habitat and Community Associations.—*Parvisedum leiocarpum* occurs on more or less level sites in shallow depressions that retain water seasonally. Known microhabitats include Northern Basalt Flow and Northern Volcanic Ashflow vernal pools (Sawyer and Keeler-Wolf 1995), low areas in meadows and gravelly flats, and hollows in exposed rocks. A few plants were found on a man-made berm within a flat that supported a large population. The occupied habitats occur adjacent to oak woodland, chaparral, or grassland. Substrates on which *P. leiocarpum* occur frequently are of volcanic origin and often are gravelly (Patterson 1986). Soil pH at one site ranged from 6.2 to 6.4 (Clausen 1975). Soil types are not known for all historical sites, but this species grows on at least the Glenview-Bottlerock complex, the Konocti-Benridge complex, the Konocti Variant-Konocti- Hambright complex and the Speaker-Sanhedrin-Maymen association.

Extant and historical localities ranged in elevation from 518 to 792 meters (1,700 to 2,600 feet) (Moran 1997, California Natural Diversity Data Base 2003). Plants that frequently grow in the same vernal pools and meadows with *Parvisedum leiocarpum* include *Mimulus tricolor*, *Lasthenia fremontii*, and *Plagiobothrys stipitatus*. The only immediate associate in the rock pools at the Little High Valley site is an unidentified moss (class Musci). Two other plants featured in this recovery plan co-occur with *Parvisedum leiocarpum*: *Navarretia leucocephala* ssp. *pauciflora* co-occurs at three sites; and *Gratiola heterosepala* is present at one of the three. *Lasthenia burkei*, an endangered plant that is not addressed in this recovery plan, occurs at Manning Flat, but is found across the road from the *Parvisedum leiocarpum* population (Patterson 1986, California Natural Diversity Data Base 2003).

4. Reasons for Decline and Threats to Survival

Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to *Parvisedum leiocarpum* are described below.

Land conversion for housing and agriculture, highway widening, and road maintenance continue as specific threats to *Parvisedum leiocarpum* habitat at five

of the historical localities (Patterson 1986, California Department of Fish and Game 1990*b*). At each of the extant occurrences, *P. leiocarpum* occupies no more than 0.04 hectare (0.1 acre), so even small habitat losses to any of these factors could easily extirpate an entire population (Patterson 1986). Also, the extremely small populations are likely highly vulnerable to elimination from random fluctuations in environmental conditions, natural catastrophes, and genetic bottlenecks (Menges 1991); the restricted range of the species means that a regional catastrophe could drive the entire species to extinction.

5. Conservation Efforts

Parvisedum leiocarpum was federally listed as an endangered species on June 18, 1997 (U.S. Fish and Wildlife Service 1997*b*). *Parvisedum leiocarpum* was previously State listed as endangered in 1990 (California Department of Fish and Game 1991). The California Native Plant Society has recognized this species as rare and endangered since its first list was published (Powell 1974); it is still on the California Native Plant Society List 1B, assigned the highest endangerment rating possible (California Native Plant Society 2001).

The California Department of Fish and Game funded a status survey of *Parvisedum leiocarpum* in 1986 (Patterson 1986). Patterson conducted additional surveys in 1987, then petitioned the California Fish and Game Commission to list *P. leiocarpum* as an endangered species (Patterson 1988). None of the localities for this species are in public ownership, and no conservation measures have been implemented by any of the landowners.

N. *TUCTORIA GREENEI* (GREENE'S TUCTORIA)

1. Description and Taxonomy

Taxonomy.—The genus *Tuctoria* is in the grass family, subfamily Chloridoideae, and is a member of the Orcuttieae tribe, which also includes *Neostapfia* and *Orcuttia* (Reeder 1965, Keeley 1998). Vasey (1891) originally assigned the name *Orcuttia greenei* to this species, from a type specimen collected in 1890 "on moist plains of the upper Sacramento, near Chico, California", presumably in Butte County (Hoover 1941, Crampton 1958). Citing differences in lemma morphology, arrangement of the spikelets, and other differences (see "Description" below), Reeder (1982) segregated the genus *Tuctoria* from *Orcuttia* and created the new scientific name *Tuctoria greenei* for this species. Subsequent research suggests that *Tuctoria* is intermediate in evolutionary position between the primitive genus *Neostapfia* and the advanced

genus *Orcuttia* (Keeley 1998, L. Boykin *in litt.* 2000). Several other common names have been used for this species, including Chico grass (Scribner 1899), awnless Orcutt grass (Abrams 1940), Greene's orcuttia (Smith *et al.* 1980), and Greene's Orcutt grass (California Department of Fish and Game 1991, U.S. Fish and Wildlife Service 1985*c).*

Description and Identification.—The basic characteristics pertaining to all members of the Orcuttieae were described above in the *Neostapfia colusana* account. The genus *Tuctoria* is characterized by flattened spikelets similar to those of *Orcuttia* species, except that the spikelets of *Tuctoria* grow in a spiral, as opposed to a distichous, arrangement. *Tuctoria* species have short-toothed, narrow lemmas. The juvenile and terrestrial leaves of *Tuctoria* are similar to those of *Orcuttia*, but *Tuctoria* does not produce the floating type of intermediate leaves (Reeder 1982, Keeley 1998). *Tuctoria* appears to be intermediate between *Neostapfia* and *Orcuttia* in its degree of aquatic specialization (Keeley 1998).

Tuctoria greenei (**Figure II-23**) grows in tufts of several stems, which are erect or decumbent and break easily at the base. The entire plant tends to be pilose, but is only slightly viscid. The stems are usually 5 to 15 centimeters (2.0 to 5.9 inches) tall and are not branched. *Tuctoria greenei* has purplish nodes and leaves no wider than 5 millimeters (0.20 inch). The inflorescence can be as much as 8 centimeters (3.1 inches) long; it may be partly hidden by the leaves when young, but is held above the leaves at maturity. The inflorescence usually consists of 7 to 15 spikelets, but may contain as many as 40. The spikelets are arranged in a spiral, with those in the upper half crowded together and those near the base more widely separated. Each spikelet consists of 5 to 15 florets and two glumes. The lemmas are 4 to 5 millimeters (0.16 to 0.20 inch) long and have squarish tips with 5 to 9 very short teeth; the central tooth is tipped by a very small spine. The roughened seeds are about 2 millimeters (0.08 inch) long (Vasey 1891, Hoover 1941, Griggs 1977*b*, Stone *et al.* 1988, Reeder 1982) and weigh about 0.5 milligram (1.8×10^{-5} ounce) (Griggs 1980). *Tuctoria greenei* has a diploid chromosome number of 24 (Reeder 1982).

Tuctoria greenei is differentiated from Orcutt grasses by the spiral arrangement of spikelets and lack of floating juvenile leaves, from *Neostapfia colusana* by the shape of the spikelets and the inflorescence, and from both by the shape of the lemmas. *Tuctoria greenei* can be distinguished from *T. mucronata* by the squarish lemma tip; smaller, roughened seeds; and inflorescence held above the leaves in the former. Both can be told from the remaining *Tuctoria* species by stem length, seed shape, and range. The chromosome number of *T. greenei* also differs from the other two species in the genus (Reeder 1982).

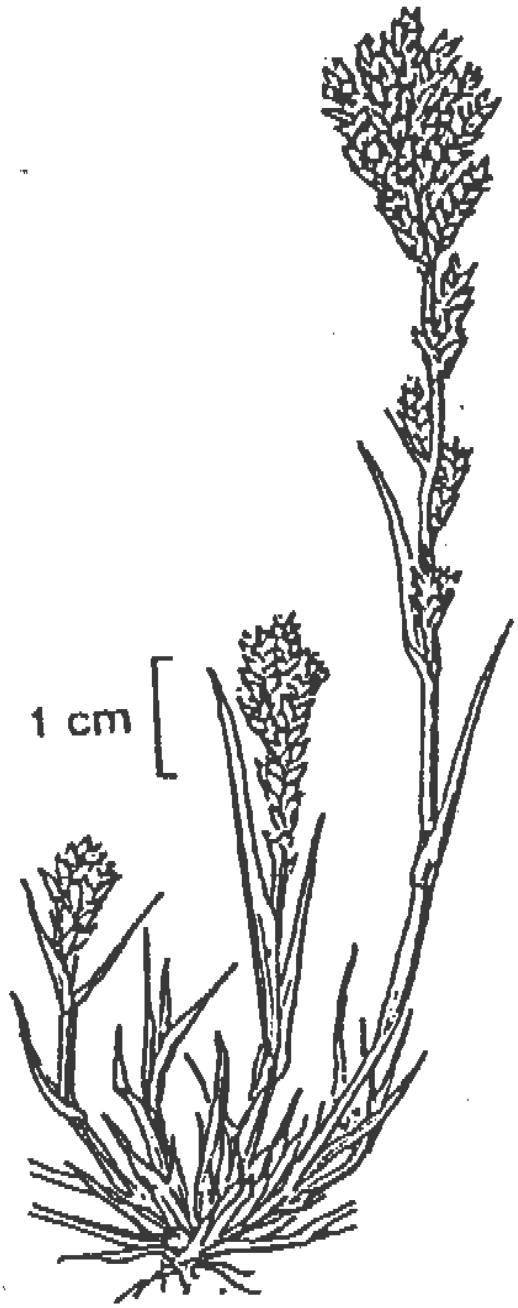

Figure II-23. Illustration of *Tuctoria greenei* (Greene's tuctoria). (Reprinted from the Jepson Manual, J. Hickman, Ed., 1993, with permission from the Jepson Herbarium. © Regents of the University of California)

2. Historical and Current Distribution

Historical Distribution.—After its discovery in Butte County in 1890, *Tuctoria greenei* was not reported again for over 40 years (**Figure II-24**). However, during extensive surveys in the late 1930's, Hoover (1937, 1941) found the species at 12 sites in Fresno, Madera, Merced, San Joaquin, Stanislaus, Tehama, and Tulare Counties. In fact, he described it as the most common of all *Orcuttia* species, with which it was classified at the time. By 2003, *T. greenei* had been reported from a total of 44 occurrences in those eight counties, plus Shasta County (Stone *et al.* 1988, Oswald and Silveira 1995, California Natural Diversity Data Base 2001). The majority of these were in the Southern Sierra Foothills and Northeastern Sacramento Valley Vernal Pool Regions, with one each in the Modoc Plateau and Solano-Colusa Vernal Pool Regions.

Current Distribution.—About half of the historical occurrences of *Tuctoria greenei* are presumed to be extant; 11 are certainly extirpated, and 10 others are possibly extirpated (Alexander and Schlising 1997, California Natural Diversity Data Base 2003). The majority of the extant occurrences are in the Northeastern Sacramento Valley Vernal Pool Region, particularly in the Vina Plains. The next largest concentration is in the Southern Sierra Foothills Vernal Pool Region, where the only remaining occurrences are in eastern Merced County. The other two extant occurrences are in Glenn (Oswald and Silveira 1995, J. Silveira *in litt.* 2000) and Shasta Counties (California Natural Diversity Data Base 2003); the former is in the Solano-Colusa Vernal Pool Region, and the latter is in the Modoc Plateau Vernal Pool Region (Keeler-Wolf *et al.* 1998). *Tuctoria greenei* is believed extirpated from Fresno, Madera, San Joaquin, Stanislaus, and Tulare Counties (Stone *et al.* 1988, Skinner and Pavlik 1994, California Natural Diversity Data Base 2003).

3. Life History and Habitat

The basic life history strategy and habitat requirements of *Tuctoria* species were described earlier in this document, under discussions for *Neostapfia colusana* and *Orcuttia inaequalis*.

Reproduction and Demography.—Optimum germination of *Tuctoria greenei* seed occurs when the seed is exposed to light and anaerobic conditions after stratification (Keeley 1988). Germination occurs about 2 months following inundation (Keeley 1998). *Tuctoria* seedlings do not develop floating juvenile leaves, as does *Orcuttia* (Griggs 1980, Keeley 1998). The plants apparently do not tolerate inundation; all five *T. greenei* plants in a Glenn County pool died

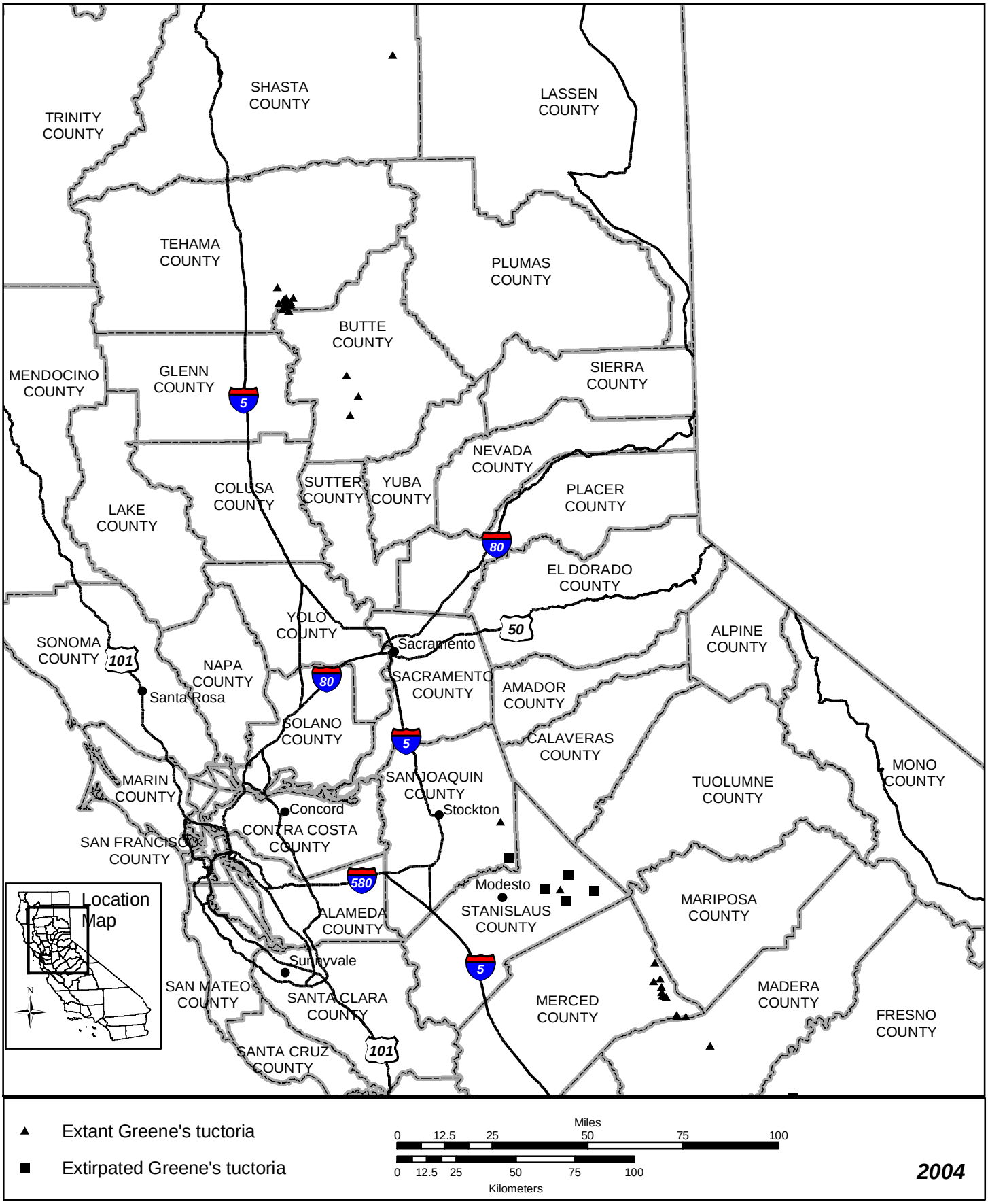

Figure II-24. Distribution of *Tuctoria greenei* (Greene's tuctoria)

when the pool refilled during late spring rains in 1996 (J. Silveira *in litt.* 1997). *Tuctoria greenei* flowers from May to July (Skinner and Pavlik 1994), with peak flowering in June and July (Griggs 1981, Broyles 1987).

As with other vernal pool annuals, population size in *Tuctoria greenei* varies widely from year-to-year, and populations that have no visible plants one year can reappear in large numbers in later years. Population fluctuations may be due to annual variations in weather, particularly rainfall, to changes in management, or combinations of the two. Such fluctuations were observed at scattered sites in Butte and Tehama Counties during the 1970's (Griggs 1980, Griggs and Jain 1983) and at Sacramento National Wildlife Refuge, where the population in the single occupied pool ranged from zero to 60 plants between 1994 and 1999 (J. Silveira *in litt.* 2000). Fluctuations of as much as three orders of magnitude were documented on the Vina Plains Preserve during the 1980's and 1990's; the high 1995 population estimates followed a winter of favorable rainfall (Alexander and Schlising 1997) and long period without livestock grazing; cattle grazing on the Vina Plains Preserve was discontinued in the growing season of 1987-1988 and did not resume until the growing season of 1995-1996 (D. Alexander *in litt.* 1998).

However, populations that decline to zero and then do not reappear under favorable conditions may in fact be extirpated. A Stanislaus County population (Element Occurrence 39) numbered fewer than 100 plants in 1973, dropped to 2 the following year, and remained at zero for the next 3 years (Griggs 1980, Griggs and Jain 1983). The population was not monitored for the following decade. Although the vernal pool was still intact as of 1986, *Tuctoria greenei* was not observed during surveys that year; however, the winter had been drier than average. In 1987, following a winter of favorable rainfall, *T. greenei* still was not present, even though *Neostapfia colusana* was found in large numbers (Stone *et al.* 1988). The area had been “rather heavily grazed” in 1987 (Stone *et al.* 1988), but livestock grazing intensity during the 1970's is not known.

In a demographic study conducted during 1977-1978 on two populations from Butte and Tehama Counties, 0 to 54 percent of seedlings survived to maturity. Plants that reached flowering stage achieved a density of 82 to 133 per square meter (7.6 to 12.4 per square foot) and averaged 111 seeds per plant (Griggs 1980, Griggs and Jain 1983). In 1995, density of *Tuctoria greenei* on the Vina Plains Preserve ranged from 7 to 133 plants per square meter (0.7 to 12.4 per square foot) (Alexander and Schlising 1997).

A study of genetic partitioning in five species of *Orcuttia* and *Tuctoria* (Griggs 1980, Griggs and Jain 1983) revealed that *T. greenei* had the lowest genetic

diversity (50 percent) of the species studied. As with the other species, plants originating from the same seed parent accounted for about the same degree of genetic diversity (44 percent) as others within the same population (46 percent). Only 10 percent of the total genetic variability observed in the species was due to between-population differences, indicating that just a few of the same alleles dominated in the populations studied. However, Griggs' genetic study included only two populations from adjacent counties (Butte and Tehama) and did not consider geographically distant occurrences.

Habitat and Community Associations.—*Tuctoria greenei* has been found in three types of vernal pools: Northern Basalt Flow, Northern Claypan, and Northern Hardpan (Sawyer and Keeler-Wolf 1995) on both low and high terraces (Stone *et al.* 1988). Occupied pools are or were underlain by iron-silica cemented hardpan, tuffaceous alluvium, or claypan (Stone *et al.* 1988). Of pools where the species was known to be extant in 1987, the median size was 0.6 hectare (1.5 acres), with a range of 50 square meters (0.01 acre) to 3.4 hectares (8.4 acres) (Stone *et al.* 1988). Stone *et al.* (1988) noted that *T. greenei* grew in shallower pools than other members of the tribe or on the shallow margins of deeper pools, but they did not quantify pool depth. At the Vina Plains, *T. greenei* grew in pools of "intermediate" size, which dried in April or early May of 1995 (Alexander and Schlising 1997). The Central Valley pools containing *T. greenei* are (or were) in grasslands; the Shasta County occurrence is surrounded by pine forest (California Natural Diversity Data Base 2003). Occupied pools in the Central Valley are (or were) at elevations of 33.5 to 134 meters (110 to 440 feet) (Stone *et al.* 1988), whereas the Shasta County occurrence is at 1,067 meters (3,500 feet) (California Natural Diversity Data Base 2003).

In the Northeastern Sacramento Valley Vernal Pool Region, *Tuctoria greenei* grows mostly on Anita clay and Tuscan loam soils, with one occurrence on Tuscan stony clay loam. Soil types are not certain for several other occurrences in this region; one is on either the Rocklin or the San Joaquin series, and the others are unknown. The single occurrence in the Solano-Colusa Vernal Pool Region is on strongly saline-alkaline Willows clay (J. Silveira *in litt.* 2000). In the Southern Sierra Foothills Vernal Pool Region, *T. greenei* is known to grow on a number of different soil series including Archerdale, Bear Creek, Exeter, Meikle, Ramona, Raynor, Redding, and San Joaquin. Soil types have not been determined for occurrences in the other regions.

At the Vina Plains Preserve, frequent associates of *Tuctoria greenei* are *Eryngium castrense* and *Marsilea vestita* (Alexander and Schlising 1997). Elsewhere in the Sacramento Valley and in the San Joaquin Valley, *T. greenei* often grows in association with *E. vaseyi*, *Plagiobothrys stipitatus*, and *Alopecurus saccatus*

(foxtail). The rare *Chamaesyce hooveri* co-occurs with *T. greenei* at six sites in the Sacramento Valley. Other rare plants that grow in the same vernal pools with *T. greenei* at one or two occurrences are: *Orcuttia pilosa*, *O. tenuis*, and *Gratiola heterosepala* (Broyles 1987, Stone *et al.* 1988, California Natural Diversity Data Base 2003).

4. Reasons for Decline and Threats to Survival

Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to *Tuctoria greenei* are described below.

One potential additional factor unique to this and some other vernal pool plant species may be decimation by grasshopper outbreaks. Grasshoppers have been noted consuming entire populations of *Tuctoria greenei* before they set seed (Griggs 1980, Griggs and Jain 1983, Stone *et al.* 1988). However, the actual effect of such predation on subsequent plant population size has not been assessed.

Primary threats to this species are also continuing. Agricultural conversion and inappropriate livestock grazing practices pose threats to virtually all of the occurrences remaining in the San Joaquin Valley, although one small population is on a site that has been proposed for protection as a mitigation bank (California Natural Diversity Data Base 2003). Fifteen populations of *Tuctoria greenei* throughout its range are subject to adverse effects related to cattle grazing (Stone *et al.* 1988, B. Corbin *in litt.* 2000, California Natural Diversity Data Base 2003). Small population size poses a continuing threat to seven occurrences in Butte, Glenn, and Merced Counties. Each of these populations numbered 110 or fewer *T. greenei* plants at its peak (Stone *et al.* 1988, California Natural Diversity Data Base 2003). The Shasta County population also may have declined to the point where it could be extirpated by random causes; although it consisted of 2,500 plants in 1993 and 1994, the population declined to 120 in 1996 and 35 in 1998, despite favorable hydrological conditions (B. Corbin *in litt.* 2000).

Urbanization, including construction of a landfill, is a potential threat to the species. The occurrence in Merced County that grows in the bed of a flood-control reservoir is threatened by inundation during wet years (California Natural Diversity Data Base 2003).

5. Conservation Efforts

Tuctoria greenei was listed as federally endangered on March 26, 1997 (U.S. Fish and Wildlife Service 1997*a*). The State of California listed *T. greenei* as rare in 1979 (California Department of Fish and Game 1991), and the California Native Plant Society had recognized it as rare and endangered even earlier (Powell 1974). Currently, the California Native Plant Society (2001) includes *T. greenei* on List 1B, ranking it as "endangered throughout its range". In 2003, critical habitat was designated for *T. greenei* and several other vernal pool species in *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon* (U.S. Fish and Wildlife Service 2003).

Surveys by Hoover (1937, 1941) documented the historic range of *Tuctoria greenei*. Later surveys by Crampton (1959) and Medeiros (1976) revealed the destruction of various occurrences. The most recent, comprehensive survey (Stone *et al.* 1988) was funded by us to determine the status of *T. greenei* and related species. During the course of their surveys and related projects, Stone and others (1988) discovered four populations that were previously unknown. Research conducted by Griggs (1980) provided insights into the demography, ecology, and genetics of *T. greenei*, among other species. As part of his research, Griggs attempted to introduce *T. greenei* to two pools in Butte County, but the species never became established. Keeley (1988) conducted research on the conditions necessary for germination. We and the California Department of Fish and Game supported an ecological study of *T. greenei* and other rare species on the Vina Plains Preserve in 1995 (Alexander and Schlising 1997).

Six occurrences of *Tuctoria greenei* are on The Nature Conservancy's Vina Plains Preserve. This species has grown in as many as seven pools on the preserve in certain years (Stroud 1990, Alexander and Schlising 1997), including one pool on the Wurlitzer Unit (California Natural Diversity Data Base 2003). The Glenn County population, on the Sacramento National Wildlife Refuge, is the only occurrence known from public land.

O. *TUCTORIA MUCRONATA* (SOLANO GRASS)

1. Description and Taxonomy

Taxonomy.—Solano grass is in the Orcuttieae tribe of the grass family (Reeder 1965). Solano grass was originally described under the name *Orcuttia mucronata*, based on specimens collected "12 miles due south of Dixon, Solano County" (Crampton 1959). Reeder (1982) transferred this species to a new genus,

Tuctoria, resulting in the currently accepted name *Tuctoria mucronata*. Other common names are Crampton's Orcutt grass (Griggs 1977*b*), mucronate orcuttia (Smith *et al.* 1980), and Crampton's tuctoria (Skinner and Pavlik 1994).

Description and Identification.—Characteristics of the Orcuttieae were described earlier in this document under the *Neostapfia colusana* account and those common to the genus *Tuctoria* were presented in the *T. greenei* account. *Tuctoria mucronata* (**Figure II-25**) is grayish-green, pilose, and viscid. The tufted stems are decumbent, 12 centimeters (4.7 inches) or less long, and do not branch. The leaves are 1 to 4 centimeters (0.4 to 1.6 inches) long, are rolled inward, and have pointed tips. The inflorescence is 1.5 to 6 centimeters (0.6 to 2.4 inches) long, and its base is partially hidden by the uppermost leaves. As for this genus, the spikelets are arranged in a spiral; the 7 to 19 spikelets in the inflorescence of *T. mucronata* are crowded together. Spikelets range from 7 to 13 millimeters (0.28 to 0.51 inch) in length and consist of 5 to 10 florets, plus two glumes. The lemmas are 5 to 7 millimeters (0.20 to 0.28 inch) long and taper towards the tip, which is curved outward. The lemma teeth are not obvious except for the central one, which has a sharply pointed tip up to 1 millimeter (0.04 inch) long. *Tuctoria mucronata* has smooth seeds about 3 millimeters (0.12 inch) long and a diploid chromosome number of 40 (Crampton 1959, Reeder 1982, Reeder 1993).

Unlike *Tuctoria greenei*, the inflorescence of *T. mucronata* remains partly hidden by the leaves, even at maturity. In addition, *T. mucronata* stems are shorter than those of *T. greenei*, and the former has tapered lemmas and larger, smoother seeds. The spiral arrangement of the spikelets and single obvious tooth per lemma distinguish *T. mucronata* from the Orcutt grasses. Finally, the tapered lemmas of *T. mucronata* differ from the fan-shaped lemmas of *Neostapfia colusana* (Reeder 1982).

2. Historical and Current Distribution

Historical Distribution.—Prior to 1985, *Tuctoria mucronata* was known only from Olcott Lake in Solano County, which is believed to be the type locality (Crampton 1959, California Natural Diversity Data Base 2003) (**Figure II-26**). Another occurrence was discovered in 1985 about 4 kilometers (2.5 miles) southwest of Olcott Lake (California Natural Diversity Data Base 2003). A third occurrence, comprising the largest population now known, was discovered in 1993 on a Department of Defense communications facility in Yolo County (California Natural Diversity Data Base 2003). All three sites are in the Solano-Colusa Vernal Pool Region (Keeler-Wolf *et al.* 1998).

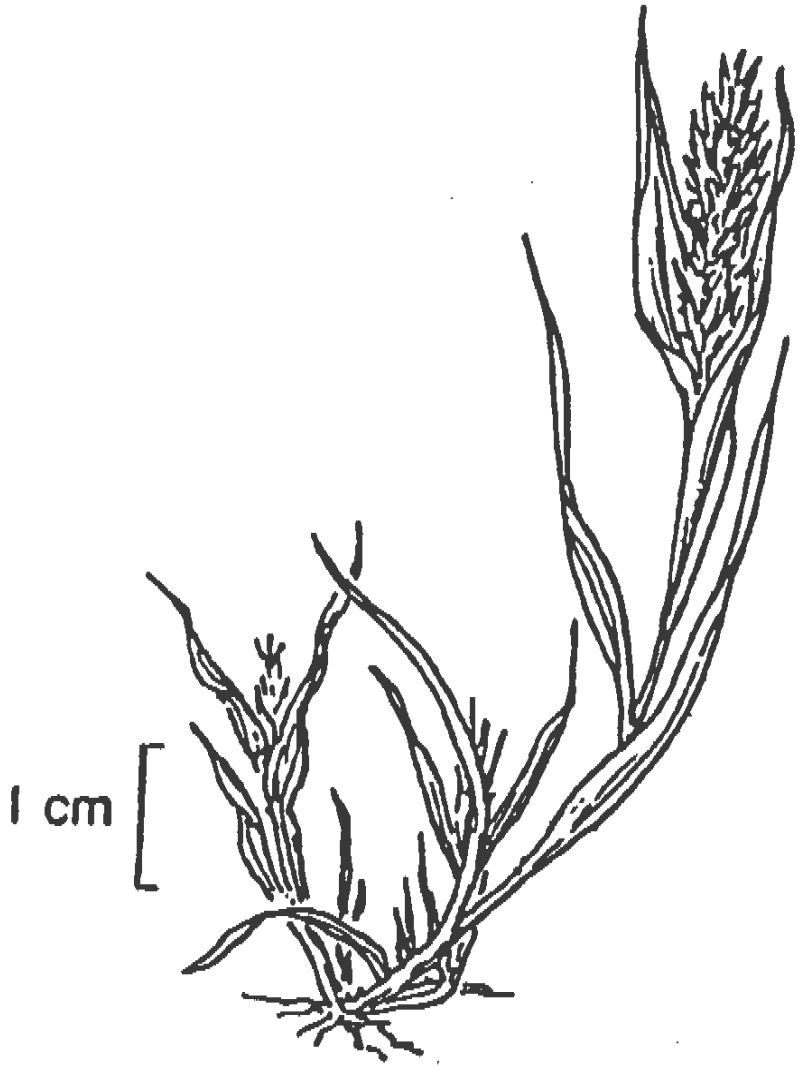

Figure II-25 Illustration of *Tuctoria mucronata* (Solano grass). (Reprinted from the Jepson Manual, J. Hickman, Ed., 1993, with permission from the Jepson Herbarium. © Regents of the University of California)

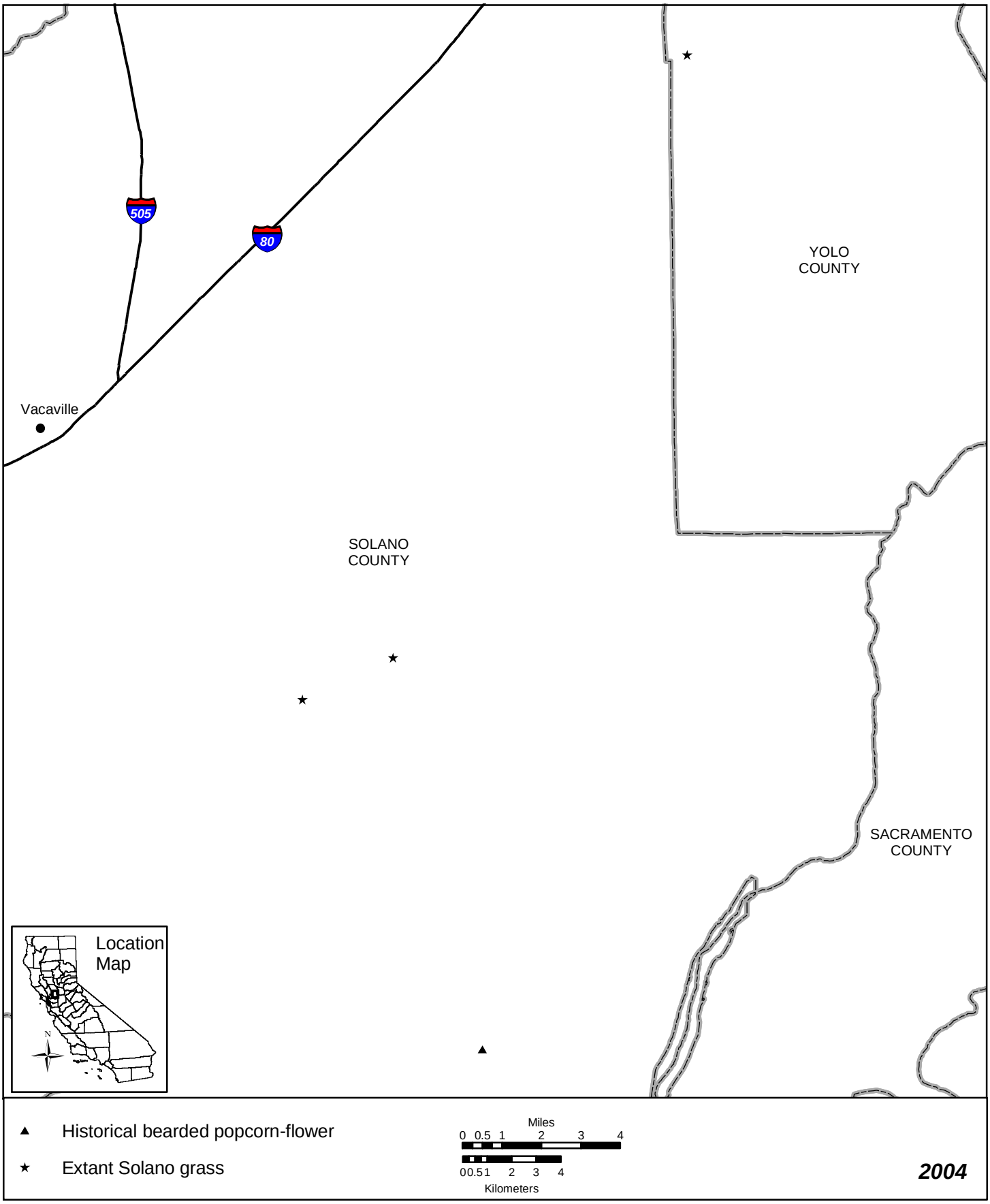

Figure II-26. Distribution of *Tuctoria mucronata* (Solano grass) and historical distribution of *Plagiobothrys hystriculus* (bearded popcorn flower).

Current Distribution.— *Tuctoria mucronata* may have been extirpated from Olcott Lake; the species has not been found there since 1993, when only four individual plants were observed (California Natural Diversity Data Base 2003). The other Solano County site is extant, as is the one in Yolo County.

3. Life History and Habitat

Typical life-history and habitat characteristics for all members of the Orcuttieae and for all *Tuctoria* species were presented earlier in this document, under the *Neostapfia colusana* and *Orcuttia inaequalis* accounts.

Reproduction and Demography.—The germination period for *Tuctoria mucronata* seeds is not known, but is presumed to be in May or June (U.S. Fish and Wildlife Service 1985*a*). *Tuctoria* seedlings do not produce floating juvenile leaves (Griggs 1980). This species typically flowers in June and sets seed during July (Holland 1987). The demography of *Tuctoria mucronata* has not been investigated in detail. Annual estimates or counts at Olcott Lake (Holland 1987, California Natural Diversity Data Base 2003) indicated that population sizes for this species fluctuate dramatically from year-to-year, as do other members of the Orcuttieae. *Tuctoria mucronata* was not observed at Olcott Lake from 1976 through 1980, then reappeared in 1981 (Holland 1987), indicating that viable seeds can persist in the soil for at least 5 years. Apparently both drought years and years of excessively high rainfall are unfavorable for *T. mucronata*; the largest populations were observed after seasons of 45 to 60 centimeters (17.7 to 23.6 inches) of precipitation (Holland 1987).

Habitat and Community Associations.—*Tuctoria mucronata* has been found only in the Northern Claypan type of vernal pool (Sawyer and Keeler-Wolf 1995) within annual grassland (California Natural Diversity Data Base 2003). Pools where *T. mucronata* occurs tend to be milky from suspended sediments (Holland 1987). The occupied pools in Solano County are more properly described as alkaline playas or intermittent lakes, due to their large surface area (Crampton 1959, U.S. Fish and Wildlife Service 1985*a*), whereas those at the Yolo County site are "relatively small" (C. Witham *in litt.* 2000*a*). Soils underlying known *T. mucronata* sites are saline-alkaline clay or silty clay in the Pescadero series (Crampton 1959, California Natural Diversity Data Base 2003). Known occurrences are at elevations of about 5 to 11 meters (15 to 35 feet) (California Natural Diversity Data Base 2003).

Tuctoria mucronata is most commonly associated with *Frankenia salina*, *Eryngium aristulatum*, and *Neostapfia colusana*; *N. colusana* occurs near *T. mucronata* at all three sites. Additional associates include *Cressa truxillensis*,

Distichlis spicata, *Phyla nodiflora*, *Crypsis schoenoides*, *Eleocharis macrostachya*, and *Malvella leprosa* (Crampton 1959, California Natural Diversity Data Base 2003). Other than *N. colusana*, the only other rare plant featured in this recovery plan that co-occurs with *T. mucronata* is *Astragalus tener* var. *tener*; the two taxa grow in the same vernal pool complex in Yolo County, but are not in the same pool (California Natural Diversity Data Base 2003).

4. Reasons for Decline and Threats to Survival

Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to *Tuctoria mucronata* are described below.

One additional factor potentially involved in the decline of this particular species may be overcollection (T. Griggs *in litt*. 2000, California Natural Diversity Data Base 2003). Other additional factors include the evidence that the Yolo County habitat for *Tuctoria mucronata* has been degraded by discing, excavation, herbicide runoff, application of salt, and industrial contaminants in the groundwater (K. Fuller pers. comm. 1997, C. Witham *in litt.* 2000*a*, California Natural Diversity Data Base 2003).

A number of specific threats to the species are also continuing. The continuing specific threats include competition from aggressive plants at all three known sites. The primary competitors are *Phyla nodiflora* at Olcott Lake (C. Witham *in litt.* 2000*a*), *Malvella leprosa* and *Crypsis schoenoides* at the other site in Solano County (California Natural Diversity Data Base 2003), and *Lepidium latifolium* (broad-leaved pepper-weed) in Yolo County (K. Fuller *in litt.* 1999). Altered hydrology may threaten the Olcott Lake occurrence, if it is extant (T. Griggs *in litt*. 2000). Effects of inappropriate grazing continue to threaten the other Solano County population, as does trampling by hunters (California Natural Diversity Data Base 2003). Habitat degradation at the Yolo County site has not been remedied and therefore continues to be a threat (California Natural Diversity Data Base 2003). Small population size is a threat to the occurrence southwest of Olcott Lake, and to the one at Olcott Lake, if it is not already extirpated. Both of these sites have declined to fewer than 100 plants.

5. Conservation Efforts

Tuctoria mucronata was listed as an endangered species on September 28, 1978 (U.S. Fish and Wildlife Service 1978*a*). A recovery plan was then prepared, which became effective 7 years following the listing (U.S. Fish and Wildlife Service 1985*a*). The California Fish and Game Commission listed *T. mucronata* as endangered in 1979 (California Department of Fish and Game 1991). *Tuctoria mucronata* is also on the California Native Plant Society's List 1B, with the highest endangerment rating possible (Skinner and Pavlik 1994). In fact, the California Native Plant Society has recognized this species as rare and endangered since it first compiled such lists (Powell 1974). In 2003, critical habitat was designated for *T. mucronata* and several other vernal pool species in *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon* (U.S. Fish and Wildlife Service 2003).

The Nature Conservancy acquired Olcott Lake in 1980 as part of the Jepson Prairie Preserve. The preserve was transferred to the Solano County Farmlands and Open Space Foundation in 1997, which manages it jointly with the University of California, Davis (C. Witham *in litt.* 1998). Livestock grazing is now excluded from the areas of the lake formerly occupied by *Tuctoria mucronata* (U.S. Fish and Wildlife Service 1985*a*, California Natural Diversity Data Base 2003). Money from the California Endangered Species Tax Check-Off Fund has been used to repair fences and post signs in the Jepson Prairie Preserve (California Department of Fish and Game 1991). The Nature Conservancy (1991) conducted some research on the control of *Phyla nodiflora* using herbicides and mechanical removal in the early 1990's. Private individuals have partially implemented one aspect of the recovery plan, which was to survey suitable habitats for *T. mucronata*; their efforts led to the discovery of the two populations that were unknown at the time of listing (California Natural Diversity Data Base 2003).

P. STATE-LISTED AND OTHER PLANT SPECIES OF CONCERN

1. *Astragalus tener* var. *ferrisiae* (Ferris' Milk-vetch)

Taxonomy.—Milk-vetches are members of the pea family (Fabaceae). Ferris' milk-vetch was recognized and named as a distinct variety (*Astragalus tener* var. *ferrisiae*) only recently (Liston 1990*b*). However, Ferris had collected the type specimen in 1926, "3 miles west of Colusa," in Colusa County (Liston 1990*b*). Specimens now attributed to Ferris' milk-vetch formerly had been included under Jepson's milk-vetch (*Astragalus rattanii* var. *jepsonianus*), a serpentine endemic plant (Barneby 1964 as cited in Liston 1990*b*). According to

Liston (1990*b*), further confusion about the taxonomy was generated when Abrams (1944) mistakenly provided a drawing of Ferris' milk-vetch labeled as Clara Hunt's milk-vetch (*Astragalus clarianus*). There is some speculation that Ferris' milk-vetch is an ecomorph of alkali milk vetch, *Astragalus tener* var. *tener*, a somewhat more common species of concern found in vernal pool habitats (C. Witham pers. comm. 2003). An alternative common name for *Astragalus tener* var. *ferrisiae* is Sacramento Valley milk-vetch.

Description and Identification.—The flower structure of *Astragalus* and related genera is complex. Although the calyx is unremarkable, the corolla consists of five petals that differ in size, shape, and sometimes in color. The outermost petal, which is called the banner, often curves upward away from the other petals. Just inside the banner is a pair of petals that are very narrow at the base; these separate but similar petals are known as the wings. The innermost pair of petals is called the keel because the two petals are fused to form a flattened structure resembling a boat. The pistil and stamens are hidden inside the keel. Although each flower has ten stamens, only one is separate; the filaments of the other nine are fused together (Smith 1977).

Astragalus tener var. *ferrisiae* is a delicate annual with one or more stems up to 26 centimeters (10.2 inches) long. The pinnately compound leaves have 7 to 15 wedge-shaped leaflets. The dense inflorescences arise from the leaf axils and contain 3 to 12 pinkish-purple flowers each. In *A. tener* var. *ferrisiae*, the banner ranges from 7.8 to 9.6 millimeters (0.31 to 0.38 inch) in length and has a white spot in the center. The keel is shorter than the wings, which are 5.8 to 7.1 millimeters (0.23 to 0.28 inch) long. Fruits of *A. tener* var. *ferrisiae* are crescent-shaped, papery pods with narrow, stalk-like bases. The pods are 2.7 to 5 centimeters (1.1 to 2.0 inches) long, about 2 millimeters (0.08 inch) wide, and have a groove running the length of the underside. The stalk-like base is at least 3 millimeters (0.12 inch) long. At maturity, the fruit stalks are deflexed at an angle of about 45 degrees. Each pod contains between 10 and 16 smooth seeds divided between two chambers (Liston 1990*b*, A. Liston *in litt.* 1993, Spellenberg 1993). The diploid chromosome number of *A. tener* var. *ferrisiae* is not known.

The other varieties of *Astragalus tener* have shorter, straighter fruits than *A. tener* var. *ferrisiae*, and their fruits do not have long, stalk-like bases (Liston 1990*b*, A. Liston *in litt.* 1993, Spellenberg 1993). All other *Astragalus* species that overlap in range have erect fruit stalks and rough seeds (Liston 1992). *Astragalus rattanii* var. *jepsonianus* is further distinguished from *A. tener* var. *ferrisiae* by its fruit shape and flower color (purple keel, white wings, and a white banner tipped with purple). Although *A. clarianus* has a pod similar in shape to that of *A. tener* var. *ferrisiae*, the former is shorter. Moreover, the flowers of *A. clarianus* differ

in that the keel is longer than the wings and the banner is whitish with a purple tip (Liston 1990*b*, Liston 1992, Spellenberg 1993).

Historical Distribution.—A total of 17 occurrences of *Astragalus tener* var. *ferrisiae* have been reported to date (**Figure II-27**). Four of these are historical localities reported by Liston (1990*b*, 1992) that are not catalogued in the California Natural Diversity Data Base (2003). The seven historical localities in the Solano-Colusa Vernal Pool Region included College City, Colusa, and Mountain House in Colusa County; Dunnigan and Saxon in Yolo County; Olcott Lake in Solano County; and the Sacramento National Wildlife Refuge in Glenn County. Three occurrences were discovered in the Northeastern Sacramento Valley Vernal Pool Region (T. Keeler-Wolf *in litt*. 2000, J. Silveira *in litt*. 2000) since 1989. All three were on the Llano Seco Unit of the Sacramento River National Wildlife Refuge in Butte County (California Natural Diversity Data Base 2001). Seven other historical localities were outside of the vernal pool regions designated by Keeler-Wolf *et al.* (1998) or were not described in sufficient detail to determine the region. These sites include Biggs, Nord, Oroville Road, Sacramento River, and Upper Butte Basin Wildlife Management Area in Butte County; Yuba City in Sutter County; and an unidentified "causeway" location.

Current Distribution.— Although the California Natural Diversity Data Base (2003) lists seven occurrences as "presumed extant," despite repeated visits, only one has been confirmed extant since 1996. The extant occurrence is at Saxon Station in Yolo County, which is in the Solano-Colusa Vernal Pool Region. Its identity is awaiting confirmation by species expert Aaron Liston (C. Witham pers. comm. 2003). Several of the historical collection sites currently support only *Astragalus tener* var. *tener* (Liston 1990*b*, California Natural Diversity Data Base 2003). Morphology of the plants seems to vary depending on associated vegetation, casting doubt on the validity of this taxon (C. Witham pers. comm. 2003).

Reproduction and Demography.—The life history of *Astragalus tener* var. *ferrisiae* has not been studied. Most of the information on reproductive biology and genetics in the species was gathered from *A. tener* var. *tener* and another variety of the same species, *A. tener* var. *titi* (coastal dunes milk-vetch) because the researcher (Liston 1992) was unaware of any extant populations of *A. tener* var. *ferrisiae*. Many of his observations apply to the species *A. tener* as a whole, and other information provided in the *A. tener* var. *tener* species account may also apply to *A. tener* var. *ferrisiae*.

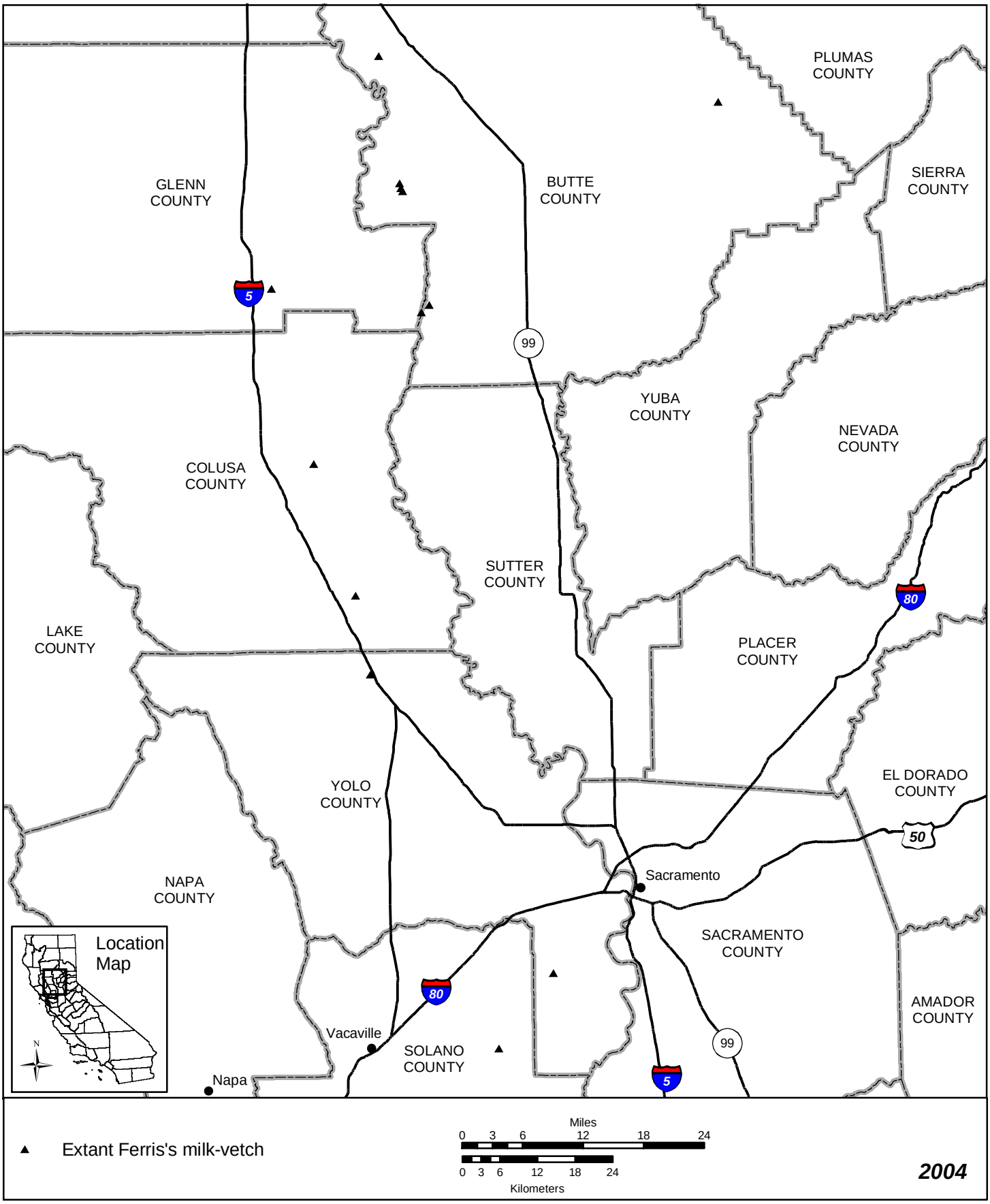

Figure II-27. Distribution of *Astragalus tener* var. *ferrisiae* (Ferris' milk-vetch)

Astragalus tener var. *ferrisiae* is an annual, but the conditions necessary for seed germination are unknown. It flowers in April and May (Skinner and Pavlik 1994). The pollinators are not known for certain. Liston (1992) predicted that butterflies would pollinate all varieties of *A. tener*, even though most other species of *Astragalus* are pollinated by bees. His rationale was that the flower structure, in which the wings are pressed tightly together with the keel shorter than the wings, would not allow bees to reach the nectar glands with their mouthparts. Butterflies are known to visit other *Astragalus* species with similar flower morphology (Liston 1990*a* cited in Liston 1992). Little is known about seed dispersal in *A. tener*, except that the pod does not split until it drops from the plant (Liston 1992). Liston (1992) speculated that this species would form a soil seed bank because seeds of related species undergo dormancy (Liston 1990*a* cited in Liston 1992).

Demography of *Astragalus tener* var. *ferrisiae* has not been monitored. Among occurrences for which the population size has been estimated, two numbered 200 and 400 plants when they were discovered, and two others numbered 10 or fewer. If the populations of *A. tener* var. *ferrisiae* follow a pattern similar to that of *A. tener* var. *tener*, plants may reappear in future years at sites where they have been absent for a number of years.

Habitat and Community Associations.—Since it was first discovered, *Astragalus tener* var. *ferrisiae* has been found in a variety of habitats including vernal meadows, "tule land" (presumably a marsh), borders of drainages, and fallow rice fields. The factors common to collection sites were that they were alkaline, moist in the springtime, and level (Liston 1992, Skinner and Pavlik 1994, California Natural Diversity Data Base 2001). This taxon does not occur in vernal pools per se and therefore is not referenced by vernal pool type in *A Manual of California Vegetation* (Sawyer and Keeler-Wolf 1995). *Astragalus tener* var. *ferrisiae* grows on clay soils (California Natural Diversity Data Base 2001 and unprocessed data, J. Silveira *in litt.* 2000). Collection localities were at elevations ranging from 6 to 46 meters (20 to 150 feet). Plant species associated with *A. tener* var. *ferrisiae* have rarely been reported. It was growing with *Sidalcea hirsuta* (hairy checker-mallow), *Scirpus mucronatus* (bog bulrush), *Eleocharis obtusa* (blunt spikerush), and *Phalaris lemmonii* (Lemmon's canary grass) near Biggs and among "weedy grasses and forbs" at Upper Butte Basin Wildlife Management Area (California Natural Diversity Data Base 2001).

Reasons for Decline and Threats to Survival.— Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft

recovery plan. Additional, specific threats to *Astragalus tener* var. *ferrisiae* are described below.

Much of the suitable habitat in its historical range has been converted to agriculture (Skinner and Pavlik 1994). The reasons why this variety no longer occurs at Olcott Lake, which is in a nature preserve, are unknown.

Permanent flooding is a potential threat to *Astragalus tener* var. *ferrisiae* at wildlife management areas if waterfowl production is given priority (California Natural Diversity Data Base 2001). Competition from unspecified upland plants is a problem at the Upper Butte Basin Wildlife Management Area (C. Rocco *in litt.* 1993) and probably at all sites in the Sacramento Valley (J. Silveira *in litt.* 2000). Small population size is a concern for all of the extant occurrences, which ranged in size from 10 to 400 individuals during the 1990's; growing plants have been absent from all but one population over the past several years (C. Witham pers. comm. 2003). An additional threat is a decline in pollinators. Pollinating insects may breed in areas outside of *A. tener* var. *ferrisiae* habitat and thus may be subject to different threats than the plants. However, until the specific pollinators of *A. tener* var. *ferrisiae* have been identified, the robustness of their populations cannot be assessed.

Conservation Efforts.—*Astragalus tener* var. *ferrisiae* has no Federal or State protection. The California Native Plant Society includes this variety on List 1B, giving it the highest endangerment rating possible (Skinner and Pavlik 1994). Dr. Vernon Oswald discovered several populations during the past decade while exploring Butte and Glenn Counties (California Natural Diversity Data Base 2001 and unprocessed data). Five occurrences are afforded some protection by virtue of their location on public land, but no particular conservation efforts have been undertaken in those areas.

2. *Astragalus tener* var. *tener* (Alkali Milk-vetch)

Taxonomy.—Alkali milk-vetch is in the pea family. Gray (1864) named *Astragalus tener*, commonly known as alkali milk-vetch. He gave the type locality only as “California ... from near Monterey or San Francisco” (Gray 1864, p. 206). No varieties were named until Barneby (1950) reduced *Astragalus titi*, commonly known as coastal dunes milk-vetch, from a full species to the variety *Astragalus tener var. titi*. In so doing, the combination *Astragalus tener* var. *tener* was created automatically to represent Gray’s original material (*i.e.*, alkali milk-vetch), according to accepted rules of botanical nomenclature. Another common name by which this variety is known is slender rattle-weed (Abrams 1944).

Description and Identification.—*Astragalus tener* var. *tener* (**Figure II-28**) is similar in most respects to *A. tener* var. *ferrisiae*. However, the two taxa differ in leaflet shape and fruit morphology. *Astragalus tener* var. *tener* leaflets vary, even on the same plant, from narrow and pointed to wedge-shaped with blunt or notched tips. In *A. tener* var. *tener*, the pod is only 1 to 2.5 centimeters (0.4 to 1.0 inch) long and straight or only slightly curved. The base of the pod is typically rounded; if stalk-like, the base is much less than 3 millimeters (0.12 inch) long. Also, the fruits are deflexed all the way to the stem of the inflorescence. *Astragalus tener* var. *tener* pods contain between 8 and 14 seeds (Gray 1864, Liston 1990*b*, A. Liston *in litt.* 1993, Spellenberg 1993). The plants have a diploid chromosome number of 22 (Liston 1992).

The variable leaflets and shorter, straighter pods, which are more strongly deflexed, distinguish *Astragalus tener* var. *tener* from *A. tener* var. *ferrisiae* (Liston 1990*b*, A. Liston *in litt.* 1993, Spellenberg 1993). *Astragalus tener* var. *titi* has a shorter banner (5.2 to 6 millimeters [0.20 to 0.24 inch] long) and only 5 to 11 seeds per pod (Spellenberg 1993). This species can be distinguished from all other species of *Astragalus* that occur in the same areas by its deflexed fruit stalks and smooth seeds (Liston 1992). Additional identifying features were given in the *A. tener* var. *ferrisiae* account presented earlier in this document.

Historical Distribution.—*Astragalus tener* var. *tener* formerly occurred in the Central Coast, Lake-Napa, Livermore, San Joaquin Valley, Solano-Colusa, and Santa Rosa vernal pool regions (Keeler-Wolf *et al.* 1998), as well as in several locations outside of the named regions (**Figure II-29**). Between 1864 and the early 1980's, collections were made in more than 40 separate sites within 13 counties, ranging from the Salinas Valley and the San Francisco Bay area to the Central Valley (Barneby 1950, Liston 1989). Populations in the San Francisco Bay and Sacramento-San Joaquin Delta areas were being extirpated by the mid-1960's, but additional sites were discovered in the Central Valley after that time (Liston 1989, Skinner and Pavlik 1994, California Natural Diversity Data Base 2001). Alameda and Solano Counties had the largest number of historical collection sites, with 10 each, followed by Yolo County with 9 sites. Specimens were collected from two sites each in Contra Costa, Santa Clara, and San Joaquin Counties. *Astragalus tener* var. *tener* was known from one site each in Merced, Monterey, Napa, San Benito, San Francisco, Sonoma, and Stanislaus Counties prior to 1988 (A. Liston *in litt.* 1988, California Natural Diversity Data Base 2001).

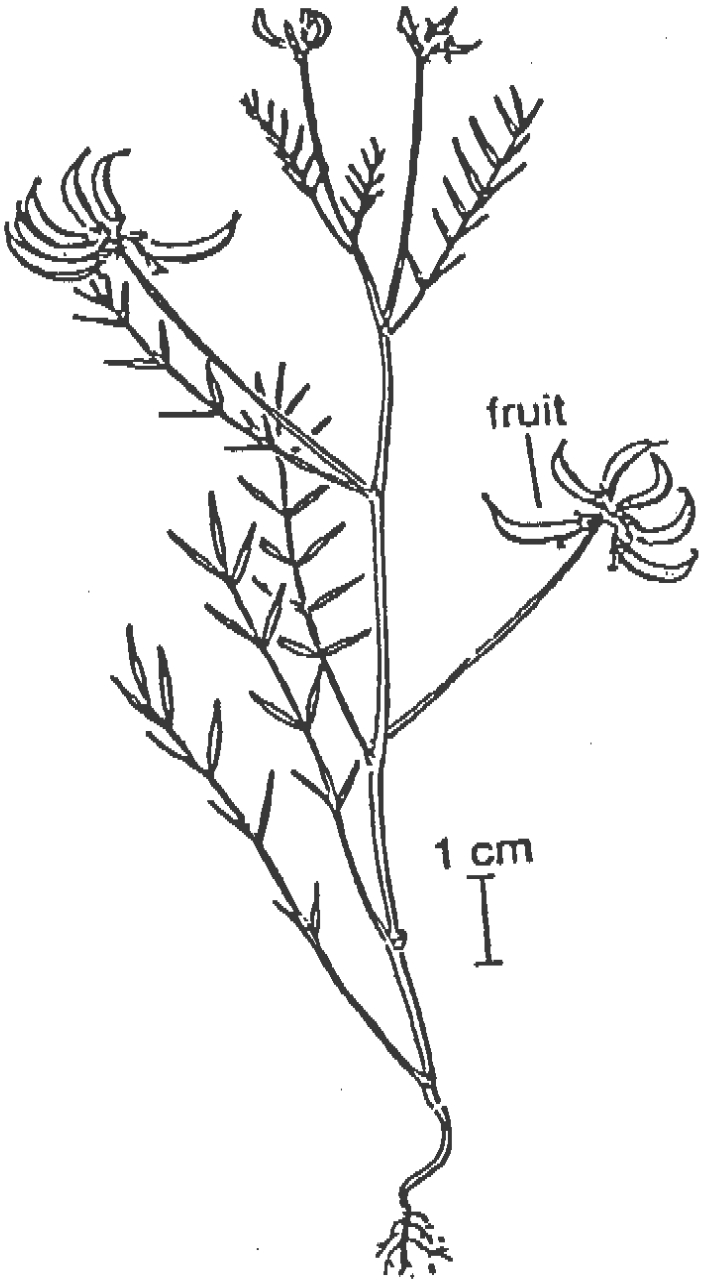

Figure II-28. Illustration of *Astragalus tener* var. *tener* (alkali milk-vetch). (Reprinted from the Jepson Manual, J. Hickman, Ed., 1993, with permission from the Jepson Herbarium. © Regents of the University of California)

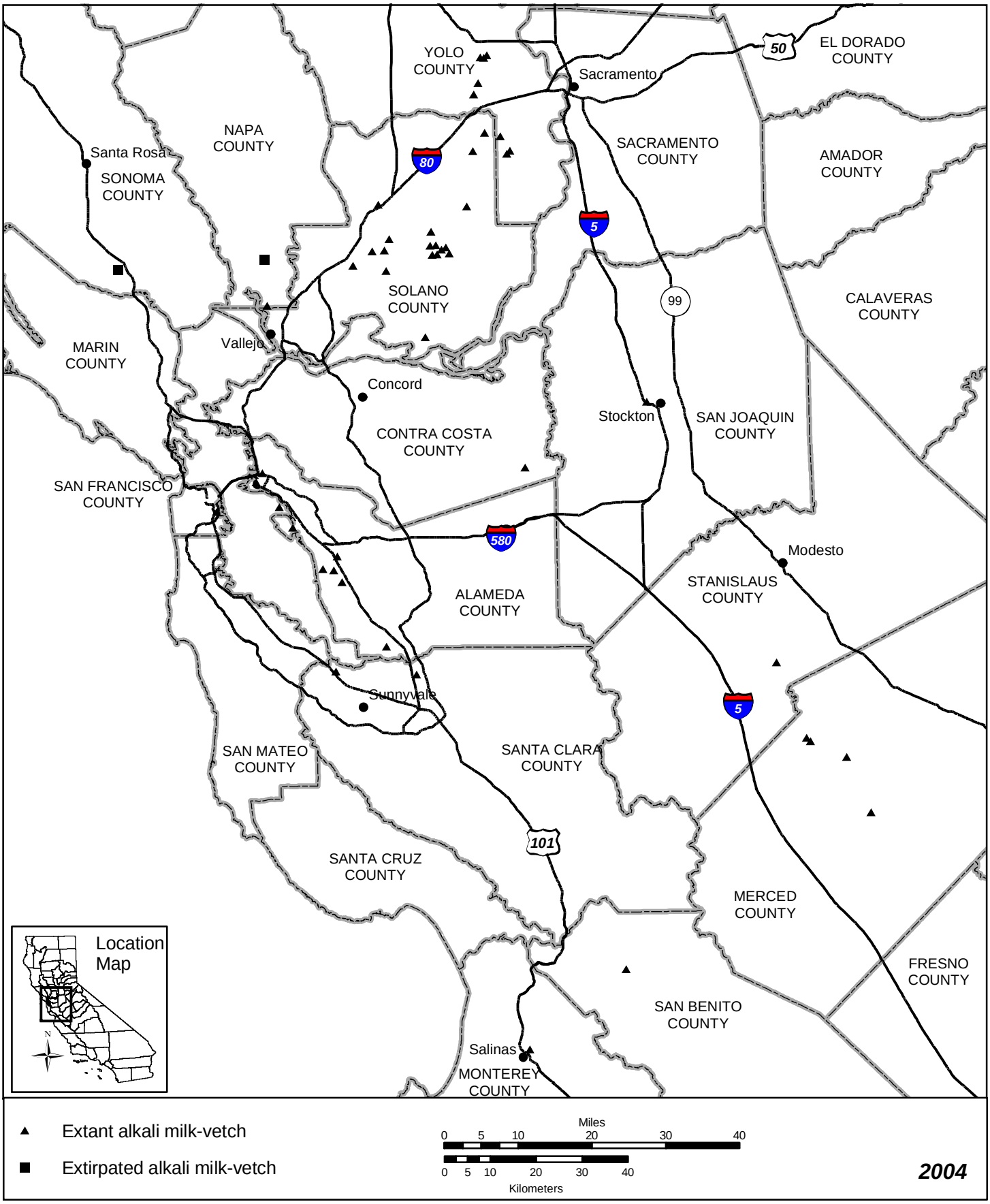

Figure II-29. Distribution of *Astragalus tener* var. *tener* (alkali milk-vetch).

Current Distribution.—Of the 58 occurrences of *Astragalus tener* var. *tener* that have been reported, 23 are presumed to be extant (A. Liston *in litt.* 1988, California Natural Diversity Data Base 2001). Fifteen of those were discovered within the past decade, including one (Silveira 1996) that has not yet been assigned an element occurrence number (California Natural Diversity Data Base 2001). The majority (16) of the extant occurrences are in the Solano-Colusa Vernal Pool Region (Keeler-Wolf *et al.* 1998); most are in the Dozier-Fairfield area of Solano County, but three are southeast of Woodland in Yolo County (C. Witham *in litt.* 1990, California Natural Diversity Data Base 2001). Five other occurrences of *A. tener* var. *tener* are clustered between Merced, Newman, and Los Banos in north-central Merced County (Silveira 1996, California Natural Diversity Data Base 2001), which is in the San Joaquin Valley Vernal Pool Region (Keeler-Wolf *et al.* 1998). The single occurrence of *A. tener* var. *tener* that remains in the Lake-Napa Vernal Pool Region is located in Napa County (Keeler-Wolf *et al.* 1998, California Natural Diversity Data Base 2001). The other extant occurrence, at Albrae in the Central Coast Vernal Pool Region, was considered to be "possibly extirpated" until about 40 plants were rediscovered in a created pool there in 1999 (California Natural Diversity Data Base 2001).

Reproduction and Demography.—The dates and conditions under which seeds of *Astragalus tener* var. *tener* germinate are not known. *Astragalus tener* var. *tener* flowers from March through June (Skinner and Pavlik 1994). The plants become inconspicuous within a few weeks of flowering (C. Witham *in litt.* 1993, A. Liston *in litt.* 2000). As described under the *A. tener* var. *ferrisiae* account, the probable pollinators are butterflies. However, C. Witham (*in litt.* 2000*a*) noted that butterflies are not common in the grassland habitats of *A. tener* var. *tener*. Liston's (1992) genetic studies indicated that plants within a population crossed randomly and did not suffer from excessive inbreeding, even though individual pistils can be fertilized by pollen from the same plant. *Astragalus tener* var. *tener* did not produce seeds when crossed experimentally with *A. tener* var. *titi* or with other closely-related species (Liston 1992). Seed dormancy and dispersal in *A. tener* were discussed in the *A. tener* var. *ferrisiae* account.

Based on analysis of proteins, Liston (1992) determined that *Astragalus tener* var. *tener* had more genetic variation within populations than the other six taxa in his study, although genetic diversity was low in the entire group. Genetic diversity among populations of *A. tener* var. *tener* was minimal. He also determined that *A. tener* var. *tener* and *A. tener* var. *titi* were very similar genetically. Unfortunately, *A. tener* var. *ferrisiae* was not available for inclusion in Liston's study because no populations were known to be extant at that time.

Collectively, the two varieties of *A. tener* that Liston studied had two gene forms that were not found in the other five taxa (Liston 1992).

The demography of this taxon has not been investigated in detail. However, monitoring results indicated that populations could change by two orders of magnitude from one year to the next, as in one Solano County population that increased from 4 plants in 1993 to 350 in 1994 (California Natural Diversity Data Base 2001). Of the populations whose sizes have been estimated, six had fewer than 100 plants at maximum, six others numbered between 100 and 500 plants, and one had more than 500 (California Natural Diversity Data Base 2001).

Habitat and Community Associations.—The range of plant communities in which *Astragalus tener* var. *tener* has been found is indicative of its broad geographic range. This taxon has been reported from vernal pools and playas, edges of salt marshes, alkali meadows, and moist grassy flats (California Natural Diversity Data Base 2001). The vernal pool types in which it grows are Northern Basalt Flow, Northern Claypan, Northern Hardpan, and Northern Volcanic Ashflow (Sawyer and Keeler-Wolf 1995). Optimum pool depth, duration, and area are unknown.

Soil types have been reported for only a few *Astragalus tener* var. *tener* occurrences in the Solano-Colusa Vernal Pool Region; those in Solano County are Solano-Pescadero and Pescadero clay, whereas one in Yolo County is Capay silty loam. The sites where this taxon grows typically are alkaline. Current and historical *A. tener* var. *tener* sites range in elevation from 1.5 to 88 meters (5 to 290 feet); one vaguely described site may have been 168 meters (550 feet) in elevation (California Natural Diversity Data Base 2001).

The species associated with *Astragalus tener* var. *tener* vary throughout its range. Plants that have been reported to occur with *Astragalus tener* var. *tener* in two or more of the vernal pool regions are *Bromus* spp. (bromes), *Castilleja densiflora* (dense-flowered owl's-clover), *Downingia pusilla* (dwarf downingia), *Lasthenia* spp. (goldfields), *Layia chrysanthemoides* (vernal pool layia), *Myosurus minimus*, and *Psilocarphus oregonus* (Oregon woolly-heads). In the Solano-Colusa Vernal Pool Region, from which multiple reports were available, the most frequent associates of *Astragalus tener* var. *tener* are *Lepidium latipes* var. *latipes* (dwarf peppergrass), *Lasthenia fremontii*, and *Distichlis spicata*, in order of frequency. Among the other plants featured in this recovery plan, those occurring in the same pools with *Astragalus tener* var. *tener* throughout its range include *Lasthenia conjugens*, *Neostapfia colusana*, *Atriplex persistens*, and *Legenere limosa*. In addition, *Chamaesyce hooveri*, *Tuctoria mucronata*, and *Gratiola heterosepala* grow in some of the same vernal pool complexes as *Astragalus tener* var. *tener*,

but in different pools. The endangered *Cordylanthus palmatus* (palmate-bracted bird's-beak) occurs with *Astragalus tener* var. *tener* near Woodland (California Natural Diversity Data Base 2001), but it is included in a different recovery plan (U.S. Fish and Wildlife Service 1998*a)*.

Reasons for Decline and Threats to Survival.—Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to *Astragalus tener* var. *tener* are described below.

Agricultural conversion remains a threat to *Astragalus tener* var. *tener* (Skinner and Pavlik 1994). However, anecdotal evidence suggests that *A. tener* var. *tener* may benefit from some types of temporary surface disturbance. It was observed growing above a recently buried pipeline at two different sites, probably because the disturbance temporarily reduced the cover of competing plants (C. Witham *in litt.* 1998). *Astragalus tener* var. *tener* also appeared in a created vernal pool near Albrae, where it had not been observed since 1923 (California Natural Diversity Data Base 2001).

Grazing by cattle, sheep, or horses has been mentioned as a possible threat at 10 occurrences. However, all of the grazed populations were rated as being in "good" to "excellent" condition, including two used as permanent cattle pastures (California Natural Diversity Data Base 2001). Moreover, grazing may be necessary to reduce competition, for example competition from filaree (*Erodium* species) at the Arena Plains Unit of the Merced National Wildlife Refuge in Merced County (J. Silveira *in litt.* 2000). Competitors that threaten *A. tener* var. *tener* include *Lepidium latifolium* and *Salsola* spp. (Russian thistle) in Yolo County, and *Melilotus indica* (sweet clover) and *Lolium multiflorum* in Alameda County (California Natural Diversity Data Base 2001). Extirpation from random processes is also a threat to virtually all of the populations due to their small numbers of plants, which make them vulnerable to chance events. Loss of pollinators due to destruction or degradation of their habitat also is a threat to *A. tener* var. *tener* because it would not be able to set seed if pollinators were absent. Threats specific to the Yolo County site where *A. tener* var. *tener* grows near *Tuctoria mucronata* were described under the latter species. Another occurrence will be impacted by construction of drainage basins for the proposed Springlake development (M. Showers, pers. comm. 2004).

Conservation Efforts.—*Astragalus tener* var. *tener* currently is neither federally- nor State-listed. The California Native Plant Society did not consider it

to be a rare taxon until 1994; it is now on List 1B and is regarded as endangered in a portion of its range (Skinner and Pavlik 1994). Dr. Aaron Liston visited historical sites and conducted research on the breeding systems and genetics of *A. tener* var. *tener* and related taxa (A. Liston *in litt.* 1988, Liston 1989, Liston 1990*a*, Liston 1992). Carol Witham undertook surveys for *A. tener* var. *tener* in Solano and Yolo Counties beginning in 1990 and discovered many of the populations now known (C. Witham *in litt.* 1990, C. Witham *in litt.* 1993, California Natural Diversity Data Base 2001). Additional populations were found during surveys for other vernal pool plants (California Natural Diversity Data Base 2001) and during recent pre-construction surveys for a gas pipeline (BioSystems Analysis 1994).

Twelve occurrences of *Astragalus tener* var. *tener* occur on sites protected by conservation organizations or on public land. Three are within the Jepson Prairie Preserve in Solano County (C. Witham *in litt.* 1990, California Natural Diversity Data Base 2001). Two occurrences are on the Wilcox Ranch in Solano County part of which is owned and managed by The Nature Conservancy and the other part of which is owned and managed by Solano County (Marty, pers. comm. 2004). Four occurrences are on Federal or State wildlife areas in Merced County: the Arena Plains Unit of the Merced National Wildlife Refuge, Kesterson National Wildlife Refuge, the Los Banos Wildlife Management Area, and the North Grasslands Wildlife Management Area (Silveira 1996, California Natural Diversity Data Base 2001). *Astragalus tener* var. *tener* grows on land administered by the U.S. Department of Defense at Travis Air Force Base in Solano County and the U.S. Air Force Communications Facility in Yolo County (California Natural Diversity Data Base 2001). Also, one Yolo County occurrence is on property protected by a conservation easement with the City of Woodland (C. Witham *in litt.* 1990, California Natural Diversity Data Base 2001). However, this taxon is not necessarily protected simply by virtue of existing on public lands. No particular management activities have been undertaken for *A. tener* var. *tener*, and monitoring is sporadic. Project proponents at the proposed Springlake development will salvage soil supporting *A. tener* var. *tener* and reapply the soil to a "safe site"; it is not known if translocation of soil will be successful (M. Showers, pers. comm. 2004).

3. *Atriplex persistens* (Vernal Pool Smallscale)

Taxonomy.—This species is in the goosefoot family (Chenopodiaceae). Vernal pool smallscale was recognized as a unique species only recently. Stutz and Chu (1993) gave it the scientific name *Atriplex persistens*. Specimens of vernal pool smallscale collected prior to publication of the name had been incorrectly assigned to Parish's brittlescale (*Atriplex parishii*), a southern

California species. The type locality of vernal pool smallscale is "Glenn Co., 5 miles S of Willows, 1/4 mi SW of Sacramento Wildlife Refuge Headquarters" (Stutz and Chu 1993). Other common names by which it is known are vernal pool saltbush (Silveira 1996, Keeler-Wolf *et al.* 1998) and persistent-fruited saltscale (California Department of Fish and Game 1999, California Natural Diversity Data Base 2001).

Description and Identification.—*Atriplex persistens* (**Figure II-30**) is an annual. The plants appear silvery-green (Silveira 1996) because the leaves and branches are covered with whitish, mealy scales. The 10- to 20-centimeter (4- to 8-inch) long stems may be upright or curved outward, and the branches originate from the base. *Atriplex persistens* has alternate, stalkless leaves 2 to 4 millimeters (0.08 to 0.16 inch) long. The leaves are basically egg-shaped with smooth margins, although their bases range from heart-shaped to triangular. Male and female reproductive parts are borne in separate, inconspicuous flowers. The male flowers occur in clusters in the upper leaf axils or at the branch tips, whereas the female flowers occur singly in the lower leaf axils. Each fruit consists of a single, reddish-brown seed enclosed by two bracts. The bracts are 3 to 4 millimeters (0.12 to 0.16 inch) long, wider at the tip than at the base, coarsely toothed on the upper margins, and have a few tubercles on their surfaces. At maturity, the center and base of each bract become hardened. The fruits remain on the branches even after the plants have died, a characteristic reflected in the scientific name of the species. The diploid chromosome number of *A. persistens* is 18 (Stutz and Chu 1993).

The annual species most easily confused with *Atriplex persistens* is *A. parishii*. However, *A. parishii* is restricted to southern California; male and female flowers occur together in axillary clusters; the fruiting scales remain soft, are not toothed, and are widest below the middle; and the fruits detach easily from the stem. *Atriplex fruticulosa* (ball saltbush) has hardened fruiting bracts, but they are widest at the middle, the fruits are not persistent, the leaves are longer than in *A. persistens*, and the plants are perennial (Stutz and Chu 1993, Taylor and Wilken 1993).

Historical Distribution.—*Atriplex persistens* was collected from only five localities prior to 1990, all in the San Joaquin Valley Vernal Pool Region (Keeler-Wolf *et al.* 1998) (**Figure II-31**). The earliest record is from 1926, when Howell collected the species southwest of Merced, Merced County. Another site was discovered southwest of Merced during the late 1980's (Stone *et al.* 1988, California Natural Diversity Data Base 2001). In the 1960's, *A. persistens* was collected south of Modesto in Stanislaus County and west of Pixley in Tulare County (Stutz and Chu 1993, California Natural Diversity Data Base 2001).

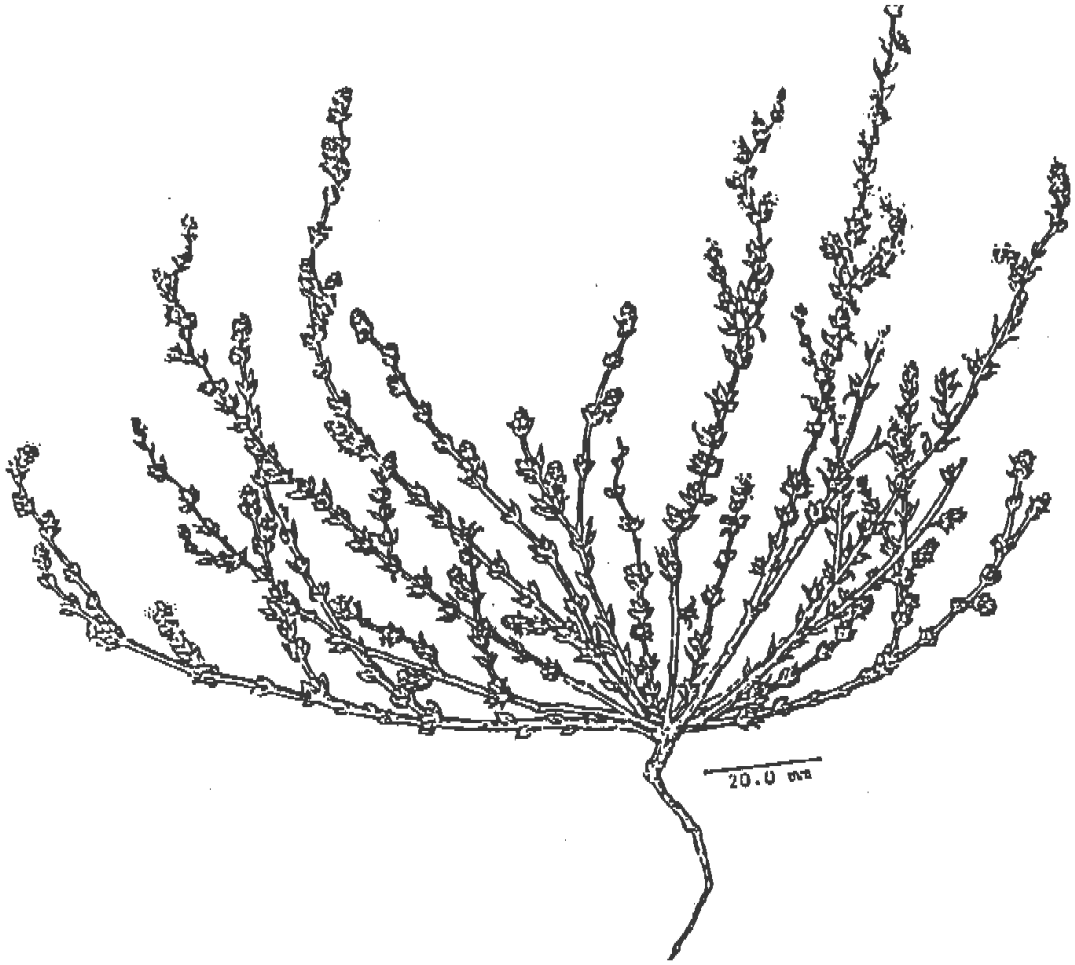

Figure II-30. Illustration of *Atriplex persistens* (vernal pool smallscale). (Reprinted from the California Botanical Society with permission)

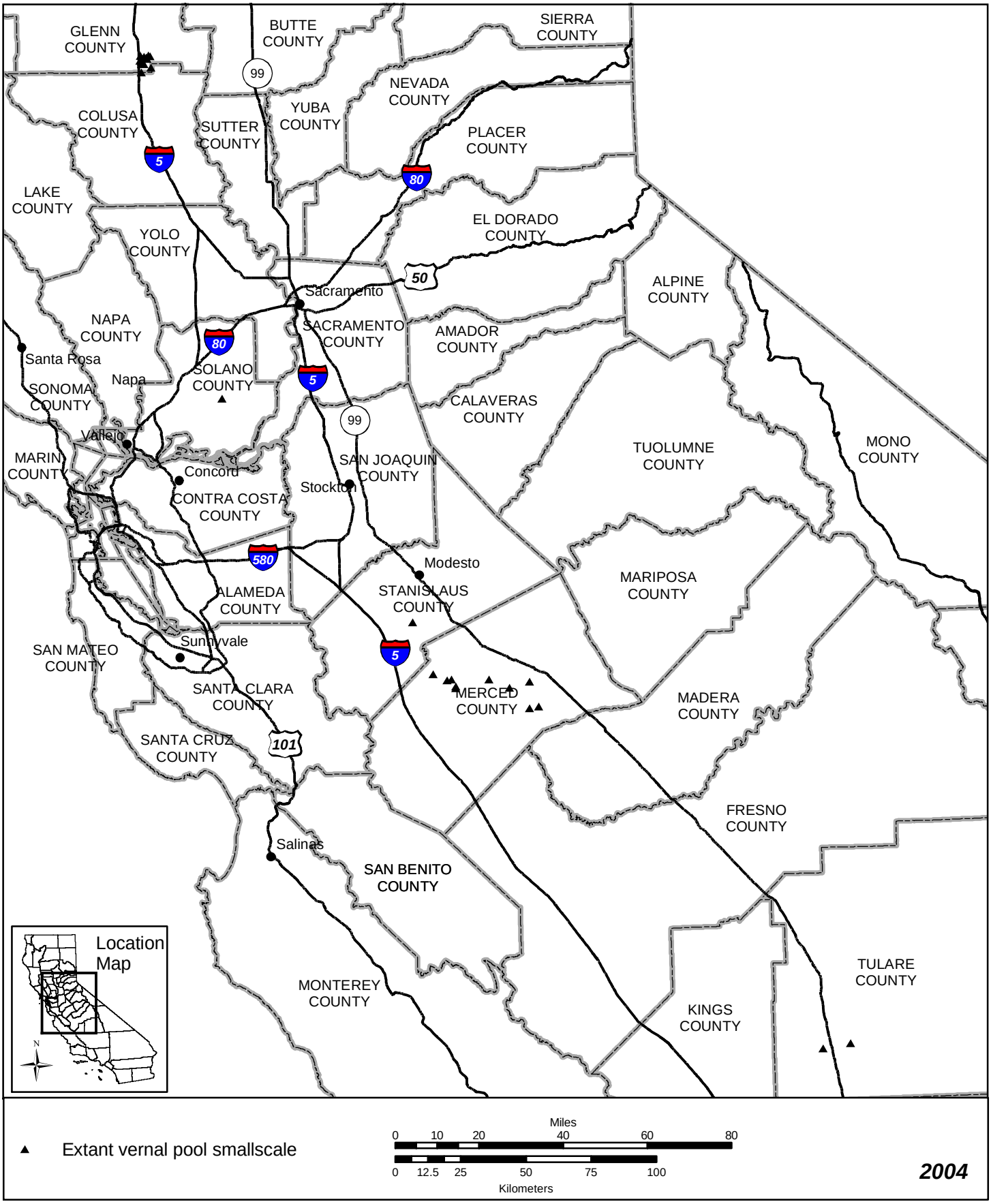

Figure II-31. Distribution of *Atriplex persistens* (vernal pool smallscale)

Another occurrence was discovered near Pixley in 1985 (California Natural Diversity Data Base 2001).

Current Distribution.—Since 1990, 20 additional populations of *Atriplex persistens* have been found in Glenn, Merced, and Solano Counties. However, three occurrences apparently have been extirpated, one each in Merced, Stanislaus, and Tulare Counties. Thus, of 25 known occurrences, 22 are believed to remain extant (California Natural Diversity Data Base 2001). Twelve of these are in the Solano-Colusa Vernal Pool Region, and the other 10 are in the San Joaquin Valley Vernal Pool Region (Keeler-Wolf *et al.* 1998). The largest concentration, comprising 11 occurrences, is on the Sacramento National Wildlife Refuge in Glenn County. The second-largest concentration is in central Merced County between Los Banos and Merced, where nine occurrences remain extant. The other two extant occurrences are in Solano and Tulare Counties (California Natural Diversity Data Base 2001).

Reproduction and Demography.—*Atriplex persistens* was described so recently that little information has been collected on its life history. However, it is a summer annual that flowers from July through September (Stutz and Chu 1993).

Germination dates and conditions have not been reported, nor have demographic parameters or pollination agents. Population size has been reported only for the Arena Plains Unit of the Merced National Wildlife Refuge, where about 10,000 plants were observed in 1995 (California Natural Diversity Data Base unprocessed data).

Habitat and Community Associations.—*Atriplex persistens* has been observed only in large, alkaline vernal pools, where it occurs in the bottoms of the basins as opposed to the edges (D. Taylor pers. comm. 1997). These pools are referable to the Northern Claypan type (Keeler-Wolf *et al.* 1998). The Glenn County pools contained water about 15 to 30 centimeters (6 to 12 inches) deep in the springs seasons of 1991 and 1993 (Stutz and Chu 1993). In Merced County, this species occurs on sandy, silty clay soils (California Natural Diversity Data Base 2001); soil types have not been noted elsewhere. Reported populations were at elevations ranging from 8 to 98 meters (25 to 320 feet) (California Natural Diversity Data Base 2001).

Atriplex persistens co-occurs with many of the other plant species featured in this recovery plan, including *Chamaesyce hooveri* (at four sites); *Orcuttia pilosa* (three sites); *Neostapfia colusana*, *Astragalus tener* var. *ferrisiae*, and *Astragalus tener* var. *tener* (two sites each); and *Tuctoria greenei* and *Legenere limosa* (one

site each) (Stone *et al.* 1988, Oswald and Silveira 1995, Silveira 1996, J. Silveira *in litt.* 2000, California Natural Diversity Data Base 2001). Other plants with which it is commonly associated are *Cressa truxillensis*, *Bassia hyssopifolia* (hyssop-leaved bassia), *Frankenia salina*, *Grindelia camporum* , *Hemizonia pungens* (common spikeweed), and *Distichlis spicata* (J. Silveira *in litt.* 2000).

Reasons for Decline and Threats to Survival.—Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to *Atriplex persistens* are described below.

The comparison of recent versus historical accounts of this species fails to document a decline. Although Stutz and Chu (1993) indicated that they could not find the species at any of the historical sites, it has since been rediscovered in Merced and Tulare Counties. Nevertheless, much suitable habitat of this species throughout the Central Valley has no doubt been lost or degraded, due to the same primary factors that have reduced populations of various other vernal-pool-related species addressed earlier in this document.

One specific continuing threat is altered hydrology, which threatens the survival of *Atriplex persistens* in the East Grasslands of Merced County, where vernal pools have been flooded illegally for use as duck ponds (J. Silveira *in litt.* 2000).

Conservation Efforts.—*Atriplex persistens* has no official Federal or State status. However, the California Native Plant Society has added it to List 1B of the sixth edition of their *Inventory of Rare and Endangered Vascular Plants of California* (California Native Plant Society 2001), indicating that they view the species as endangered throughout its range.

Although *Atriplex persistens* has not been the subject of focused survey efforts, it has been discovered during general surveys for vernal pool plants (Stutz and Chu 1993, Silveira 1996, D. Taylor *in litt.* 1997). Of the 22 *A. persistens* populations currently known to be extant, 17 (77.3 percent) are on public land or in nature preserves. However, no specific measures have been undertaken to conserve or manage for this species on these or other sites. The occurrences in public ownership include 11 on the Sacramento National Wildlife Refuge and 4 in Merced County: 2 in San Joaquin Grasslands State Park, and 1 each on the Arena Plains Unit of the Merced National Wildlife Refuge and the North Grasslands Wildlife Management Area. The two nature preserves where *A. persistens* occurs are the Jepson Prairie in Solano County and the Pixley Vernal Pool Preserve in

Tulare County (Stutz and Chu 1993, D. Taylor *in litt.* 1997, California Natural Diversity Data Base 2001).

4. *Eryngium spinosepalum* (Spiny-sepaled Button-celery)

Taxonomy.—Spiny-sepaled button-celery is a member of the carrot family. The scientific name first used for spiny-sepaled button-celery was *Eryngium globosum* (Jepson 1922). However, the name *Eryngium globosum* had already been used to represent an entirely different species, so Mathias (1936) changed the name of spiny-sepaled button-celery to *Eryngium spinosepalum*. Hoover (1937) decided that this taxon was more appropriate at the rank of variety than species and thus suggested the name *Eryngium vaseyi* var. *globosum* in his thesis. Hoover's thesis did not meet the requirements for official publication of a scientific name; Mathias and Constance (1941) later properly published Hoover's combination *Eryngium vaseyi* var. *globosum*. That name remained in use until Sheik (1978) decided that spiny-sepaled button-celery deserved the rank of species and returned to the scientific name *Eryngium spinosepalum*, which remains in use (Constance 1993). However, some vernal pool experts (J. Stebbins *in litt.* 2000*a*) question whether spiny-sepaled button-celery should be considered a species due to the presence of intermediate forms. Other common names for this plant are spiny-sepaled coyote-thistle (Smith *et al.* 1980) and spiny coyote-thistle (EIP Associates 1994). The type locality of spiny-sepaled button-celery is Exeter, in Tulare County (Jepson 1922).

Description and Identification.—*Eryngium spinosepalum* has stout, branching, hairless stems 30 to 75 centimeters (11.8 to 29.5 inches) tall. The terrestrial leaves consist of a short petiole (less than 2 centimeters [0.8 inch] long) and a spiny-toothed or deeply-lobed blade 9 to 35 centimeters (3.5 to 13.8 inches) long. The flower heads of *E. spinosepalum* are spherical or egg-shaped, 0.8 to 2 centimeters (0.3 to 0.8 inch) in diameter, and contain more than 10 flowers each. Each flower head is on a stalk 2 centimeters (0.8 inch) long or less. The narrow bracts are spiny on the margin and on the underside, and typically protrude beyond the flower heads. Conversely, most bractlets are shorter than the flower head; each has a broad, papery margin at the base and only a few spines. The individual flowers of *E. spinosepalum* are tiny, with white petals and distinctive sepals. The sepals are 3.5 to 4.5 millimeters (0.14 to 0.18 inch) long, egg- or lance-shaped, and deeply divided into 3 to 8 spiny lobes or teeth. Fruits of *E. spinosepalum* are oblong to egg-shaped and 2.5 to 3 millimeters (0.10 to 0.12 inch) long (Jepson 1922, Abrams 1951, Mason 1957, Constance 1993). The diploid chromosome number of *E. spinosepalum* is 32 (Constance 1993). Unlike *E. constancei*, *E. spinosepalum* lacks hairs, has more than 10 flowers per head, the main stems are stout, and the stems supporting the flower heads are short.

Eryngium spinosepalum is similar to both *E. castrense* and *E. vaseyi*, but both have narrower flower heads (no more than 15 millimeters [0.59 inch] in diameter) than *E. spinosepalum*. *Eryngium castrense* also has more deeply lobed leaves than *E. spinosepalum*, bracts and bractlets that are similar to each other and densely covered with spines, and bractlets that protrude well beyond the flower heads. *Eryngium vaseyi* also has deeply lobed leaves; the bracts and bractlets are similar to those of *E. spinosepalum*, but the sepals of the former are entire and shorter (2 to 3 millimeters [0.08 to 0.12 inch]) than those of *E. spinosepalum*.

Many plants found in nature are intermediate between *Eryngium spinosepalum* and either *E. castrense* or *E. vaseyi* in the size of the heads, length of the bractlets, and shape of the sepal margin. Moreover, individual plants and even single heads of *E. spinosepalum* may have both entire and toothed sepals (Hoover 1937, R. Stone *in litt.* 1992). The intermediate forms are thus difficult to classify, leading to uncertainties about the range of each taxon.

Historical Distribution.—Typical *Eryngium spinosepalum* was known historically from the Southern Sierra Foothills Vernal Pool Region (Keeler-Wolf *et al.* 1998) in Fresno and Tulare Counties (**Figure II-32**). Hoover and others collected typical *E. spinosepalum* specimens from Orange Cove (Hoover 1937), east of Minkler, Sand Creek Basin, north of Sanger, and Squaw Valley, all in Fresno County (California Natural Diversity Data Base 2001). Specimens were collected from the following Tulare County sites between 1902 and 1954: Exeter, "Kaweah," Lemon Cove, Redstone Park near Visalia, west of Springville, and Woodlake (Jepson 1922, Hoover 1937, California Natural Diversity Data Base 2001). The exact location of Redstone Park (Hoover 1937) is not certain because it is not shown on maps, but it could possibly be in the San Joaquin Valley Vernal Pool Region rather than the Southern Sierra Foothills Vernal Pool Region. Plants intermediate between *E. spinosepalum* and *E. castrense* or *E. vaseyi* were found in the Central Coast, Livermore, and San Joaquin Valley vernal pool regions. The five westernmost locations were in Contra Costa, Merced, San Joaquin, and Stanislaus Counties (Hoover 1937). Additional sites farther east included at least three in Kern County (Hoover 1937, Twisselmann 1967) and one in Fresno County, where specimens were collected in 1971 (California Natural Diversity Data Base 2001).

Current Distribution.—The California Natural Diversity Data Base (2001) currently includes 19 extant occurrences of *Eryngium spinosepalum* and 4 that are known or presumed extirpated; it does not include intermediate populations. In addition, three of the typical populations reported historically are not included in the California Natural Diversity Data Base (2001), but could still be extant. Thus, 26 typical populations have been reported, of which 22 may

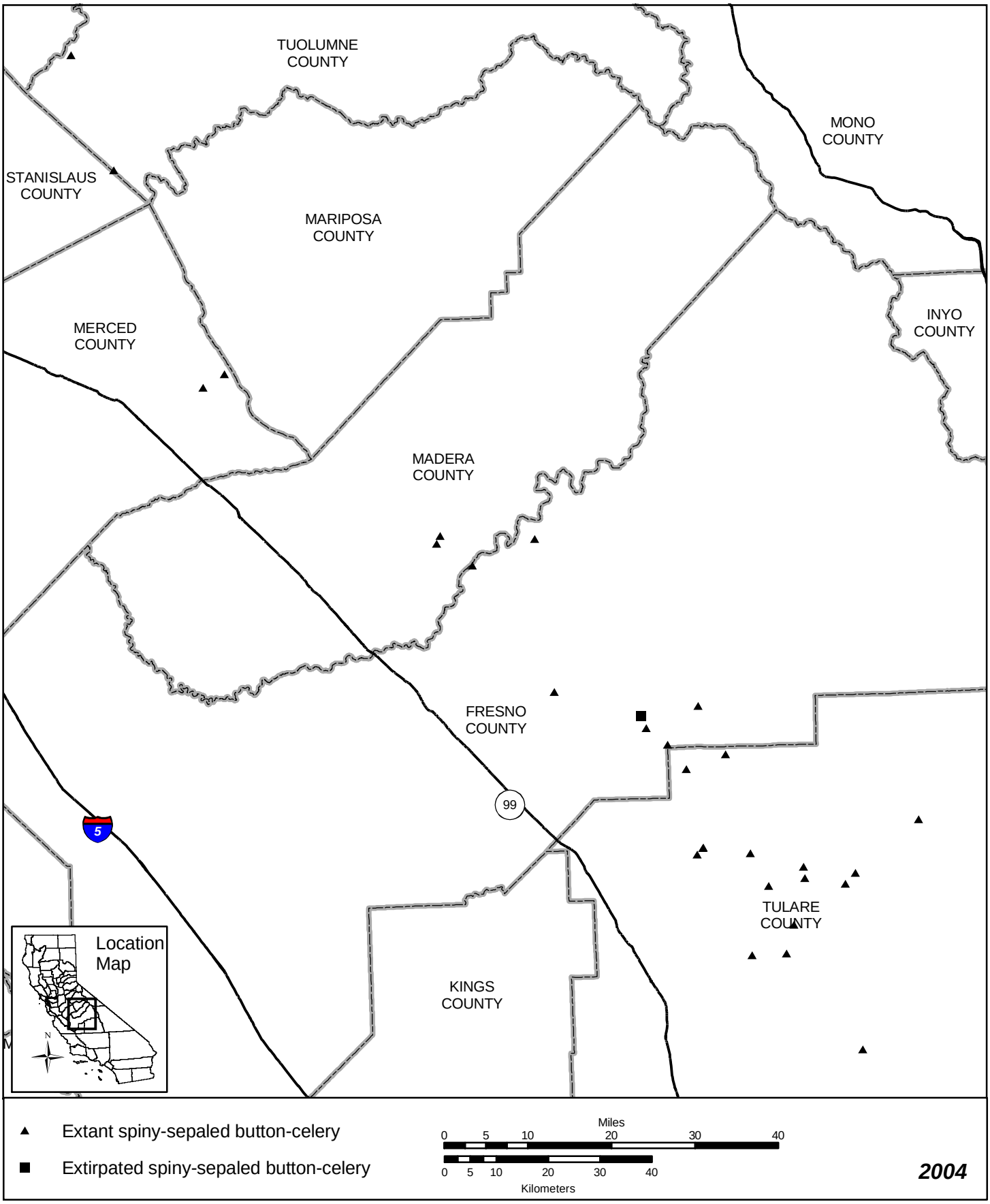

Figure II-32. Distribution of *Eryngium spinosepalum* (spiny-sepaled button-celery).

remain extant. Thirteen of the populations presumed to be extant are in Tulare County, five are in Fresno County, and two each are in Madera and Tuolumne Counties (Jepson 1922, Hoover 1937, California Natural Diversity Data Base 2001). Many populations of this species are isolated, but minor areas of concentration (three to four occurrences) are in the vicinity of Lake Kaweah in Tulare County and in the Orange Cove-Kaktus Korner area spanning the Tulare-Fresno County line. Two sites are known near Seville in Tulare County, and two others are in the Four Corners area of Madera County. According to Keeler-Wolf *et al.* (1998), *E. spinosepalum* is restricted to the Southern Sierra Foothills Vernal Pool Region.

Intermediate forms of *Eryngium* and other populations whose identity has not been confirmed have been reported from a total of 15 sites. Seven of these populations are extant: three in Fresno County (S. Snover *in litt.* 1994), three in Madera County (R. Stone *in litt.* 1992), and one in Merced County (Stebbins *et al.* 1993). The eight historical localities of intermediates (Hoover 1937, Twisselmann 1967, California Natural Diversity Data Base 2001) have not been revisited in 30 to 60 years and may or may not be extant.

Reproduction and Demography.—Unlike most of the vernal pool plants included in this recovery plan, *Eryngium spinosepalum* is a perennial. *Eryngium spinosepalum* flowers in April and May (Skinner and Pavlik 1994). Its pollinators, seed dispersal agents, and population demographics are unknown. As a perennial, population sizes probably do not fluctuate drastically between years, except in response to major disturbances.

Habitat and Community Associations.—*Eryngium spinosepalum* grows in both Northern Hardpan and Northern Claypan vernal pools (Sawyer and Keeler-Wolf 1995), as well as in roadside ditches (Mason 1957), depressions, and swales in annual grassland and oak woodlands (Twisselmann 1967, California Natural Diversity Data Base 2001). Characteristics of pools supporting *E. spinosepalum* have been described only from the Stone Corral Ecological Reserve in Tulare County. There, the species grew in two "swale-like" Northern Claypan Vernal Pools about 0.5 and 2.4 hectares (1.2 and 6.0 acres) in area, respectively. The smaller pool was about 41 centimeters (16 inches) deep, and the larger was more than 46 centimeters (18 inches) deep. Soil pH ranged from 6.1 to 7.1 at various points below the smaller pool and from 7.0 to 7.5 below the larger pool. Population size was in the thousands in the larger pool and in the hundreds in the smaller one (Stebbins *et al.* 1995). Both pools occur on Lewis clay loam over lime-silica hardpan at the rim of the saline-alkali basin (Stone *et al.* 1988).

Sites from which typical *Eryngium spinosepalum* has been reported range in elevation from 107 meters (350 feet) at Stone Corral Ecological Reserve to about 472 meters (1,550 feet) at Squaw Valley (California Natural Diversity Data Base 2001). Intermediate forms of *Eryngium* have been reported from elevations of 67 meters (220 feet) in Merced County (Stebbins *et al.* 1993) to about 1,000 meters (3,281 feet) at Lynns Valley in Kern County (Twisselmann 1967).

Species most frequently associated with *Eryngium spinosepalum* include *Psilocarphus brevissimus*; upland grasses such as *Bromus* spp., *Hordeum marinum* ssp. *gussoneanum* (Mediterranean barley), and *Lolium multiflorum* ; unidentified species of *Plagiobothrys*; and other species of *Eryngium* (California Natural Diversity Data Base 2001). Listed vernal pool plants with which *E. spinosepalum* grows are *Chamaesyce hooveri* and *Orcuttia inaequalis*, both at the Stone Corral Ecological Reserve complex (Stone *et al.* 1988, California Natural Diversity Data Base 2001). An intermediate form of *Eryngium* also grows with *O. inaequalis* in Madera County (R. Stone *in litt.* 1992, J. Stebbins *in litt.* 2000*a*). *Brodiaea insignis* (Kaweah brodiaea), a State-listed endangered species that does not occur in vernal pools, grows with typical *E. spinosepalum* at three sites near Lake Kaweah (California Natural Diversity Data Base 2001).

Reasons for Decline and Threats to Survival.—Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to *Eryngium spinosepalum* are described below.

One former population of *Eryngium spinosepalum* in Fresno County was extirpated by conversion to an orange grove. Another in Tulare County was in an area that has been developed for urban and agricultural uses (California Natural Diversity Data Base 2001).

Specific continuing threats include proposed construction of a new dam at Lake Kaweah, which would inundate one occurrence of *Eryngium spinosepalum* at the east end of the lake (U.S. Army Corps of Engineers 1996, California Natural Diversity Data Base 2001). Road construction and maintenance threaten one Fresno County occurrence and the two in Madera County. A development has been proposed for the single Tuolumne County site (California Natural Diversity Data Base 2001). In addition, many of the other occurrences representing typical *E. spinosepalum* face potential threats. Seven of the 15 extant occurrences are threatened by conversion to intensive agriculture, particularly to citrus groves, or by development for residential or urban uses. Although the pollinating agents for

E. spinosepalum have not yet been determined, if insects are the pollinators a decline in their populations due to habitat loss is a potential problem.

Conservation Efforts.—*Eryngium spinosepalum* has no formal protection at either the Federal or State level. This species was a Federal Category 2 candidate for listing (U.S. Fish and Wildlife Service 1985*c*) until we eliminated that classification (U.S. Fish and Wildlife Service 1996*a*). The California Native Plant Society has considered *E. spinosepalum* to be rare for many years (Smith *et al.* 1980) and currently includes this species on its List 1B, noting that it is endangered in a portion of its range (California Native Plant Society 2001). This species has not been targeted for any particular conservation efforts. The only protected occurrence of *E. spinosepalum* is at the California Department of Fish and Game's Stone Corral Ecological Reserve (Stebbins *et al.* 1995). Three other occurrences are on public land owned by the U.S. Army Corps of Engineers or the California Department of Transportation, but they are not free from threats (California Natural Diversity Data Base 2001).

5. *Gratiola heterosepala* (Boggs Lake Hedge-hyssop)

Taxonomy.—Boggs Lake hedge-hyssop has been known by only one scientific name, *Gratiola heterosepala*, since it was first named by Mason and Bacigalupi (1954). The type locality is Boggs Lake, in Lake County (Mason and Bacigalupi 1954). This species is a member of the figwort family.

Description and Identification.—*Gratiola heterosepala* (**Figure II-33**) is a an erect annual with hollow stems 2 to 10 centimeters (0.8 to 3.9 inches) tall. The stems are mostly hairless, except for a few glandular hairs in the inflorescence. The leaves are opposite and have entire margins. Leaves near the base of the stem are 1 to 2 centimeters (0.4 to 0.8 inch) long and lance-shaped, but the leaves become shorter, wider, and blunt-tipped farther up on the stem. The 6 to 8 millimeters (0.23 to 0.31 inch) long flowers are borne singly in the upper leaf axils. Each corolla has two lips; the tube and upper lip are yellow, whereas the lower lip is white. However, the flowers appear yellow from a distance. The calyx is 4 to 6 millimeters (0.16 to 0.24 inch) long and has five sepals of differing lengths and shapes, giving rise to the specific epithet, *heterosepala* (meaning different sepals). The upper three sepals are united for about one-third of their length; the center sepal is longer than the others. The two lower sepals are separate and have notched tips, in contrast to the blunt tips of the upper sepals. The fruit of *G. heterosepala* is a small, dry, pear-shaped capsule that is about the same length as the calyx. The tiny seeds are oblong and have narrow lengthwise ridges (Mason and Bacigalupi 1954, Mason 1957, Wetherwax 1993).

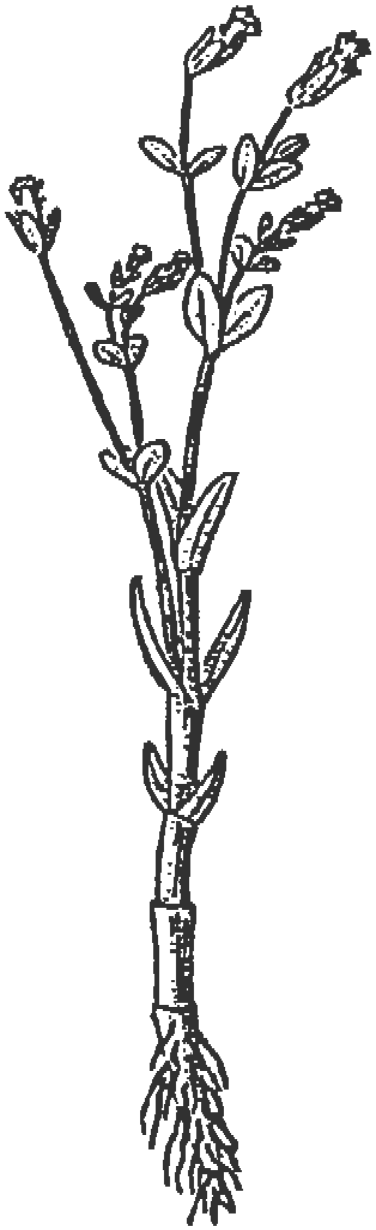

Figure II-33. Illustration of *Gratiola heterosepala* (Boggs Lake hedge-hyssop). (Reprinted from the Jepson Manual, J. Hickman, Ed., 1993, with permission from the Jepson Herbarium. © Regents of the University of California)

Gratiola heterosepala is most similar to *G. ebracteata* (bractless hedge-hyssop). However, in *G. ebracteata* the sepals are longer, pointed, and are separate almost all the way to their bases; all five corolla lobes are white; and the seeds have both lengthwise and crosswise ridges. The other California species, *G. neglecta* (common American hedge-hyssop), has bracts below the calyx, purplish corolla lobes, and a corolla at least twice as long as the calyx (Mason 1957, Wetherwax 1993).

Historical Distribution.—This species was first collected in Lake County in 1923. The exact collection site is uncertain, but probably was Boggs Lake, where the species also was collected in 1929 and 1953 (Mason and Bacigalupi 1954) (**Figure II-34**). Another site was found in Madera County in 1961, then one in Sacramento County in 1977 (California Natural Diversity Data Base 2001). During the 1980's, 20 additional occurrences were discovered in California, plus one in Lake County, Oregon (California Department of Fish and Game 1987*d*). These additional California occurrences included nine in Shasta County; three each in Fresno, Placer, and Sacramento Counties; and one each in Lake and Modoc Counties (California Natural Diversity Data Base 2001). Thus, the historical range included the Lake-Napa, Modoc Plateau, Southeastern Sacramento Valley, and Southern Sierra Foothills vernal pool regions (Keeler-Wolf *et al.* 1998).

Current Distribution.—Currently, *Gratiola heterosepala* is known from 82 extant occurrences in California plus 1 in Oregon. Only one of the historical occurrences is believed to have been extirpated; it was in Sacramento County. In addition to the four vernal pool regions where it was known historically, *G. heterosepala* is now known from the Northeastern and Northwestern Sacramento Valley and the Solano-Colusa vernal pool regions (Keeler-Wolf *et al.* 1998). Additional counties of occurrence are Merced, San Joaquin, Solano, and Tehama (C. Witham *in litt.* 2000*b*, California Natural Diversity Data Base 2001).

The primary area of concentration for *Gratiola heterosepala*, with 32 occurrences (39 percent), is the Modoc Plateau, where occurrences are known from Lassen, Modoc, and Shasta Counties in California and Lake County in Oregon (Kaye *et al.* 1990, B. Corbin *in litt.* 2000, California Natural Diversity Data Base 2001). Two secondary areas of occurrence are the southeastern Sacramento Valley and the northeastern Sacramento Valley, with 17 extant occurrences (20 percent) each. The southeastern Sacramento Valley concentration is in Placer, Sacramento, and San Joaquin Counties, primarily between the cities of Roseville and Elk Grove. The northeastern Sacramento Valley concentration is in the vicinity of Dales, in Tehama County. The Southern Sierra Foothills Vernal Pool Region has six occurrences (7 percent), including four in Fresno County and one

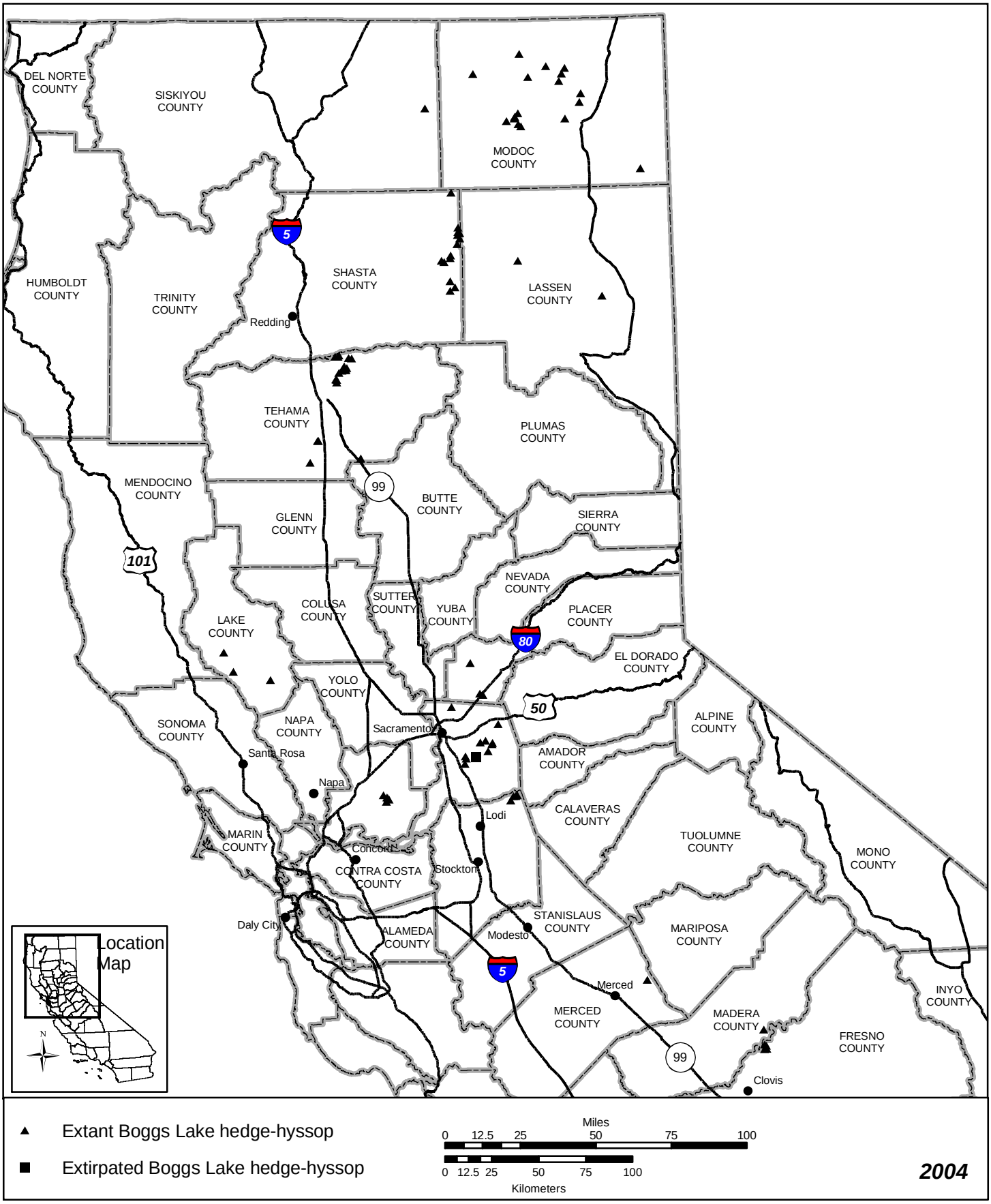

Figure II-34. Distribution of *Gratiola heterosepala* (Boggs Lake hedge-hyssop).

each in Madera (California Natural Diversity Data Base 2001) and Merced (C. Witham *in litt.* 2000*b*) Counties. Five (6 percent) occurrences in Solano County are within the Solano-Colusa Vernal Pool Region. The remaining occurrences include three (4 percent) each in Lake and Tehama Counties, representing the Lake-Napa and Northwestern Sacramento Valley vernal pool regions, respectively (California Natural Diversity Data Base 2001).

Reproduction and Demography.— Most of the life history information regarding *Gratiola heterosepala* comes from an intensive study of the Oregon population by Kaye *et al.* (1990). California plants are morphologically similar to those in Oregon and grow in similar habitats; therefore, the life history of *G. heterosepala* is presumed to be similar in the two states.

The seeds of *Gratiola heterosepala* most likely germinate in response to autumn or winter rains (Kaye *et al.* 1990, Corbin *et al.* 1994). By the time the water recedes the plants already are in bud or in flower; flowering can begin when as much as 5 centimeters (2.0 inches) of water remains (Kaye *et al.* 1990, Corbin *et al.* 1994). Throughout the range of the species, flowers are open between April and August, with those at the highest elevations flowering later (Corbin *et al.* 1994). Each plant typically produces only one or two flowers (Kaye *et al.* 1990, Corbin *et al.* 1994), which mature into fruits within 1 to 2 weeks after flowering begins. The plants disappear quickly after seed-set (Corbin *et al.* 1994). Kaye *et al.* (1990) determined that *Gratiola heterosepala* is self-compatible and does not require insects for pollination. During their one-season study in Oregon, plants set equal amounts of seed whether or not insects were excluded. Moreover, insects were not observed visiting the flowers in natural settings (Kaye *et al.* 1990). The Oregon population averaged about 150 seeds per fruit, but the number of fruits per plant was not reported. The fruits showed no insect damage (Kaye *et al.* 1990). Seed dispersal agents are not known, and seed longevity in the soil has not been tested. However, seeds in one population on the Lassen National Forest (Shasta County) apparently remained dormant for 3 years, which was the interval between observations of growing plants (Corbin *et al.* 1994).

California populations of *G. heterosepala* range in size from only a few individuals to over 1 million (California Natural Diversity Data Base 2001). As observed with other vernal pool annuals, population numbers fluctuate greatly from year-to-year (Corbin *et al.* 1994). The Boggs Lake population declined from 1,000 individuals in 1981 to zero in 1989 and remained at zero until 1997, when 5 plants were found (Serpa 1993, California Natural Diversity Data Base 2001). The plants were widely scattered at Boggs Lake historically, with individuals growing isolated from each other (Mason and Bacigalupi 1954). At

the one Vina Plains occurrence, the density of *G. heterosepala* was 67.4 plants per square meter (6.3 per square foot) in 1995 (Alexander and Schlising 1997).

Habitat and Community Associations.—*Gratiola heterosepala* occurs in vernal pools and in marshy areas on the margins of reservoirs and lakes, as well as in man-made habitats such as borrow pits and cattle ponds (Kaye *et al.* 1990, Corbin *et al.* 1994, California Natural Diversity Data Base 2001). It has been found in several types of vernal pools, including Northern Basalt Flow, Northern Claypan, Northern Hardpan, Northern Volcanic Ashflow, and Northern Volcanic Mudflow (Sawyer and Keeler-Wolf 1995). Occupied wetlands are amongst annual grassland, *Quercus* woodland, *Juniperus* (juniper) woodland, or coniferous forest (California Department of Fish and Game 1987*d*, Kaye *et al.* 1990, Corbin *et al.* 1994, California Natural Diversity Data Base 2001).

Although *Gratiola heterosepala* most often occurs on the margins of lakes and pools where water does not become too deep (Corbin *et al.* 1994), it also has been found in the beds of deeper vernal pools (California Natural Diversity Data Base 2001). Clay is the most frequently encountered soil underlying occupied habitats, although loam and loamy sand also have been noted. Most sites are underlain by an impermeable layer (Corbin *et al.* 1994, California Natural Diversity Data Base 2001). Kaye and others (1990) noted that in juniper woodlands, *G. heterosepala* occurred on acidic soils with a pH of about 5. Some northern California sites are on slightly acidic soils, but soil pH has not been tested in other areas (Corbin *et al.* 1994).

Known *Gratiola heterosepala* sites in California range in elevation from 8 meters (25 feet) in Solano County to at least 1,576 meters (5,170 feet) in Modoc County (B. Corbin *in litt.* 2000, California Natural Diversity Data Base 2001). A reported occurrence of *G. heterosepala* at North Emerson Lake Modoc County is at 2,400 meters (7,900 feet) in elevation (California Natural Diversity Data Base 2001), but several species experts have revisited the site and found only *G. ebracteata* (B. Corbin *in litt.* 2000, G. Schoolcraft *in litt.* 2000). The elevation of the Lake County, Oregon, occurrence is 1,634 meters (5,340 feet) (Kaye *et al.* 1990).

The most frequent associate of *Gratiola heterosepala* is *G. ebracteata* (California Natural Diversity Data Base 2001); the latter may form dense colonies containing only a few individuals of *G. heterosepala* (Mason and Bacigalupi 1954). Other typical associates, in order of frequency, are *Plagiobothrys stipitatus*, *Downingia bicornuta* (two-horned downingia), *Orcuttia tenuis*, and *Eleocharis macrostachya*. Several of the rare, threatened, and endangered plants in this recovery plan co-occur with *G. heterosepala*; these taxa include *O. tenuis* at 20 sites, *Tuctoria greenei* at 2 sites, and *Castilleja campestris* ssp. *succulenta*,

O. pilosa, *Chamaesyce hooveri*, *Legenere limosa*, *Myosurus minimus* ssp. *apus*, *Navarretia leucocephala* ssp. *plieantha*, *O. viscida*, and *O. inaequalis* at 1 site each (Corbin B. 2000, California Natural Diversity Data Base 2001).

Reasons for Decline and Threats to Survival.—Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to *Gratiola heterosepala* are described below.

Habitat conversion for housing was responsible for the extirpation of one *Gratiola heterosepala* population in Sacramento County (California Natural Diversity Data Base 2001). Cattle trampling destroyed many immature plants at the Oregon occurrence (Kaye *et al.* 1990). Four occurrences have been disturbed but not extirpated by hydrological alterations such as excavation and damming, and another three by surface disturbances such as discing and grading (California Natural Diversity Data Base 2001). Urban growth through residential development, shopping center construction, and landfill expansion threatens seven of the populations in Placer and Sacramento Counties (California Natural Diversity Data Base 2001). Competition from *Taeniatherum caput-medusae* potentially threatens *G. heterosepala* at five sites of occurrence on the Modoc Plateau (Corbin *et al.* 1994). Nine of the extant occurrences contain fewer than 100 individuals at their maximum, and several are undergoing rapid declines (California Natural Diversity Data Base 2001). These populations are sufficiently small that they are in danger of extirpation from chance events (Menges 1991).

Livestock grazing may or may not pose a threat to the survival of *Gratiola heterosepala*. Although 48 California occurrences are subject to grazing by cattle, sheep, horses, or feral pigs (Corbin *et al.* 1994, B. Corbin *in litt.* 2000, California Natural Diversity Data Base 2001), only 6 of those were reported to have heavy grazing or severe trampling (California Natural Diversity Data Base 2001). Trampling and herbivory can be detrimental if they occur before seed set or if use is concentrated in a small area. However, moderate grazing is believed to be a compatible use if it occurs after *G. heterosepala* sets seed (Mason and Bacigalupi 1954, California Department of Fish and Game 1987*d*). Directed research is necessary to establish appropriate use levels and seasons. The 47 occurrences administered by the U.S. Forest Service, U.S. Fish and Wildlife Service and the U.S. Bureau of Land Management potentially are subject to disturbance or destruction from livestock grazing and trampling, activities associated with logging, assorted recreational uses, hydrological alterations, road construction, fire suppression, weed competition, and herbicide drift (Corbin *et al.*

1994, California Natural Diversity Data Base 2001). However, management guidelines proposed by the agencies (Corbin *et al.* 1994) (see also "Conservation Efforts" below) would mitigate such disturbances.

Conservation Efforts.—*Gratiola heterosepala* has no Federal listing status. It was listed as endangered by California in 1978 (California Department of Fish and Game 1991) and is a candidate for listing in Oregon (Skinner and Pavlik 1994). It was included in the California Native Plant Society's first list of rare and endangered plants (Powell 1974). In the most recently published listing by this group (Skinner and Pavlik 1994), *G. heterosepala* was placed on List 1B. The U.S. Forest Service formerly considered *G. heterosepala* to be "sensitive" but has reclassified it as a "special interest plant" because it is more abundant than previously thought (B. Corbin *in litt.* 2000). The U.S. Bureau of Land Management classifies *G. heterosepala* as a "special status" species (Corbin *et al.* 1994).

Twelve (14 percent) of the known occurrences of *Gratiola heterosepala* are in nature reserves. Seven of those are on ecological reserves operated by the California Department of Fish and Game, including four at Dales Lake in Tehama County, two at Thomes Creek in Tehama County, and one at Big Table Mountain in Fresno County. Nature reserves owned by private conservation organizations support another five occurrences, including two at Big Table Mountain Preserve in Fresno County (one of which is partially on Federal land) and one each at Boggs Lake Preserve in Lake County, Vina Plains Preserve in Tehama County, and Jepson Prairie Preserve in Solano County. When The Nature Conservancy managed the Boggs Lake Preserve, they erected fences around colonies of *G. heterosepala* to exclude horses and deer (Serpa 1993). Volunteers conduct annual monitoring and searches for *G. heterosepala* and other rare plants at the Boggs Lake, Jepson Prairie, and Vina Plains preserves (Baldwin and Baldwin 1991, California Natural Diversity Data Base 2001).

Forty-seven (57 percent) of *Gratiola heterosepala* occurrences are on Federal land, which does not necessarily mean that they are protected from future disturbance. Among the occurrences on Federal land, 32 are on the Lassen and Modoc National Forests in Lassen, Modoc, and Shasta Counties. Two of these occurrences are in areas with special designations, the Murken Botanical Special Interest Area and the South Warner Wilderness, where many uses are restricted (Corbin *et al.* 1994). Another 15 occurrences are at least partially on lands administered by the U.S. Bureau of Land Management in five different resource areas. These occurrences include six in Tehama County, five in Shasta County, two in Fresno County (one of which is partially on a private nature reserve), and one each in Lassen County, California, and Lake County, Oregon (Kaye *et al.*

1990, Corbin *et al.* 1994, B. Corbin *in litt.* 2000, California Natural Diversity Data Base 2001). Four of the occurrences on U.S. Bureau of Land Management property are in wilderness study areas (Corbin *et al.* 1994) and may be afforded additional protection if Congress designates those areas as official wilderness. The U.S. Forest Service and the U.S. Bureau of Land Management developed a formal conservation strategy for *G. heterosepala* (Corbin *et al.* 1994) on lands they administer in northeastern California. Their goal was to protect 90 percent of the plants and sites from direct disturbance and hydrological alterations over a 10-year period. Additional conservation measures identified in the plan were comparisons of grazed and control areas, monitoring, surveys, and acquisition through land exchanges. However, due to funding priorities and the reclassification from "sensitive" status, intensive monitoring has been discontinued (B. Corbin *in litt.* 2000). The agencies have fenced several sites in northeastern California (Corbin *et al.* 1994, B. Corbin *in litt.* 2000) and in Fresno County (California Department of Fish and Game 1991, A. Franklin *in litt.* 1993) to prevent cattle from trampling *G. heterosepala*. *Gratiola heterosepala* also may benefit from a grazing-management experiment being conducted at Big Table Mountain in Fresno County (see discussion under *Castilleja campestris* ssp. *succulenta*).

Numerous groups and individuals, including the U.S. Forest Service, and U.S. Bureau of Land Management participated in surveys for this species over the past decade, resulting in the identification of many new populations (Kaye *et al.* 1990, Corbin *et al.* 1994, B. Corbin *in litt.* 2000, California Natural Diversity Data Base 2001). Some of the surveys were in Oregon, where the Oregon Department of Agriculture and the U.S. Bureau of Land Management also funded studies to determine the breeding system of *Gratiola heterosepala* (Kaye *et al.* 1990).

6. *Juncus leiospermus* var. *ahartii* (Ahart's Dwarf Rush)

Taxonomy.—This taxon was first described in 1986 as *Juncus leiospermus* var. *ahartii* (Ertter 1986), although it had been recognized as unique more than 10 years earlier (L. Ahart *in litt.* 1986). The type locality is on the Ahart Ranch in Butte County, northeast of Honcut (Ertter 1986). Ahart's dwarf rush is a member of the rush family (Juncaceae) and is also known by the common name Ahart's rush (U.S. Fish and Wildlife Service 1996*b*).

Description and Identification.—*Juncus leiospermus* var. *ahartii* is a small, reddish, grass-like plant from 2 to 6 centimeters (0.8 to 2.4 inches) tall. Each plant may produce as many as 100 slender stems from its base, but the individual stems do not branch. The grass-like leaves arise from the base and are about half as long as the stems. Each stem produces only a single, tiny flower at

its tip. The 6 to 10 petal-like parts per flower are not differentiated into sepals and petals but instead are all similar in appearance. They are lance-shaped, 2.4 to 3.6 millimeters (0.09 to 0.14 inch) long, and are maroon with a green or reddish stripe down the center. The flowers have two to five stamens with anthers greater than 0.7 millimeter (0.03 inch) long and a style 0.9 to 4 millimeters (0.04 to 0.16 inch) long. The fruit is a spherical or egg-shaped capsule 2.5 to 4.5 millimeters (0.10 to 0.18 inch) long, which contains many tiny, smooth seeds. The diploid chromosome number of *J. leiospermus* var. *ahartii* is 32 (Ertter 1986, Swab 1993).

The most closely related species, *Juncus leiospermus* var. *leiospermus* (Red Bluff dwarf rush), has several flowers clustered together. *J. uncialis* (inch-high dwarf rush) is similar to *J. leiospermus* var. *ahartii* in that it has only one flower per stem, but the former is less than 3.5 centimeters (1.4 inches) tall and has a shorter style and anthers. Other annual rushes have one or more of the following characteristics: thread-like stems, flowers in heads, shorter styles and anthers, or conspicuous ridges on the seeds (Ertter 1986, Swab 1993).

Historical Distribution.—When it was named, *Juncus leiospermus* var. *ahartii* was known from four occurrences in two areas. Three of the four historical occurrences were on the Ahart Ranch in Butte County, where this species occurred in about 10 separate pools (**Figure II-35**). The fourth occurrence was near the town of Jenny Lind in Calaveras County (Ertter 1986). The Ahart Ranch is in the Northeastern Sacramento Valley Vernal Pool Region, and Jenny Lind is in the Southeastern Sacramento Valley Vernal Pool Region (Keeler-Wolf *et al.* 1998).

Current Distribution.—This taxon is believed to remain extant on the Ahart Ranch and near Jenny Lind, although these sites have not been revisited since 1986. In addition, *Juncus leiospermus* var. *ahartii* has been found at the Oroville Municipal Airport in Butte County, near the Lincoln Airport in Placer County (California Natural Diversity Data Base 2001), and in the Buffalo Creek area of Sacramento County (California Natural Diversity Data Base unprocessed data). Thus, a total of seven occurrences are presumed to be extant. All are in either the Northeastern Sacramento Valley or the Southeastern Sacramento Valley vernal pool regions (Keeler-Wolf *et al.* 1998).

Reproduction and Demography.—Very little information concerning *Juncus leiospermus* var. *ahartii* has been reported. It is an annual that flowers in April and May (L. Ahart *in litt.* 1986, California Natural Diversity Data Base 2001). Germination dates and conditions are unknown. *Juncus leiospermus* var. *ahartii* is wind-pollinated (Ertter 1986). In years of low rainfall, each plant

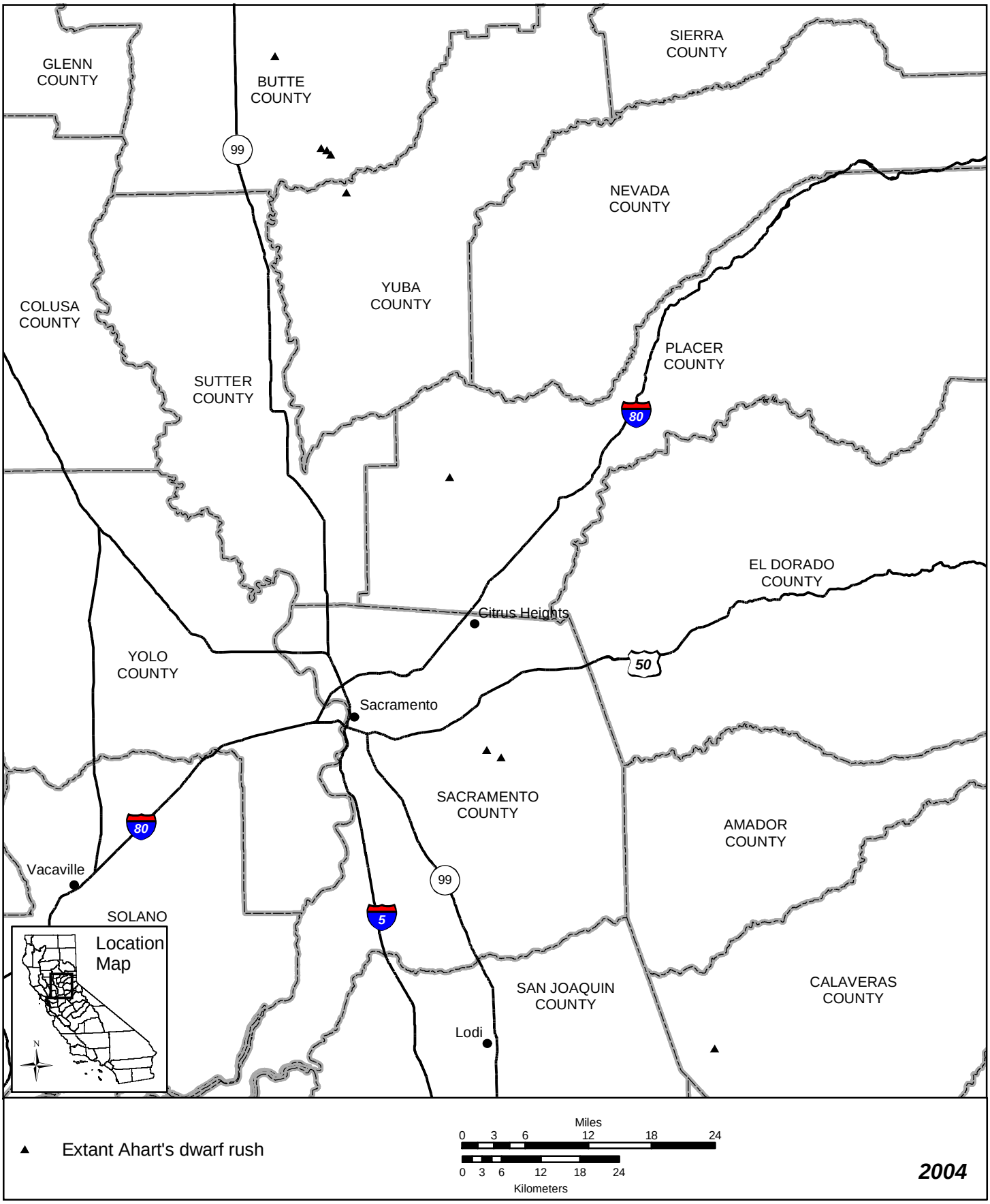

Figure II-35. Distribution of *Juncus leiospermus* var. *ahartii* (Ahart's dwarf rush).

typically has only a single stem. Moreover, larger populations have been observed in wet than in dry years (L. Ahart *in litt.* 1986).

Habitat and Community Associations.—*Juncus leiospermus* var. *ahartii* occurs in the Northern Basalt Flow, Northern Claypan, Northern Hardpan, and Northern Volcanic Mudflow vernal pool types (Sawyer and Keeler-Wolf 1995). The surrounding plant communities were not mentioned, except that the vernal pools at the type locality were in a grain field. Microhabitats from which the plants have been reported are the edges of vernal pools, bottoms of intermittent drainages, and on pocket gopher (*Thomomys* species) and ground squirrel (*Spermophilus* species) mounds (L. Ahart *in litt.* 1986, Ertter 1986, California Natural Diversity Data Base 2001). Soils underlying the pools typically are acidic clays (Ertter 1986). Known occurrences are at about 30 to 90 meters (100 to 300 feet) in elevation (California Natural Diversity Data Base 2001).The most frequent associate is *J. uncialis* (L. Ahart *in litt.* 1986, Ertter 1986, California Natural Diversity Data Base 2001).

Reasons for Decline and Threats to Survival.——Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to *Juncus leiospermus* var. *ahartii* are described below. Expansion of the runway at Oroville Municipal Airport destroyed part of the *Juncus leiospermus* var. *ahartii* population (California Natural Diversity Data Base 2001). The type locality for *J. leiospermus* var. *ahartii* was dry-farmed in the 1970's. However, the disturbance created by plowing and the associated reduction in competing species apparently were beneficial to this taxon. Farming has since ceased in the area (L. Ahart *in litt.* 1986, Ertter 1986), but the response of *J. leiospermus* var. *ahartii* has not been determined. The Lincoln site has been degraded by off-road vehicle use, road construction, livestock grazing, and unspecified “disturbance” from adjacent developments (California Natural Diversity Data Base 2001). Other populations may have been destroyed before their discovery because much of the suitable habitat for *J. leiospermus* var. *ahartii* has been converted to agriculture and housing (Ertter 1986).

The Lincoln occurrence is on the site of a proposed housing development, which would destroy all of the occupied pools there (California Natural Diversity Data Base 2001). Random events coupled with small population size (Menges 1991) are a potential threat to three of the occurrences, which range in size from 45 to about 120 individuals (L. Ahart *in litt.* 1986, California Natural Diversity Data Base 2001).

Conservation Efforts.—*Juncus leiospermus* var. *ahartii* was a Category 1 candidate for Federal listing even before it was officially named (U.S. Fish and Wildlife Service 1983b). However, in 1996 candidate status was withdrawn because insufficient information was available to propose this taxon for listing, and existing data suggested that it was not in danger of extinction throughout a significant portion of its range (U.S. Fish and Wildlife Service 1996*b*). *Juncus leiospermus* var. *ahartii* has no State status. The includes it on List 1B and considers it to be rare and of limited distribution, but not in danger of extinction (California Native Plant Society 2001). The only conservation measure implemented for this taxon to date was the establishment of a preserve near the Oroville Municipal Airport (California Natural Diversity Data Base 2001).

7. *Legenere limosa* (Legenere)

Taxonomy.—Greene (1890) originally published the scientific name *Howellia limosa* for legenere. He gave the type locality only as "the lower Sacramento" (Greene 1890, p. 81). Based on label information from Greene's collections, the type locality has been further described as "Fields of the lower Sacramento Valley near Elmira, Solano County, California" (McVaugh 1943, p. 14). McVaugh (1943) determined that this species differed sufficiently from *Howellia* to be transferred to a new genus, *Legenere*. Thus, the currently accepted name for this species is *Legenere limosa*. Legenere is the only species in its genus (Morin 1993), which is in the bellflower family (Campanulaceae). Another common name for this species is Greene's legenere (Morin and Niehaus 1977, Holland 1984).

Description and Identification.—*Legenere limosa* is an inconspicuous annual. The entire plant is hairless. The main stems are 10 to 30 centimeters (3.9 to 11.8 inches) long and decumbent, although any branches are erect. Extra roots often arise from the lower nodes. The leaves, which are produced underwater, are 1 to 3 centimeters (0.4 to 1.2 inches) long and narrowly triangular; they fall off the plant before flowers appear. The egg-shaped or oval bracts are 6 to 12 millimeters (0.24 to 0.47 inch) long and remain throughout the flowering period. A single flower arises above each bract. *Legenere limosa* flowers may or may not have corollas, and a single plant can produce both types of flowers. When present, the corollas are white or yellowish, 3.5 to 4 millimeters (0.14 to 0.16 inch) long, and two-lipped. The upper two corolla lobes are narrower than the lower three, and the corolla tube is slit on the upper side. The stamens are joined to form a tubular structure. The flower stalks are very slender and elongate as the fruit matures, reaching a final length of as much as 3 centimeters (1.2 inches). *Legenere limosa* has a cylindrical capsule 6 to 10 millimeters (0.24 to 0.39 inch) long, which splits open only at the tip. Each capsule contains up to 20 seeds,

which are about 1 millimeter (0.04 inch) long, brown, smooth, and shiny (McVaugh 1943, Mason 1957, Abrams and Ferris 1960, Holland 1984, Morin 1993). The chromosome number of *L. limosa* has not been determined.

The genera most likely to be confused with *Legenere limosa* are *Howellia, Downingia*, *Lobelia*, and *Porterella*. Both *Howellia* and *Downingia* have capsules that split along the sides, whereas the capsule of *L. limosa* opens at the tip. Moreover, *Downingia* flowers are not stalked. The *Lobelia* species in California have either red or blue flowers and spherical fruits, as opposed to the whitish flowers and cylindrical fruits of *L. limosa*. *Porterella* has showy blue flowers with yellow or white marks at the base of the corolla lobes, and it occurs at higher elevations than *L. limosa* (Morin and Niehaus 1977, Holland 1984, Morin 1993).

Historical Distribution.—Between 1890 and 1984, *Legenere limosa* had been reported from 12 sites in 8 counties encompassing 6 vernal pool regions. The historical counties of occurrence were Solano (three sites, including the type locality), Lake and Sacramento (two sites each), and Napa, Placer, San Mateo, Sonoma, and Stanislaus Counties (one site each) (Hoover 1937, Mason 1957, Rubtzoff and Heckard 1975, Holland 1984) (**Figure II-36**). These sites were located in the Central Coast, Lake-Napa, Santa Rosa, Solano-Colusa, Southeastern Sacramento Valley, and Southern Sierra Foothills vernal pool regions (Keeler-Wolf *et al.* 1998). As of 1984 the only three populations believed to remain extant were in Napa, Placer, and Sacramento Counties (Holland 1984).

Current Distribution.—Since 1984, *Legenere limosa* has been rediscovered at several historical sites and has been found at numerous new locations. During that time, the type locality and six other occurrences have been extirpated. Among the 42 occurrences presumed to be extant, 20 are in Sacramento County, including 9 in the vicinity of Elk Grove and 6 in the vicinity of the former Mather Air Force Base. Another area of concentration, with 10 extant occurrences, is near Dozier in Solano County. Other counties where this species is presumed to remain are Lake, Napa, Placer, San Joaquin, San Mateo, Shasta, and Tehama (Skinner and Pavlik 1994, California Natural Diversity Data Base 2001). The vernal pool regions (Keeler-Wolf *et al.* 1998) where *Legenere limosa* remains extant are Lake-Napa, Northeastern Sacramento Valley, Northwestern Sacramento Valley, Santa Rosa, Solano-Colusa, and Southeastern Sacramento Valley. It has been extirpated from the Southern Sierra Foothills Vernal Pool Region. Please refer to the Draft Santa Rosa Plains Recovery Plan (in development) for information regarding occurrences within the Santa Rosa vernal pool region, as identified by Keeler-Wolf *et.al*. (1998). The Central Coast Vernal Pool Region occurrence in San Mateo County has not been rediscovered

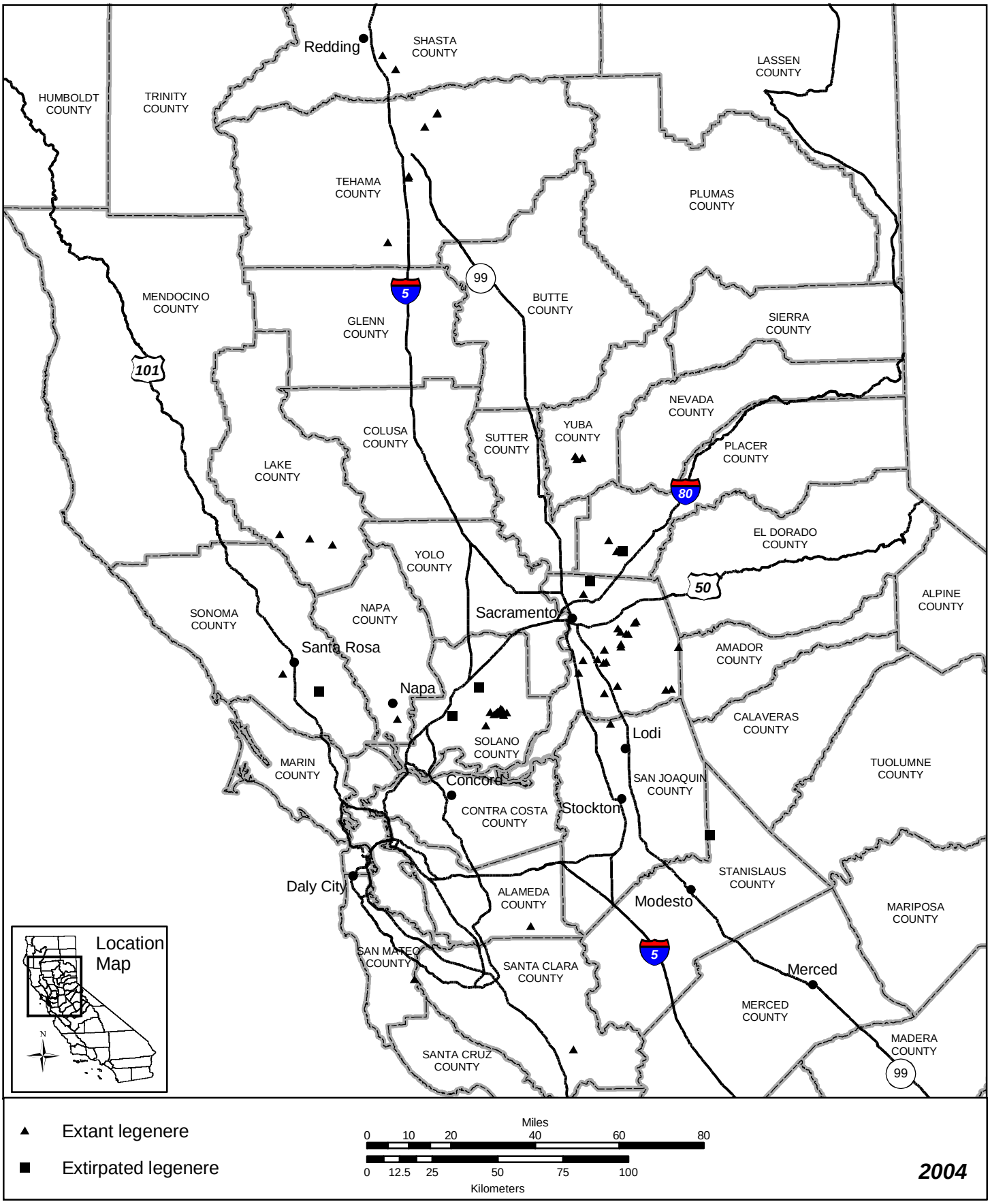

Figure II-36. Distribution of *Legenere limosa* (legenere).

since 1906 but is presumed to be extant because suitable habitat remains in the area (California Natural Diversity Data Base 2001).

Reproduction and Demography.—*Legenere limosa* seeds germinate between late February and April. The specific conditions necessary for seed germination are unknown. The plants grow through the standing water; as the water evaporates or recedes, *L. limosa* stems may collapse onto the lake bottom or become caught on taller, stronger plants (Holland 1984). *L. limosa* flowers during April, May, or June (Morin and Niehaus 1977, Holland 1984, Skinner and Pavlik 1994). Pollination in *L. limosa* has not been studied, but the small, inconspicuous flowers suggest that it may be self-pollinated (Holland 1984). By late June, each plant typically produces 6 to 10 capsules containing several hundred seeds each. Seed dispersal agents are unknown but may include gravity, water, and waterfowl. Most populations contain densities of less than one plant per square meter (10.8 square feet) (Holland 1984). *Legenere limosa* is even more variable than are other vernal pool annuals; entire populations have disappeared for decades, then reappeared (Holland 1984, California Natural Diversity Data Base 2001). Thus, a persistent soil seed bank most likely exists. Survival rates and other aspects of demography have not been investigated.

Habitat and Community Associations.—*Legenere limosa* grows in a variety of habitats including vernal pools, vernal marshes, artificial ponds, and floodplains of intermittent streams. Occupied vernal pool types include Northern Basalt Flow, Northern Claypan, Northern Hardpan, Northern Volcanic Ashflow, and Northern Volcanic Mudflow (Sawyer and Keeler-Wolf 1995). The surrounding plant community may be grassland, open woodland, or hardwood forest containing *Quercus* species (oaks) or *Aesculus californica* (California buckeye). At one site, *L. limosa* grows in both a vernal pool and the adjacent grassland (California Natural Diversity Data Base 2001). The vernal pools and lakes supporting *L. limosa* vary in size from about 4 square meters (43 square feet) to 41 hectares (100 acres) (Holland 1984, California Natural Diversity Data Base 2001). When it occurs in large pools and vernal lakes, *L. limosa* grows only in the shallower areas (less than 20 centimeters [8 inches] deep) (Holland 1984). Substrates in occupied areas may have been deposited by streams or volcanic flows. Soils underlying the pools themselves typically are shallow, acidic clays with few stones (Holland 1984). *Legenere limosa* has been reported from elevations ranging from 3 meters (10 feet) in Solano County to 884 meters (2,900 feet) in Lake County (California Natural Diversity Data Base 2001).

Legenere limosa occurs most often with *Lasthenia glaberrima* and *Eleocharis macrostachya*, and to a lesser extent with *Gratiola heterosepala* and *Downingia pusilla*. In addition to *Gratiola heterosepala*, other plants in this recovery plan

that co-occur with *Legenere limosa* are *Navarretia leucocephala* ssp. *plieantha*, and *Orcuttia tenuis* (California Natural Diversity Data Base 2001 and unprocessed data).

Reasons for Decline and Threats to Survival.—Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to *Legenere limosa* are described below.

Of the four occurrences of *Legenere limosa* known to be extirpated, two were destroyed by conversion to agriculture, one by changes in hydrology, and one by urban development (Holland 1984, California Natural Diversity Data Base 2001). Several sites where the species still occurs have been degraded by discing or other agricultural practices, inappropriate livestock grazing, dirt biking, and trash dumping (California Natural Diversity Data Base 2001). The San Mateo County site has been subjected to logging and hydrological changes; *L. limosa* has not been observed there in over 90 years (Holland 1984). *Legenere limosa* occurred at Boggs Lake in the 1950's but has not been seen there since (Rubtzoff and Heckard 1975, Holland 1984, California Natural Diversity Data Base 2001), even though suitable habitat remains.

About one-third of the extant occurrences of *Legenere limosa* are in areas slated for commercial or residential development (Holland 1984, California Natural Diversity Data Base 2001). In fact, some of the populations extant in 1983 already may have been destroyed by development, but they have not been visited since that time. More than one-third of populations are subject to livestock grazing (California Natural Diversity Data Base 2001), but few appear to be declining. Holland (1984) indicated that “light” grazing during the winter and early spring did not seem to be detrimental to *L. limosa*. Competition from *Phyla nodiflora* is a threat at one Solano County site (California Natural Diversity Data Base 2001). If insects are involved in pollinating *L. limosa*, a decline in insect populations poses a potential threat.

Conservation Efforts.—*Legenere limosa* has no Federal or State status. It has been included on California Native Plant Society lists of rare and endangered species for 25 years (Powell 1974) and is currently on List 1B because it is “endangered throughout its range” (Skinner and Pavlik 1994).

Holland (1984) conducted a status survey of *Legenere limosa* in 1983 with funding from the County of Sacramento, R.C. Fuller Associates, and The Nature

Conservancy. He confirmed that several historical populations no longer persisted. New populations of this species were discovered during pre-project surveys and during searches by The Nature Conservancy volunteers (Holland 1984, California Natural Diversity Data Base 2001).

Eighteen occurrences of *Legenere limosa* are (or were) on nature preserves or publicly-owned lands. Five occurrences are known currently from the Jepson Prairie Preserve in Solano County, two from the nearby Calhoun Cut Ecological Reserve, and two from the Dales Lake Ecological Reserve. *Legenere limosa* was known from Boggs Lake before the preserve was established, but it has not been rediscovered in that area for over 40 years (Holland 1984). *Legenere limosa* occurs in abundance in several vernal pools on the Valensin Ranch Property in Sacramento County owned and managed by The Nature Conservancy (Marty, unpub.data). A population of *L. limosa* was also discovered in a restored pool on Beale Air Force Base in Yuba County, California (Marty, unpub. data.). Two occurrences, at Hog Lake and on the Stillwater Plains, are on property administered by the U.S. Bureau of Land Management. Sacramento County owns land supporting three occurrences of *L. limosa*; one is at a wastewater treatment plant, and the other two are in county parks. Finally, one occurrence is on land owned by the Sacramento Municipal Utility District (California Natural Diversity Data Base 2001). However, mere occurrence on public land is not a guarantee of protection. Only the preserves and the U.S. Bureau of Land Management occurrences are managed to promote the continued existence of *L. limosa* and other rare species. As of 1991, one Sacramento County developer had plans to preserve several pools containing *L. limosa* when he developed the property (California Natural Diversity Data Base 2001).

8. *Myosurus minimus* ssp. *apus* (Little Mousetail)

Taxonomy.—Little mousetail was first named by Greene (1885) as *Myosurus minimus* var. *apus.* The type specimen of little mousetail was collected "from the table-lands back of San Diego" (Greene 1885, p. 277). Campbell (1952) changed the rank of little mousetail from a variety to a subspecies, resulting in the new combination *Myosurus minimus* ssp. *apus*, which is in use today. This subspecies is believed to have originated as a hybrid between *Myosurus minimus* ssp. *filiformis* (thread-like mousetail) and *Myosurus sessilis* (sessile mousetail); *Myosurus minimus* var. *apus* is now self-perpetuating and therefore worthy of recognition as a separate taxon (Mason 1957, Stone 1959). However, *Myosurus minimus* var. *apus* may cross with *Myosurus sessilis* or with other mousetails and the hybrids then may interbreed again, resulting in a series of intermediates that are difficult to identify (Campbell 1952, Stone 1959) and

that may not warrant taxonomic recognition (A. Whittemore *in litt.* 1993). Mousetails are members of the buttercup family (Ranunculaceae).

Description and Identification.—*Myosurus minimus* ssp. *apus* (**Figure II-37**) is a tiny, tufted annual lacking showy flowers. Both the leaves and the scapes originate from base of the plant. The thread-like or very narrow leaves are only 2 to 9 centimeters (0.8 to 3.5 inches) tall, and the cylindrical scapes are even shorter (at most 7 centimeters [2.8 inches] long). Each scape bears a single, inconspicuous flower consisting of five to ten greenish-white sepals, three to five greenish-white petals, about 10 stamens, and 70 or more pistils. The sepals have a flattened, erect portion 2.5 to 3.5 millimeters (0.10 to 0.14 inch) long and a shorter spur pointing downward. The petals are shorter than the sepals and do not have spurs. *Myosurus minimus* ssp. *apus* has achenes that are more or less rectangular, 0.75 to 2 millimeters (0.03 to 0.08 inch) long, and have a beak no more than 0.5 millimeter (0.02 inch) long protruding upward from one side. The achenes cover almost the entire length of the scape and the beaks are closely appressed to the scape (Campbell 1952, Mason 1957, Wilken 1993). The diploid chromosome number of *M. minimus* ssp. *apus* is 16 (Stone 1957 as cited in Stone 1959).

Myosurus minimus ssp. *minimus* (common mousetail) and *M. minimus* ssp. *filiformis* have scapes taller than their leaves, and the achenes are only in the upper part of the scape. *Myosurus sessilis* has shorter spurs on the sepals than does *M. minimus* ssp. *apus*, only five stamens per flower, and the achene beaks project outward from the scape (Campbell 1952). *Myosurus minimus* ssp. *alopecuroides* (foxtail mousetail) also has outward-projecting beaks (Stone 1959). Other taxa of *Myosurus* are differentiated by their scape length in relation to leaf length, achene shape, outcurved beaks, or tendency to drop their flower parts and achenes when they are mature, which *M. minimus* ssp. *apus* does not (Campbell 1952, Mason 1957, Wilken 1993).

Historical Distribution.—*Myosurus minimus* ssp. *apus* was first collected in 1882. The typical form was known historically from southern California (Campbell 1952), occurring only in the San Diego and Western Riverside County vernal pool regions (Keeler-Wolf *et al.* 1998) (**Figure II-38**). Campbell (1952) also mentioned collections of plants that differed somewhat from those in southern California but were more similar to *M. minimus* ssp. *apus* than to other taxa. These collections were from Alameda, Fresno, Merced, San Benito, San Luis Obispo, and Stanislaus Counties, plus one site that was along the border of Colusa and Glenn Counties. Stone (1959) collected specimens that he attributed to this taxon in Colusa, Contra Costa, Kern, and Stanislaus Counties. Whittemore

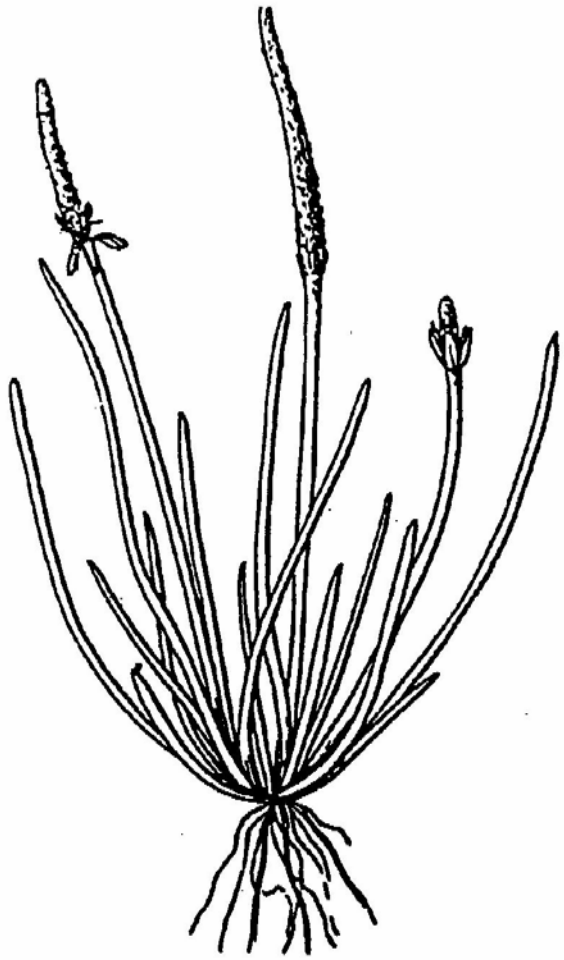

Figure II-37. Illustration of *Myosurus minimus* var. *apus* (little mousetail).

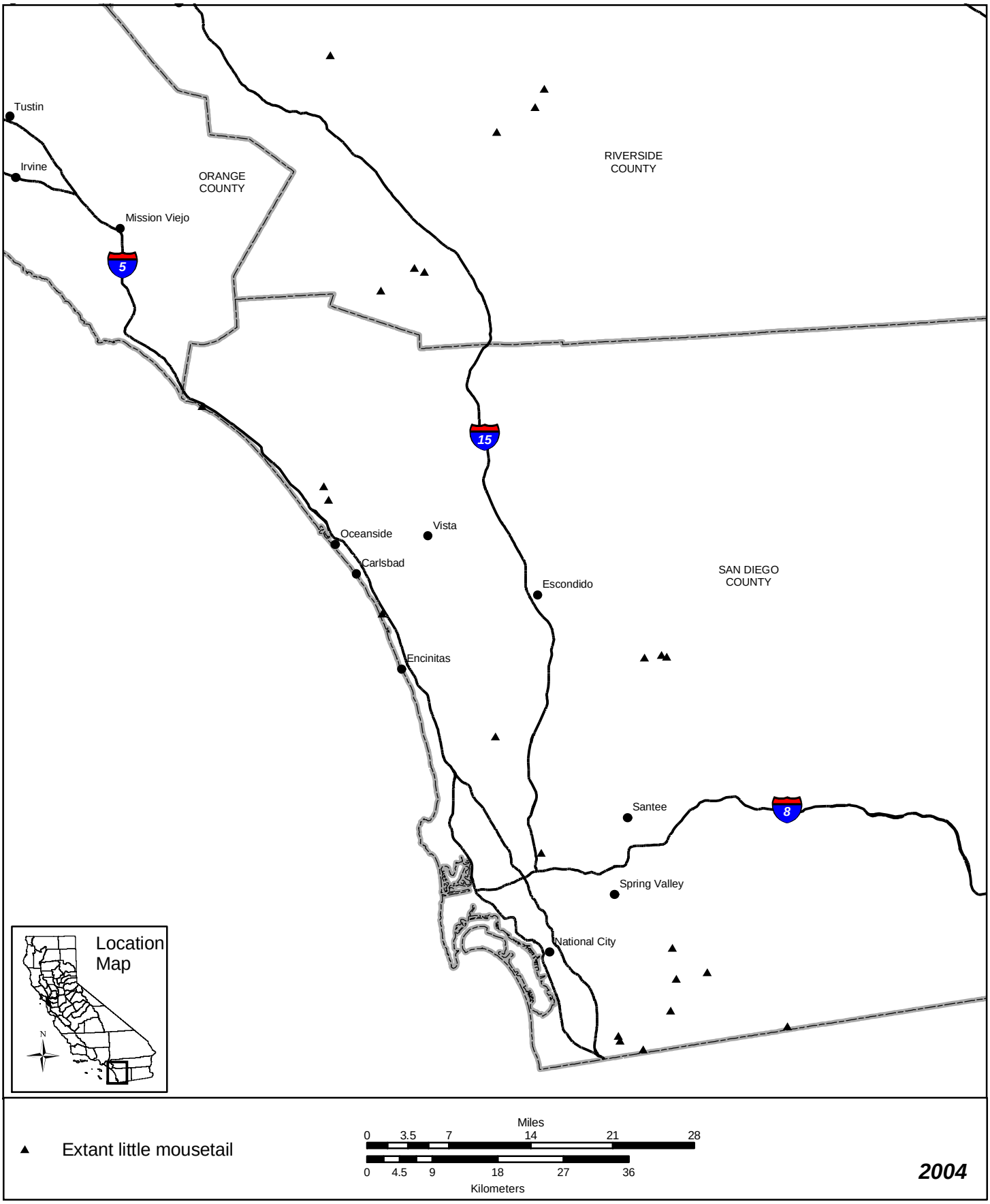

Figure II-38. Distribution of *Myosurus minimus* ssp. *apus* (little mousetail).

(*in litt.* 1993) does not believe that the atypical plants mentioned by Campbell and Stone actually represent *M. minimus* ssp. *apus*. If the questionable populations are truly *M. minimus* ssp. *apus*, it also occurred historically in the Carrizo, Central Coast, Livermore, San Joaquin Valley, and Solano-Colusa vernal pool regions, as well as in areas of Fresno and Kern Counties that are outside of the vernal pool regions designated by Keeler-Wolf *et al.* (1998).

Current Distribution.—The current distribution of *Myosurus minimus* ssp. *apus* is uncertain. Few sites have been revisited since they were first discovered, and contemporary botanists often are reluctant to assign a name to intermediate plants. The California Natural Diversity Data Base tracks only the Riverside and San Diego county occurrences; this taxon is presumed to remain extant at 17 occurrences in those two counties (California Natural Diversity Data Base 2001).

Atypical plants identified as *Myosurus minimus* ssp. *apus* have been reported recently from Alameda, Colusa, Contra Costa, and Kern Counties (Kuenster *et al.* 1994, J. Marr *in litt.* 1996, California Natural Diversity Data Base unprocessed data). An unknown subspecies of *M. minimus* still occurs in Merced County (Silveira 1996). In addition to the counties mentioned above, Skinner and Pavlik (1994) reported that *M. minimus* ssp. *apus* was extant in Butte, San Bernardino, and Stanislaus Counties, as well as Oregon and Baja California, Mexico. If all of the recent reports are correct, *M. minimus* ssp. *apus* is currently known from 10 California counties and from at least 6 vernal pool regions as defined by Keeler-Wolf *et al.* (1998). The vernal pool regions encompassing the recent reports are Livermore, Northeastern Sacramento Valley, San Diego, San Joaquin Valley, Solano-Colusa, and Western Riverside County; depending on the exact location of the Stanislaus County report, it could be in the Southern Sierra Foothills Vernal Pool Region or in the San Joaquin Valley Vernal Pool Region. The San Bernardino County report would be outside of any named vernal pool regions.

Reproduction and Demography.—The timing of seed germination in nature has not been reported. However, two greenhouse germination experiments have been conducted with related taxa. Bliss and Zedler (1998) studied an unspecified subspecies of *Myosurus minimus* from San Diego. They compared initial wetting on 30 January, 1 March, and 31 March as well as various durations of inundation. Only the earliest wetting date was effective in triggering germination; out of 178 seeds that germinated during their study, 177 (99.4 percent) germinated following the January wetting. Fifty percent of those seeds germinated by 23 February. Also, Bliss and Zedler (1998) found that moist soil was more conducive to germination and growth of *M. minimus* than was

inundated soil. Stone (1959) studied the related taxa *M. minimus* ssp. *filiformis* and *M. sessilis*. Under unspecified "standardized" conditions, both taxa reached median seed germination in 13 days. Flower buds formed about 2 months later, averaging 69 days for *M. minimus* ssp. *filiformis* and 69 days for *M. sessilis* (Stone 1959).

Myosurus minimus ssp. *apus* flowers between March and June (Skinner and Pavlik 1994). The seeds mature in late March and April in the Central Valley, whereas plants in southern California begin producing seed in May (Campbell 1952). Dispersal mechanisms have not been reported. The soil seed bank of *M. minimus* ssp. *apus* has not been studied, but Campbell (1952) reported that seeds of other *M. minimus* subspecies are viable for only 2 to 3 years following their production.

Although tiny flies (order Diptera) have been observed visiting *Myosurus minimus* ssp. *minimus*, insects apparently are not necessary to transfer pollen (Knuth 1908). Reproduction in *Myosurus* has been studied in depth by Stone (1959). He noted that the reproductive strategy of *Myosurus minimus* ssp. *apus* was similar to that of *M. sessilis*, which he reported in greater detail. Both are predominantly self-pollinating. Pollen is shed before the flower opens, when the pistils and stamens are covered by the sepals; although fertilization does not take place until 3 to 10 days later, this mechanism ensures that pollen will reach all the pistils that have developed. After the pollen is shed, the flower opens. If growing conditions are favorable, the scape will continue to elongate and produce additional pistils at its tip. Only pollen produced by other flowers would be available for fertilization of the newly-formed pistils. In mixed populations, the pollen could even come from different species or subspecies of *Myosurus*. However, Stone found that only 2 percent of plants collected from the field exhibited any evidence of hybridization. He noted that hybridization would be more likely in years with long growing seasons because the plants would have a greater opportunity to develop exposed pistils.

Myosurus species may produce between 10 and 400 pistils per flower, with at most one seed each, and most plants produce only one or two flowers. However, both the number of flowers and the number of pistils may vary depending on the growing conditions (Stone 1959). Other aspects of *M. minimus* ssp. *apus* demography are unknown.

Habitat and Community Associations.—*Myosurus minimus* ssp. *apus* occurs in Northern Claypan, Northern Hardpan, San Diego Mesa, San Jacinto Valley, and Santa Rosa Plateau vernal pool types (Sawyer and Keeler-Wolf 1995). It also grows occasionally in other types of depressions that hold water

seasonally (Stone 1959, California Natural Diversity Data Base 2001) and in alkaline marshes (Mason 1957). Most of the occupied vernal pools occur within coastal sage scrub, *Adenostoma fasciculatum* (chamise) chaparral, or annual and perennial grasslands (California Natural Diversity Data Base 2001). In one case this taxon was found in a depression in a fallow field (Stone 1959). In the few instances where the sizes of occupied pools were reported, they ranged from 25 square meters (269 square feet) to 0.12 hectare (0.3 acre) in area (Stone 1959, California Natural Diversity Data Base 2001). Similarly, the microhabitats for *M. minimus* ssp. *apus* are not well documented; several southern California populations occurred on both the margins and beds of vernal pools (California Natural Diversity Data Base 2001).

Soils at the Central Valley sites studied by Stone (1959) were all alkaline and ranged in texture from clay to sandy loam. Information on characteristics of soils elsewhere in the range are not available. According to the California Natural Diversity Data Base (2001), elevations of occurrences in San Diego and Riverside Counties range from 76 to 640 meters (250 to 2,100 feet), but sites in other parts of the State would likely extend the elevation range.

Myosurus minimus ssp. *apus* is frequently associated with other *Myosurus* taxa, including *M. minimus* ssp. *minimus*, *M. minimus* ssp. *alopecuroides*, *M. minimus* ssp. *filiformis*, and *M. sessilis* (Stone 1959, California Natural Diversity Data Base 2001). Other genera with which it occurs in the Central Valley are *Downingia*, *Plantago* (plantain), and *Lepidium* (Stone 1959). At one site, it co-occurs with *Gratiola heterosepala* (California Natural Diversity Data Base 2001, under *G. heterosepala*). The most frequent associate of *M. minimus* ssp. *apus* in southern California is the federally- and State-listed endangered *Eryngium aristulatum* var. *parishii* (San Diego button-celery), with which it co-exists at six sites. Other federally- and State-listed endangered plants that co-occur with *M. minimus* ssp. *apus* at one or two sites are *Pogogyne nudiuscula* (Otay Mesa mint), *Pogogyne abramsii* (San Diego mesa mint), and *Orcuttia californica*; the federally-listed threatened species *Navarretia fossalis* (spreading navarretia) also co-occurs with *M. minimus* ssp. *apus* at one site (California Natural Diversity Data Base 2001).

Reasons for Decline and Threats to Survival.——Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to *Myosurus minimus* ssp. *apus* are described below.

The lack of site-specific historical information and the lack of recent surveys preclude quantification of habitat loss for this taxon. However, *Myosurus minimus* ssp. *apus* probably has declined because much vernal pool habitat throughout California has been lost through agricultural conversion and development, as described in other species accounts. At one San Diego site where *M. minimus* ssp. *apus* occurs, several vernal pools were destroyed by conversion to agriculture, but it is not known whether or not this taxon had been present in those pools. Several other southern California sites where *M. minimus* ssp. *apus* occurs were disturbed by off-road vehicle use, road and powerline construction, livestock grazing, brush removal, and trash dumping (California Natural Diversity Data Base 2001).

Urban development is mentioned as a threat to one San Diego occurrence of *Myosurus minimus* ssp. *apus*. The same occurrence also is threatened by agriculture, trash dumping, livestock grazing, construction of a border crossing, and competition from weedy species. In addition, two southern California occurrences are threatened by damage from off-highway vehicles (California Natural Diversity Data Base 2001). However, other occurrences in that region also may be threatened, particularly by urban development, judging by the magnitude of threats to the listed species of southern California vernal pools (U.S. Fish and Wildlife Service 1998b). Threats have not been assessed at northern and central California occurrences of *M. minimus* ssp. *apus*. If insects do play a role in pollination of *M. minimus* ssp. *apus*, habitat loss for the pollinators could contribute to the decline of this plant.

Conservation Efforts.—*Myosurus minimus* ssp. *apus* has no official Federal status. It is not protected in California but is listed as endangered in Oregon (Skinner and Pavlik 1994). *Myosurus minimus* ssp. *apus* formerly was considered to be rare and endangered by the California Native Plant Society (Smith *et al.* 1980). Although it is still considered to be "endangered throughout its range," *M. minimus* ssp. *apus* now is on the California Native Plant Society "Review List" (List 3) of taxa for which insufficient information is available (Skinner and Pavlik 1994).

Ten of the extant occurrences are on public land or in the ownership of a conservation organization. Only three of these occurrences, all on The Nature Conservancy's Santa Rosa Plateau Preserve in Riverside County, are being managed for the benefit of rare species (California Natural Diversity Data Base 2001). Three occurrences are on Federal land in San Diego County: one is on a Navy base and the other two are on the Camp Pendleton Marine Corps installation. Two other sites are administered by State agencies; one is on California Department of Water Resources property in Contra Costa County

(Kuenster *et al.* 1994) and the other, in San Diego County, is partially owned by the California Department of Transportation (California Natural Diversity Data Base 2001). County agencies are responsible for one *Myosurus minimus* ssp. *apus* site each in Kern (J. Marr *in litt.* 1996), Riverside, and San Diego Counties (California Natural Diversity Data Base 2001). No conservation actions are known to have been taken specifically for the benefit of this taxon.

9. *Navarretia myersii* ssp. *deminuta* (Small Pincushion Navarretia)

Taxonomy.—Small pincushion navarretia was named only recently. The scientific name, *Navarretia myersii* ssp. *deminuta* (Day 1995), has not undergone any changes. The type locality for this subspecies is about 3 kilometers (2 miles) southeast of Middletown, in Lake County (Day 1995). *Navarretia myersii* ssp. *deminuta* is a member of the phlox family.

Description and Identification.—Basic morphology of the genus was described under *Navarretia leucocephala* ssp. *pauciflora*. The overall appearance of *N. myersii* ssp. *deminuta* is that of a compact head of flowers growing directly out of the ground. *Navarretia myersii* ssp. *deminuta* (**Figure II-39**) has a very short stem that is thickened below ground level and bears one or two closely-spaced pairs of leaves above ground. The narrow, usually entire leaves are 1 to 5 centimeters (0.4 to 2.0 inches) long and extend far beyond the flower head, which is only 0.8 to 2 centimeters (0.3 to 0.8 inch) wide. Typically each plant has only a single flower head, although one or two secondary heads occur occasionally. Individual flowers are stalkless, with a short-hairy calyx 5 to 6 millimeters (0.20 to 0.24 inch) long and a blue corolla 12 to 13 millimeters (0.47 to 0.51 inch) long. The corolla tube is about the same length as the calyx, and the stamens and stigma protrude from the corolla tube. Inner bracts (those closest to the flowers) are about equal to the calyx in length; they have a broad, papery base and a few lobes near the tip. Three to five outer bracts, which are 1 to 2 centimeters (0.4 to 0.8 inch) long, occur on the periphery of the head. The outer bracts are broad and papery at the base, have toothed or forked lobes between the base and the middle, and are unbranched near the tip. The capsules contain four to six seeds each (Day 1995). The chromosome number of *N. myersii* ssp. *deminuta* is not known.

Navarretia myersii ssp. *myersii* (pincushion navarretia) is the closest relative of *N. myersii* ssp. *deminuta*. The former has a white flower, the corolla is longer (17 to 21 millimeters [0.67 to 0.83 inch]) than in *N. myersii* ssp. *deminuta*, the corolla tube is two to four times as long as the calyx, and the outer bracts are lobed only above the middle. Another similar species, *N. prostrata* (prostrate navarretia), has multiple (up to 20) flower heads per plant, shorter corollas (6 to 9 millimeters

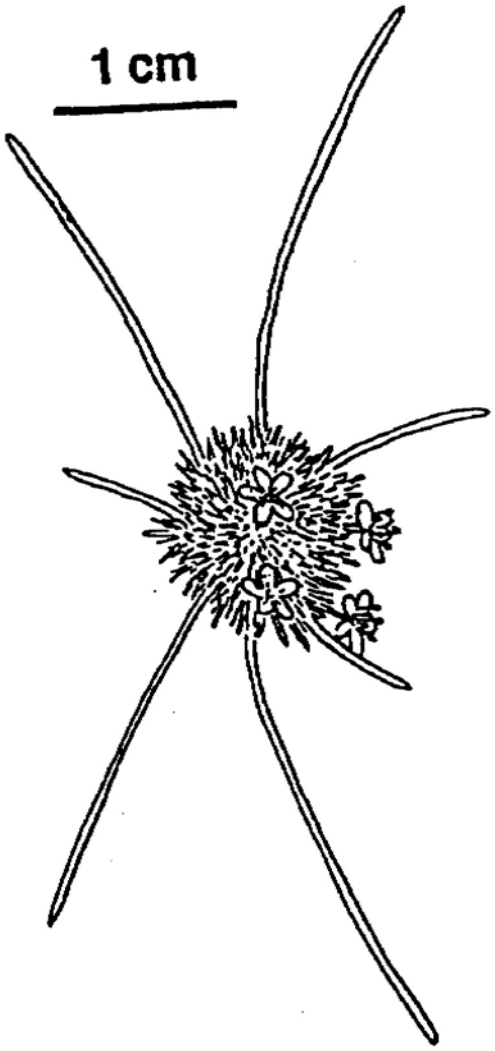

Figure II-39. Illustration of *Navarretia myersii* ssp. *deminuta* (small pincushion navarretia). (Reprinted from the California Botanical Society with permission)

[0.24 to 0.35 inch]), white or blue flowers, lobed leaves, outer bracts that are lobed throughout their length, and contains between 5 and 25 seeds per capsule (Day 1995). Other vernal pool navarretias, including *N. leucocephala* ssp. *pauciflora* and *N. leucocephala* ssp. *plieantha*, differ from *N. myersii* ssp. *deminuta* in that they have conspicuous branches and their corollas are comparatively short (Day 1993*b*).

Historical Distribution.—*Navarretia myersii* ssp. *deminuta* was just discovered in 1992 and no earlier collections are known. Thus, the historical distribution is identical with the current distribution (**Figure II-6**).

Current Distribution.—*Navarretia myersii* ssp. *deminuta* is known only from the type locality in Lake County (Day 1995, A. Day pers. comm. 1997, L. Esposito pers. comm. 1997, California Natural Diversity Data Base 2001). Thus, the taxon is restricted to the Lake-Napa Vernal Pool Region (Keeler-Wolf *et al.* 1998).

Reproduction and Demography.—The reproductive biology of *Navarretia myersii* ssp. *deminuta* has not been investigated but probably is similar to that of *N. leucocephala* ssp. *pauciflora* because they are closely-related vernal pool annuals (Day 1993*a*). *Navarretia myersii* ssp. *deminuta* flowers in April and May (Day 1995). The single population contained about 25,000 plants in 1992 (California Natural Diversity Data Base 2001). In 1993, following a season of above-average rainfall, *N. myersii* ssp. *deminuta* plants had longer leaves and more flowers than in the previous or the following years, which were drier (Day 1995).

Habitat and Community Associations.—At the single known site, *Navarretia myersii* ssp. *deminuta* occurs in vernal pools, at the edges of vernal swales, and in low areas adjacent to a road. The pools and other depressions occur within a matrix of annual grassland on clay loam soil (Day 1995, California Natural Diversity Data Base 2001). Specific types of vernal pools in which it occurs have not been reported. The type locality is at 331 meters (1,087 feet) in elevation (California Natural Diversity Data Base 2001). Plants associated with *N. myersii* ssp. *deminuta* at the site include *Eryngium aristulatum*, *Downingia concolor* (fringed downingia), *Juncus bufonius*, *Isoetes howelli* (Howell's quillwort), and *Psilocarphus brevissimus* (California Natural Diversity Data Base 2001).

Reasons for Decline and Threats to Survival.——Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered

species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to *Navarretia myersii* ssp. *deminuta* are described below. *Navarretia myersii* ssp. *deminuta* is not known to have declined; the subspecies was unknown prior to 1992.

The single locality for *Navarretia myersii* ssp. *deminuta* was threatened by a subdivision (Day 1995, California Natural Diversity Data Base 2001), which was never developed. However, the parcel is zoned rural residential, and the landowner could build a residence, drain the wetland, or make other alterations without being required to obtain permits or conduct an environmental review (L. Esposito *in litt.* 2000). No imminent threats to the population have been noted but two more remote threats are possible. The single population makes *N. myersii* ssp. *deminuta* extremely susceptible to extinction by random events, including both natural and human-caused catastrophes.

Conservation Efforts.—*Navarretia myersii* ssp. *deminuta* does not have any formal protection under Federal or State law. However, the California Native Plant Society (2001) considers *N. myersii* ssp. *deminuta* to be extremely rare and in danger of extinction, and thus has added it to List 1B. No conservation efforts have been reported other than denial of a development permit by Lake County officials (L. Esposito pers. comm. 1997).

10. *Plagiobothrys hystriculus* (Bearded Popcorn Flower)

Taxonomy.—Piper (1920) first recognized bearded popcorn flower as a unique entity, assigning the name *Allocarya hystricula*. Jepson had collected the type specimen in 1892 from the Montezuma Hills, Solano County (Piper 1920). In his monograph on *Plagiobothrys*, Johnston (1923) considered *Allocarya hystricula* to be the same as *Plagiobothrys greenei*. After several revisions to the name by various individuals, Johnston (1932 as cited in Abrams 1951) assigned the name by which bearded popcorn flower is known today, *Plagiobothrys hystriculus*. This taxon is in the borage family (Boraginaceae). Another common name for bearded popcorn flower is bearded allocarya (Smith *et al.* 1980).

Description and Identification.—*Plagiobothrys hystriculus* is an annual with erect or decumbent, branched stems 10 to 45 centimeters (3.9 to 17.7 inches) long. The stem, leaves, and calyx are sparsely to densely covered with short, straight, appressed hairs. The narrow leaves are opposite near the base of the stem but alternate above. Moreover, the leaves decrease in size up the stem, with the lower leaves 2 to 6 centimeters (0.8 to 2.4 inches) long. The flowers are widely spaced throughout the inflorescence. Each is supported by an individual stalk that is shorter than the flower, and many are subtended by bracts. The calyx

consists of five sepals fused only at the base. When the flowers open, the calyx is 3 to 6 millimeters (0.12 to 0.24 inch) long, but the lobes increase in length as the flowers mature. The white corolla is tiny (1 to 2.5 millimeters [0.04 to 0.10 inch] wide) and has a tubular base with five lobes. Each flower produces four egg-shaped nutlets 1.5 to 2.5 millimeters (0.06 to 0.10 inch) long. The nutlets have narrow lengthwise and crosswise ridges that are covered with tubercles; each tubercle is broad at the base, blunt at the tip, and is about one-sixth the length of the nutlet. The tubercles and the nutlet surface in between are densely covered with tiny, barbed bristles (Piper 1920, Jepson 1925, Abrams 1951, Messick 1993). The chromosome number of *P. hystriculus* has not been reported.

Plagiobothrys hystriculus is difficult to distinguish from *P. acanthocarpus* (adobe popcorn flower), *P. greenei* (Greene's popcorn flower), and *P. trachycarpus* (rough-fruited popcorn flower). Close inspection of the nutlets is necessary to identify the various species. Both *P. acanthocarpus* and *P. greenei* have long, pointed prickles instead of blunt tubercles. Furthermore, *P. acanthocarpus* has few bristles on the prickles or on the nutlet surface. *Plagiobothrys greenei* has longer nutlets than *P. hystriculus* and lacks crosswise ridges. *P. trachycarpus* rarely has tubercles on the nutlets but when present they lack bristles (Piper 1920, Abrams 1951, Messick 1993).

Historical Distribution.—*Plagiobothrys hystriculus* was known historically from only two Solano County sites: the type locality and Elmira, where it was collected in 1883 (Piper 1920, Hoover 1937) (**Figure II-26**). The two reported occurrences of *P. hystriculus* would fall within the Solano-Colusa Vernal Pool Region, as defined by Keeler-Wolf *et al.* (1998).

Current Distribution.—This species has not been seen since 1892, but the type locality is nonetheless presumed to be extant (California Natural Diversity Data Base 2001). Although various botanists have reported finding populations of *Plagiobothrys hystriculus*, all recent reports have been determined to represent other species (Skinner and Pavlik 1994, Skinner *et al.* 1995).

Reproduction and Demography.—The only information available on reproduction in *Plagiobothrys hystriculus* is that it flowers in April and May (Abrams 1951). Demographic data also are lacking.

Habitat and Community Associations.—The habitat of *Plagiobothrys hystriculus* is not well understood. The original collectors did not give detailed descriptions of the environment, and later botanists presented conflicting habitat descriptions. Jepson (1925, p. 853), one of only two people who collected *P. hystriculus*, described the habitat as "low plains." Hoover (1937, p. 22)

included *P. hystriculus* in his "Hog-wallow Endemism Area." Abrams (1951, p. 561) noted that the species grew on "grassy hillsides and plains." More recent works give the habitat as "grassland, probably vernal pools, wet sites" (Messick 1993, p. 389) and as Northern Claypan Vernal Pools (Sawyer and Keeler-Wolf 1995). Microhabitats, soil types, and associated species are not known. Both collection sites are less than 50 meters (164 feet) in elevation (California Natural Diversity Data Base 2001).

Reasons for Decline and Threats to Survival.——Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to *Plagiobothrys hystriculus* are described below.

The area around Elmira has been converted to agriculture; no natural land remains (Holland 1984). The type locality for *Plagiobothrys hystriculus* was not specific enough to allow determination of its current status. Threats to the survival of *P. hystriculus* cannot be assessed until extant populations are located.

Conservation Efforts.—*Plagiobothrys hystriculus* has no Federal or State status. The California Native Plant Society originally considered it to be rare (Powell 1974) but now includes it on List 1A, among those species presumed to be extinct (Skinner and Pavlik 1994). Various groups have looked for *P. hystriculus* in the course of surveying, but it has not been relocated. Thus, no other protection measures have been possible. *Plagiobothrys hystriculus* is included in this recovery plan to bring attention to the species and to encourage comprehensive surveys so that extant populations may be located.

Conservation Actions for Rediscovered Plants.- In the event of rediscovery, both immediate and long-term actions will be needed. Outlining these actions in a recovery plan increases the potential for participation by both State and Federal agencies and for funding to carry out needed actions. Three actions–status review, plant stabilization, and protection of plants and habitat–would be needed concurrently. First, a status review should be conducted immediately to assess if there are threats from current or planned activities such as grazing, fire, nonnative plant species, rodents, insects, habitat conversion, inbreeding depression, *etc.* The status review should include consideration of whether existing mechanisms for protection are adequate. The results of the status review would help determine if the plant warrants listing. Second, stabilizing the plants or populations of plants by alleviating threats to short-term survival would be essential. Such stabilization efforts may include controlling invasive nonnative or native vegetation, erosion, and/or destructive rodents and

insects, and providing insurance for the population by collecting and storing seed (if such collection would not further imperil the population's survival). Third, securing and protecting the habitat and the existing plants would be essential. If the plant is rediscovered on public lands, it would be important to work with the land manager to develop a site-specific management plan that would include yearly monitoring measures to minimize any threats. If the plant is rediscovered on private lands, the willingness of the land owner to participate in recovery efforts would need to be assessed and encouraged. If the landowner (and land manager or lessee) were amenable, an agreement should be developed to formalize plant protection. This agreement could be temporary or long-term, depending on the willingness of the landowner and the needs of the species.

After short-term mechanisms for protection are in place, then long-term management should begin. Different approaches should be evaluated. An implementation team, consisting of members with the expertise to determine appropriate measures and the means to implement measures, would be of great benefit. Options include reintroduction to historic sites, propagation in greenhouses and/or botanical gardens, and seed collection and storage. Other necessary actions would include the alleviation of threats, securing sites, maintaining or enhancing abundance, developing and implementing a monitoring plan, conducting essential research (*e.g.*, demography, genetics, reproductive biology, and propagation techniques), reassessing status every 5 years to determine if Federal listing is warranted, and coordinating efforts with conservation and recovery actions for other species covered in this recovery plan or throughout the recovery plan area. Although actions are outlined here, they will not all necessarily be appropriate to the future situation, nor is the list complete.

Q. DELTA GREEN GROUND BEETLE (*ELAPHRUS VIRIDIS*)

1. Taxonomy, Description and Identification

Taxonomy.— The delta green ground beetle (*Elaphrus viridis*) (Coleoptera: Carabidae), was named and described over 120 years ago from a single specimen sent to Dr. George Horn (Horn 1878). "California" was the only locality information supplied by the original collector, A. S. Fuller (Andrews 1978). Despite its spectacular and unmistakable appearance, nearly a century later this beetle was still an enigma to entomologists. The species was still known only from the single specimen in the Harvard Museum of Comparative Zoology. The delta green ground beetle remained a mystery until 1974, when a student from the University of California at Davis incidentally rediscovered it in Solano County at Jepson Prairie.

Goulet and Smetana (1997) discussed the genus *Elaphrus*. Lindroth (1961) rejected an application of *Elaphrus viridis* by Csiki (1927) as invalid since he felt it clearly referred to a color variation of *Elaphrus riparius*. Goulet (1983) revised the tribe Elaphrini and retained the delta green ground beetle in the genus *Elaphrus*. The specific name of *viridis* also has been retained.

Description and Identification.— Although beetles of the genus *Elaphrus* superficially resemble tiger beetles (Cicindelidae), they belong to the ground beetle family Carabidae. The delta green ground beetle is approximately 0.6 centimeter (0.25 inch) in length, and is typically colored in brilliant metallic green and bronze (**Figure II-40**), with two slightly different color forms. Most adults are metallic green with bronze spots on the elytra (first pair of wings, which in beetles are hardened and act as a protective covering), but some adults lack the spots and are nearly uniform metallic green (Goulet 1983, Serpa 1985). The larvae are generally similar to other carabid larvae, and have hardened exterior surfaces with a metallic sheen (Goulet 1983).

The range of the delta green ground beetle overlaps with other ground beetles such as *Elaphrus californicus*, *E. finitimus*, and possibly *E. mimus* (Goulet 1983, D. Kavanaugh pers. comm.). Adult delta green ground beetles can easily be distinguished from related species by their brilliant metallic colors, which are unique among California *Elaphrus*, and by the lack of outlined pits on the elytra (Goulet 1983).

In addition, the delta green ground beetle is the only known California *Elaphrus* species whose adults are active during the winter (Goulet 1983, H. Goulet pers. comm., D. Kavanaugh pers. comm.). Adult males can be differentiated from females by bundles of white sticky pads called holdfasts, located at the base of the tarsus (terminal leg segments) on the underside of their front legs, which serve to keep the male in position during mating (D. Kavanaugh pers. comm.).

2. Historical and Current Distribution

Historical Distribution.—Although the historical distribution of the delta green ground beetle is unknown, the widespread loss and disruption of wetlands and grassland habitat in California's Central Valley since the mid-1800's (Frayer *et al*. 1989, and see below) suggest that the range of this vernal pool-associated species has been reduced and fragmented by human activities, especially agricultural and water uses. The delta green ground beetle, therefore, may have inhabited a much larger range than it does presently, but significant losses of Central Valley wetlands and the lack of comprehensive insect surveys in California over the past century, in addition to the delta green ground beetle's

Figure II-40. Photograph of a delta green ground beetle (*Elaphrus viridis*) (Reprinted from Dr. David H. Kavanaugh © California Academy of Sciences with permission)

cryptic coloration (coloration adapted for concealment) and its habit of hiding in vegetation or cracks in mud, make it difficult to estimate the former historic range of this species. It is conceivable that the invasion of California's native grasslands by various introduced exotic plant species has adversely affected the delta green ground beetle, by altering the vegetation structure of its habitat, shading, soil texture, the seasonal pattern of soil moisture, and perhaps most importantly, the types and abundance of its prey, during both adult and larval stages.

Current Distribution.—To date, the delta green ground beetle has only been found in the greater Jepson Prairie area in south-central Solano County, California (**Figure II-41**). One of two sites where Dr. Fred Andrews collected the species in 1974 and 1975 was later diked and plowed, and has likely extirpated the species from that site. There have been unconfirmed reports of the delta green ground beetle from a wildlife preserve in the Sacramento Valley, in the general vicinity of the Sutter Buttes. We consider these reports unlikely at this time, but they merit investigation.

3. Life History and Habitat

Life History.—Much about the life cycle of the delta green ground beetle remains a matter of speculation, based on observations of similar species or educated guesses from limited data. The delta green ground beetle is believed to produce one brood per year (H. Goulet pers. comm., D. Kavanaugh pers. comm.). Goulet (1983) speculated that adults emerge from diapause (a period of dormancy or delayed development) and females lay their eggs in early winter. From that point onward, other than occasional observations of larvae, the species largely disappears from view until active adults reappear the following winter.

Goulet's laboratory work on delta green ground beetles, using larvae collected in 1982, demonstrated seven stages in the life cycle: egg, three larval instars (stages in the development of insect larvae between molts), pre-pupa, pupa, and adult. In the laboratory, each stage prior to the adult takes about 5 to 7 days, for a total development time of about 35 to 45 days (Goulet 1983, U.S. Fish and Wildlife Service 1985*a)*. Adults presumably live for 9 to 12 months or longer.

Larvae of the delta green ground beetle are seldom seen due to their small size and perhaps also because they hide under dense vegetation or in cracks in the ground. It is also difficult to differentiate them from other ground beetle larvae in the field. Their vision appears to be good, and they respond to large moving

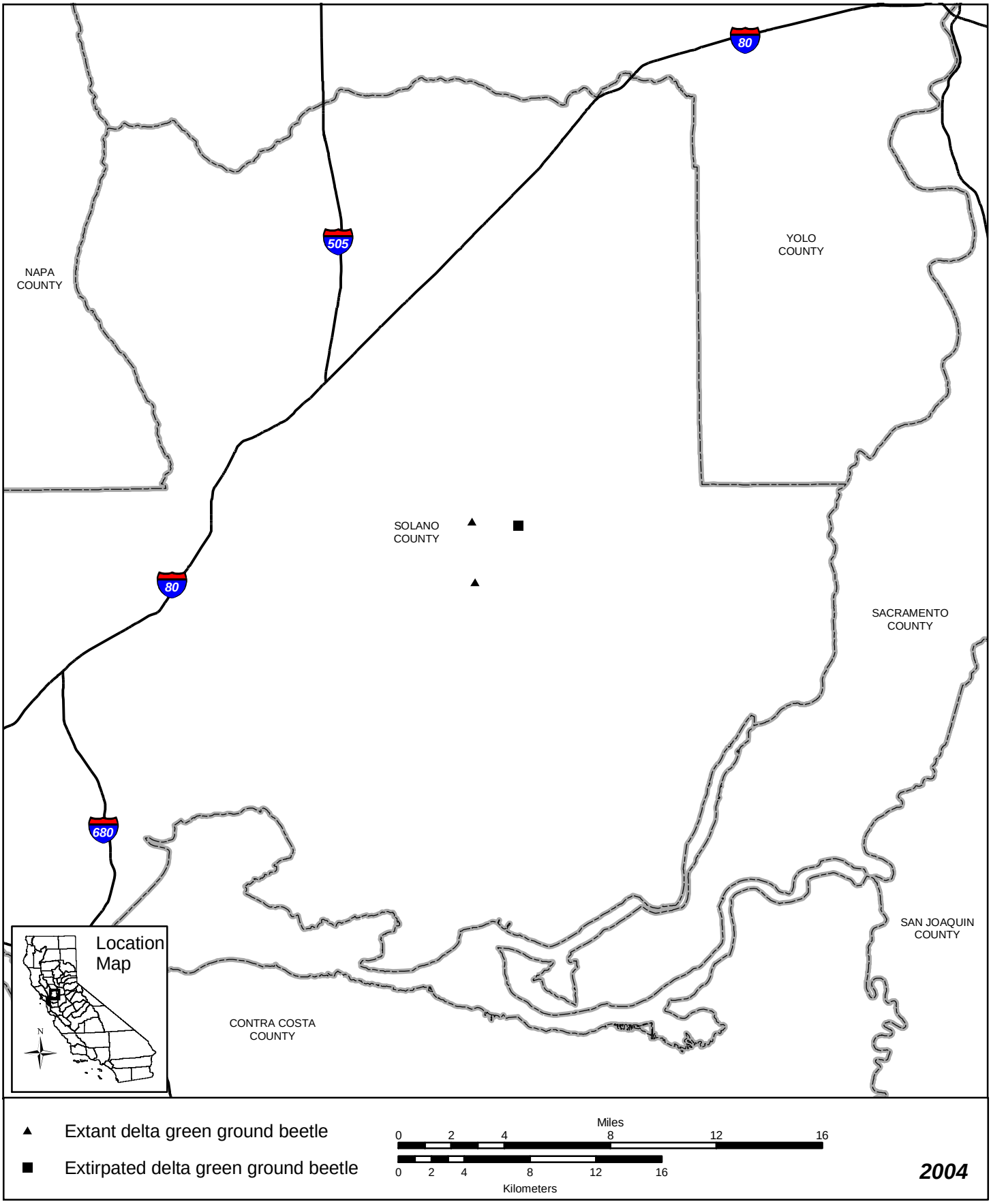

Figure II-41. Distribution of delta green ground beetle (*Elaphrus viridis*).

objects by freezing in place (R. Arnold pers. comm., H. Goulet pers. comm., D. Kavanaugh pers. comm., L. Serpa pers. comm.). Like the adults, larvae appear to hunt mostly by sight. Based on their morphology, a few observations, and comparisons with related species, the larvae are almost certainly predaceous, feeding on other small invertebrates they encounter, including springtails (order Collembola) (L. Serpa pers. comm.). Kavanaugh speculates that, as the available habitat becomes dry, delta green ground beetle larvae crawl into cracks in the soil in preparation for pupation (D. Kavanaugh pers. comm.). Some carabid species are known to burrow as deep as 45 centimeters (18 inches) in hard clay soil to overwinter (Thiele 1977). Fissures, sometimes as deep as 38 to 44 centimeters (15 to 18 inches), form each year in the Jepson Prairie area as a result of the high clay-content soils drying and shrinking after the rains stop in late spring. According to Kavanaugh's hypothesis, pupation in the delta green ground beetle takes place deep in these cracks in the ground, and these individuals survive the hot, dry summer and fall as diapausing pupae.

Adult delta green ground beetles presumably emerge from pupation after the onset of winter rains. Adults are active during the winter-spring wet season, and are most commonly observed in February, March, and April. These diurnal beetles are most likely to be observed on sunny days when the temperature is between 62 and 70 degrees Fahrenheit, and the wind is less than 8 miles per hour (L. Serpa, pers. comm. 2004). Surviving individuals may enter another diapause, as adults, in late spring or early summer. Whether adults may live for more than 1 year is unknown.

The mechanism by which the delta green ground beetle encounters the opposite sex is important but poorly known. Work by Serpa suggests that males know when a female is in their vicinity, even when they can not see her. They seem to slow up and search more diligently, possibly using olfactory cues, but unless there is a direct sighting, the male will not find the female (L. Serpa *in litt*.1997). Serpa (1985) observed six copulations that ranged from about 1 to 3 minutes in duration. A single female was observed to mate with one male once and another male twice during a thirty-minute period. It is not known whether individuals discriminate on the basis of color pattern (spotted versus unspotted) in mating (L. Serpa *in litt*.1997). Based on observations of related species, both sexes may mate several times during their lifespan.

Little or nothing is known about the sites or requirements for egg-laying by the delta green ground beetle, its fecundity (reproductive output) or survivorship (probability of survival to various ages), details of larval habitat, ecology, behavior, prey, or sites or requirements for pupation (R. Arnold pers. comm., H. Goulet pers. comm., D. Kavanaugh pers. comm., L. Serpa pers. comm.). These

gaps in our knowledge of the species and all of its life history stages constitute significant deficiencies, and seriously inhibit the planning and implementing of recovery actions for the species. Some of the additional research necessary to fill these gaps is discussed under Research Needs at the end of this account.

Goulet (1983) suggested that both larvae and adults of the delta green ground beetle are generalized predators able to eat many different kinds of prey. An important food source for the adults is springtails, although Serpa (1985) indicated that one common dark gray species may not be palatable to the delta green ground beetle. These very small, soft-bodied insects are often abundant in moist areas (L. Serpa pers. comm.). Terrestrial larvae of chironomid midges (Diptera: Chironomidae) may also be a food source for both larvae and adults (Goulet 1983, H. Goulet pers. comm.). When springtails are scarce, adult midges are apparently important prey items; the delta green ground beetles catch ones that happen to crash-land nearby (L. Serpa *in litt*. 1997). Delta green ground beetles have also been observed feeding on a few other beetle larvae of undetermined species (L. Serpa *in litt*. 1997).

While dispersal is considered to be important for carabid beetles with low population densities (den Boer 1971), such as the delta green ground beetle (R. Arnold pers. comm., D. Kavanaugh pers. comm., L. Serpa pers. comm.), no research has determined the extent or success of delta green ground beetle dispersal. Flying, rather than walking, would enable the species to locate widely distributed but localized complexes of vernal pools amidst grasslands. Goulet suggests that adult delta green ground beetles may be good fliers (H. Goulet pers. comm.), although the few observations of flight in the field have not strongly supported this view. In one observation, a delta green ground beetle that was released after being confined for photographing took five short flights of 8 centimeters (3 inches) or less over the period of an hour before it finally managed to fly out of the area. Before each flight attempt, it would orient its wing covers directly perpendicular to the sun, in an apparent attempt to increase its body temperature. It would then run rapidly up nearby 1- to 2.5-centimeter (0.4- to 1-inch) plants and take flight. On the sixth flight it obtained a height of 2 meters (6.5 feet) and had traveled a linear distance of about 5 meters (16 feet) before it was lost from sight in the glare of the sun. Additional evidence of flight comes from the discovery of one beetle drowning about 18 centimeters (7 inches) from shore, and the finding of several beetles in Olcott Lake that were 4, 7, and 35 meters (13, 23, and 115 feet) from shore Another observation in the same general area noted a previously undisturbed individual seen flying a short distance (D. Kavanaugh pers. comm.). A third record occurred when an individual was observed after a section of cracked mud was lifted from the East Olcott Lake bed. The delta green ground beetle remained still for about 3 to 5 minutes, then walked

about 5 centimeters (2 inches), raised its elytra slightly and flew away. Its flight was described as rather slow and lumbering, at a height of about 2.2 meters (7 feet) for a distance of about 15 meters (50 feet) (McGriff 1987, D. McGriff pers. comm.). Dispersal may occur only within a very restricted season, time of day (or night), or set of environmental conditions. No large migratory movements of the delta green ground beetle are known.

The delta green ground beetle has also been seen swimming on top of the water in Olcott Lake (R. Arnold pers. comm., L. Serpa pers. comm.), and moving through standing water in smaller pools that required short swimming bouts between emergent plants (L. Serpa *in litt*. 1997). Although swimming may not be very effective as a long-distance dispersal mechanism for these small beetles, it may be an important adaptation to the seasonally wet and hydrologically dynamic ecosystem of the Jepson Prairie.

Collection records since 1974 indicate that adults may be found from early February until mid-May, depending on the weather, but some have been seen as early as late fall (R. Arnold pers. comm.). While most carabids are nocturnal, the delta green ground beetle and *Elaphrus* in general are active during the daytime, with the earliest sightings around 7:40 a.m., and continue moving until after sunset (Serpa 1985). Observations by several researchers (R. Arnold pers. comm., L. Eng pers. comm., H. Goulet pers. comm.) suggest that activity may be temperature- and wind-dependent. In February and March 1982, adults were active when ambient air temperature at 2 centimeters (0.6 inch) above ground was at least 23 degrees Celsius (73 degrees Fahrenheit). Most adults were observed during midday hours (11:00 am to 3:00 pm) when winds are typically minimal. However, Serpa has reported delta green ground beetle activity at lower temperatures (Serpa 1985). Activity periods of the larvae are not well known (R. Arnold pers. comm., H. Goulet pers. comm.).

Serpa (1985) observed golden-haired dung flies (*Scatophaga stercoraria*), a saldid bug (Hemiptera: Saldidae) and a crab spider (Thomisidae) attacking adults several times, but they always released the delta green ground beetles after a second or two of contact. Serpa speculated that shorebirds are not significant predators because delta green ground beetles freeze when they see large objects move, and are so cryptically colored that they are almost impossible to see when they are not moving. As in other carabids, the delta green ground beetle stridulates (produces noise by rubbing wings together), which may serve as additional defense when captured by shorebirds (Serpa 1985). California tiger salamanders might prey on the larvae of the delta green ground beetle.

Habitat.—The delta green ground beetle lives in an area of grassland interspersed with vernal pools including several larger vernal pools (sometimes called playa pools or vernal lakes), such as Olcott Lake. Such playa pools typically hold water for longer durations than smaller vernal pools: from the onset of the rainy season through mid-summer. In south-central Solano County where the species is found, these playa pools contain former marine or *lacustrine* clays, as classified in the Pescadero soil series. Other common soil series in the surrounding grasslands are Antioch, San Ysidro, and Solano (Bates 1977). Critical habitat for the delta green ground beetle has been designated, and is described in the Conservation Efforts section below.

The preferred microhabitat of the delta green ground beetle is not well understood. Researchers have usually found adults around the margins of vernal pools and in bare areas along trails and roadsides (U.S. Fish and Wildlife Service 1985*a)*, where individuals often hide in cracks in the mud and under low-growing vegetation such as *Erodium* sp. (filaree) (Arnold 1983) and *Navarretia leucocephala* ssp. *bakeri* (Baker's navarretia) (L. Serpa pers. comm., C. Witham, pers. comm.). Arnold speculates that *N. leucocephala* ssp. *bakeri* may be a good habitat indicator for the delta green ground beetle (R. Arnold pers. comm.). In 1985, over 200 delta green ground beetles were observed near Olcott Lake and other nearby vernal lakes or pools (L. Serpa, pers. comm. 2004). Over 80 percent of these individuals were within 1.5 meters (4.9 feet) of the water's edge where soil conditions were very moist and very low growing vegetation provided cover of 25 to 100 percent (Arnold 1989).

The extent to which the delta green ground beetle also uses the grasslands beyond the less vegetated areas where it is usually seen remains unknown. The cryptic coloration of the species against the brilliant green of the early spring grass, its small size and hiding behavior all hinder detection of the animal in dense vegetation (Arnold 1983). The fact that individuals have occasionally been found along trails far from water suggests that they may range into the grassland. The delta green ground beetle's habitat may vary with the amount and frequency of rainfall. When the vernal pools become too full, the beetles are apparently pushed back away from the pool margins, and could then occur more widely in the grasslands surrounding Olcott Lake and the other pools. At high water, the remaining suitable habitat would include trails, road shoulders, and other areas of depauperate vegetation that were adequately dry. There might be a gradual retreat to the borders of the playa pools after the waters have receded (Arnold 1983, D. Kavanaugh pers. comm., L. Serpa pers. comm.). The delta green ground beetle's habitat requirements for oviposition, larval development, and pupation are almost completely unknown. In the absence of studies, it nevertheless appears

likely that the grassland matrix surrounding suitable areas of vernal pools or playa pools has habitat value for the species.

Community Association.—The delta green ground beetle is found at the Jepson Prairie, which represents the best remaining example of native bunchgrass prairie in the Central Valley (Jepson Prairie Preserve Docent Program 1998). The 634-hectare (1,566-acre) Jepson Prairie Preserve, also known as the Dozier Trust contains stands of *Nassella pulchra* (purple needlegrass), *Poa* spp. (bluegrass), and *Melica californica* (melic grass) in a mosaic of claypan vernal pools. Like many California grasslands today, aggressive introduced grasses and forbs including *Avena* spp. (wild oats), *Bromus* spp., *Hordeum* spp. (barley), *Lolium* spp. (ryegrass), and *Erodium* spp., dominate much of the Jepson Prairie (Jepson Prairie Preserve Docent Program 1998).

The greater Jepson Prairie supports a substantial number of rare and sensitive plants and animals including *Tuctoria mucronata*, *Neostapfia colusana*, conservancy fairy shrimp, and California clam shrimp (*Cyzicus californicus*) (Jepson Prairie Preserve Docent Program 1998). Habitat suitable for the delta green ground beetle is present on agricultural lands between Travis Air Force Base and Jepson Prairie Preserve, and the beetles are known to occur throughout this region (L. Serpa, pers. comm. 2004).

4. Reasons for Decline and Threats to Survival

Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to delta green ground beetle are described below.

A significant concern is that, due to its extremely limited distribution and population, the delta green ground beetle is considered very vulnerable to impacts on its habitat. The delta green ground beetle presently occupies less than 2,800 hectares (7,000 acres) (L. Serpa, pers. comm.), and measured population densities of the species are perennially low (Arnold 1983, L. Serpa *in litt*. 1997). Population estimates of the species in the wild are difficult to obtain, but in total, less than a few hundred individuals have been recorded since their rediscovery in 1974, and only about 50 specimens are known from various entomology collections worldwide. Recently, numbers of delta green ground beetles appear somewhat lower than in previous years, although such a trend has not been statistically validated (L. Serpa *in litt*. 1997, L. Serpa pers. comm.). Changes in

vegetation management, specifically the temporary removal of managed grazing, have been suggested as an explanation for the apparent decline.

Another continuing threat is related to natural gas exploration and production. Natural gas reserves occur in subterranean pockets in the Jepson Prairie area, and exploratory drilling for these reserves could pose a threat. In addition, such drilling may necessitate new roads and related infrastructure, resulting in other potential indirect impacts. Also, ditches operated in association with Olcott Lake may drain it too rapidly to support the preferred habitat for the beetle (L. Serpa *in litt*. 1997, L. Serpa pers. comm.). Small ditch systems such as this example exist in many parts of the greater Jepson Prairie (L. Serpa pers. comm., R. Thorpe pers. comm., K. Williams pers. comm., C. Witham pers. comm.) and may pose continuing threats.

There is some evidence indicating that the absence of grazing can have negative effects on the delta green ground beetle. At Olcott Lake, the number of delta green ground beetles observed decreased after a fence was erected to exclude sheep from the southern margin of the lake (the sheep were excluded to abate the impacts that the sheep were having on the population of endangered *Neostapfia colusana* in Olcott Lake) (C. Witham pers. comm., R. Reiner pers. comm.). With the exclusion of sheep, the previously grazed margin of the southern shore now has become overgrown with nonnative plants (L. Serpa pers. comm., C. Witham pers. comm.). On adjacent land used by sheep, the springtail prey of the delta green ground beetle seem to be more plentiful, as does the beetle itself (L. Serpa *in litt*. 1997, L. Serpa pers. comm.).

The adverse consequences from a lack of grazing are clearly tied to the dominance of invasive nonnative plants in the greater Jepson Prairie ecosystem. Extensive growth of nonnative grasses and forbs, which is often accompanied by development of a thatch of dead plant material on the ground and in the shallower portions of vernal pools, may threaten the delta green ground beetle because the thatch may inhibit its normal foraging and other behavior and affect the availability of prey.

Sheep grazing currently appears to be more compatible with delta green ground beetle populations than cattle grazing. Cattle tend to stand in and walk through shallow water in large numbers, and will churn and pockmark the margins of vernal and playa pools. Cattle also tend to create relatively steep, 15- to 30-centimeter (6- to 12-inch) high banks around the pools, altering the gentle muddy slope that the delta green ground beetle prefers (Serpa 1985). Sheep, in contrast, do not tend to stand or walk in water, and do not cause equivalent impacts to the pool margins (Serpa 1985, R. Arnold pers. comm., L. Serpa pers.

comm.). However, the greater damage to the beetle microhabitat observed in cattle areas could also be due to a difference in soil type, since not all pools in cattle areas suffer this degradation (L. Serpa, pers. comm. 2004).

The maintenance and monitoring of fuel pipelines and electricity transmission lines are on-going activities that may pose a threat to the delta green ground beetle. A Pacific Gas & Electric Company/Pacific Gas Transmission Company natural gas pipeline is buried along the western edge of the Jepson Prairie Preserve, and a pipeline expansion project was completed in 1992.

After the spring of 1997, erosion that was aggravated by the presence of a gas pipeline corridor required repair to prevent a drainage ditch from headcutting into a vernal pool and potentially draining it. High voltage electric transmission lines cross the greater Jepson Prairie in several locations, including lines that cross Olcott Lake, critical habitat, and the Jepson Prairie Preserve. Impacts to the delta green ground beetle from ongoing operations and maintenance activities and periodic replacement of the conductors (wires) are unknown. Future construction of new pipelines and electric transmission lines also may pose a threat to delta green ground beetles.

Illegal collecting poses a potential threat to delta green ground beetles. Beetle collecting is the pastime of a small but dedicated group of amateur and professional entomologists. Most of these collectors are conservation-minded, but a small minority collects obsessively or for financial gain without regard for law. The extent of illegal collecting of the delta green ground beetle is unknown, but the attractive appearance of the species and its rarity are likely to make it a target for unscrupulous collectors.

Sludge application could present a threat to delta green ground beetles. Solano County produces sludge at its wastewater treatment plants, and has recently approved this material for use as a soil amendment/fertilizer in grasslands in Solano County. Certain restrictions on grazing and food production apply to treated sites. Private landowners between Travis Air Force Base and Jepson Prairie Preserve have proposed a setback of 30 meters (100 feet) from vernal pools for sludge applications in this area; however, the high concentration of vernal pools in this area may make this infeasible due to their close proximity (R. Scoonover pers. comm.). There is presently no requirement that sludge be disced into the ground after application, as in Yolo County. The nutrients in sludge are likely to aggravate problems with invasive nonnative plant growth due to increased availability of nutrients. Water quality concerns also may exist if sludge is applied to pasture lands with vernal pools (R. Scoonover pers. comm.). The addition of sludge would probably be extremely detrimental to the delta

green ground beetle, since the beetle is only found in areas with low growing plants. The vegetation around the vernal pools would still be stimulated even with a much larger setback than the one proposed, and the higher and denser plants would make it much more difficult for the beetles to move about and catch their prey. In addition, until we know much more about the needs of the delta green ground beetle, the entire vernal pool grassland matrix within the beetle's range needs to be considered as habitat; protection of the vernal pools alone is insufficient (L. Serpa, pers. comm. 2004).

A final significant concern is the lack of basic life history information for the delta green ground beetle. With such a paucity of life history information, the species may be subject to threats we are unaware of, and the severity of impacts due to the threats discussed above are more or less unknown.

5. Conservation Efforts

The delta green ground beetle was proposed for federal listing on August 10, 1978, as a threatened species with critical habitat (U.S. Fish and Wildlife Service 1978*b*). On March 6, 1979, proposed critical habitat was withdrawn from consideration because of procedural and substantive changes made in 1978 amendments to the Endangered Species Act (U.S. Fish and Wildlife Service 1979). After rules for designation of critical habitat were promulgated (U.S. Fish and Wildlife Service 1980*a*), critical habitat for the species was reproposed (U.S. Fish and Wildlife Service 1980*b*). The delta green ground beetle was federally listed as a threatened species with designated critical habitat on August 8, 1980 (U.S. Fish and Wildlife Service 1980*c*). A recovery plan that included the delta green ground beetle was prepared and approved in 1985 (U.S. Fish and Wildlife Service 1985*a)*. Internationally, the delta green ground beetle is listed as "vulnerable" by the International Union for the Conservation of Nature (1983).

Two areas in south-central Solano County, separated by 0.8 kilometer (0.5 mile) and totaling 385 hectares (960 acres), were designated as critical habitat for the delta green ground beetle. Constituent elements of this habitat essential to the delta green ground beetle are the vernal pools with their surrounding vegetation, and the land areas that surround and drain into these pools.

Habitat Protection.—On December 31, 1980, approximately 647 hectares (1,600 acres) of land was purchased by The Nature Conservancy from the Southern Pacific Railroad Company, and named the Willis Linn Jepson Prairie Preserve, after the noted local botanist and author of the Jepson Manual for plant identification. In 1987, the Jepson Prairie Preserve was declared a National Natural Landmark. The Jepson Prairie Preserve became associated with ongoing

research at the University of California at Davis (Cole *in litt*. 1983), and part of the University of California Natural Reserve System (formerly the Natural Land and Water Reserve System). The Jepson Prairie Preserve site is used for the study of representative samples of both widespread habitat types and distinctive ecosystems and features of special value for teaching and research, such as the native prairie bunchgrasses, vernal pools, and playa pools.

The Solano County Farmlands and Open Space Foundation took title to the Jepson Prairie Preserve from The Nature Conservancy on September 5, 1997. A revised conservation agreement is expected to be signed by the Solano County Farmlands and Open Space Foundation and the University of California's Natural Reserve System, which will jointly manage the Preserve (P. Muick pers. comm., R. Reiner pers. comm., R. Thorpe pers. comm.).

Next to the population on the Jepson Prairie Preserve, the most significant population of delta green ground beetles is found in playa pools on the western half of the Wilcox Ranch in Solano County (L. Serpa, pers. comm. 2004). The beetle also occurs in the playa lakes on the eastern half of the Wilcox Ranch. The Nature Conservancy purchased the 1,178-hectare (2,912-acre) Wilcox Ranch in 2001 and sold the western half of the property (635 hectares [1,570 acres]) to Solano County in 2002. The eastern portion (543 hectares [1,342 acres]) of the ranch is being transferred to The Solano Land Trust and will be protected with a conservation easement (Marty, pers. comm. 2004). The western portion of the property does not have a conservation easement on it, but the deed restricts development on the property except as needed for runway expansion at Travis AFB (Marty, pers. comm. 2004). If runway expansion occurs, it would likely negatively impact the delta green ground beetle population.

A 23-hectare (57-acre) parcel at the western side of the B & J Landfill property (previously mentioned) serves as a delta green ground beetle mitigation site for a previous B & J Landfill expansion. Currently there are several mitigation banks in the review process that potentially provide habitat for the delta green ground beetle. Two of these mitigation banks are adjacent to the Jepson Prairie Preserve. One such location includes a 65 hectares (160 acres) site referred to as the Campbell Ranch Proposed Mitigation Bank and is located just northwest of the Jepson Prairie Preserve. The site adjoins designated critical habitat in Section 14 . No delta green ground beetles were observed on this site during surveys conducted in 1990 (Arnold 1990), 1994 (Geier & Geier Consulting, Inc. 1994), or 1999 (C. Witham pers. comm.). However, suitable habitat for this species may be present. A second property referred to as the Burke Ranch Potential Conservation Site, encompasses over 567 hectares (1400 acres) is under consideration for a preservation bank, mitigation bank, conservation easement or a combination of

these strategies (C. Witham pers. comm.). The site is located about 1 kilometer (0.62 mile) northwest of the Jepson Prairie Preserve and designated critical habitat. In surveys conducted in 1999, seven delta green ground beetles were observed along the edge of a modified playa-type vernal pool on this site (C. Witham pers. comm.). Other land acquisitions for conservation are in process.

Habitat Management.—Efforts are underway to control invasive nonnative plants within the Jepson Prairie Preserve. Grazing, prescribed fire, and hand application of herbicides are some of the tools being investigated to help control nonnative plants (J. Meisler pers. comm., R. Thorpe pers. comm., C. Witham pers. comm., K. Williams pers. comm., Jepson Prairie Preserve Docent Program 1998).

Although the relationship between fire and the delta green ground beetle has not yet been established, the delta green ground beetle may prefer an open canopy habitat (Arnold 1983), and therefore, fire may improve its habitat. The literature suggests that fire, which kills certain plants and removes dead plant litter, favors some native plant species and disfavors some problematic nonnative plants. However, as stated previously, seasonal application of any disturbance regime should be considered with respect to native versus nonnative species. On the Jepson Prairie, late-spring burning appears to reduce thatch and nonnative annual grasses while promoting native grasses and forbs (Jepson Prairie Preserve Docent Program 1998). Prescribed burning has been conducted on Jepson Prairie Preserve for over a decade (Leitner *in litt*. 1984). Although the burns typically did not take place in habitat known to contain delta green ground beetles, it was viewed as a "neutral to beneficial" practice for maintenance of critical elements (The Nature Conservancy term for sensitive species or resources on a site) on the Preserve including the delta green ground beetle and its habitat (R. Reiner pers. comm., L. Serpa pers. comm., C. Witham pers. comm.). Burns typically take place when the grasses have dried sufficiently. Thus, such burns may not adversely affect the species because it is inactive and presumably deep underground when burns occur (D. Kavanaugh pers. comm.). No quantitative data are available on effects of prescribed burning on the species.

In 1997, the Solano County Farmlands and Open Space Foundation received a 3-year CalFed grant to restore riparian habitat along Barker Slough and Calhoun Cut, control nonnative plants, and enhance native plant species in grasslands (Jepson Prairie Preserve Docent Program 1998). Such restoration initiatives will likely benefit native species including the delta green ground beetle.

Research.—Relatively little research has been conducted on the delta green ground beetle. Most of the information available on the ecology of this

species is a result of opportunistic observations. Through laboratory studies, Goulet (1983) documented aspects of the development of delta green ground beetles from the egg stage to adulthood. Systematic surveys, population monitoring, and demographic monitoring have not been conducted yet.

Arnold (1989) conducted an analysis of habitat features associated with delta green ground beetle observations. Habitat variables were measured at sites where delta green ground beetles were observed, and also at selected sites within four habitat types: vernal lakes, vernal pools, grasslands, and bare ground areas. Discriminant function analysis then was used to identify variables and habitats most associated with delta green ground beetle locations. In 1989, 13 delta green ground beetle localities were strongly associated with vernal lake habitat. Habitat variables most strongly associated with delta green ground beetle observations were *Navarretia* cover, proximity to water, *Frankenia* cover, *Downingia* cover, and soil type. Among the variables least associated were sheep dung concentrations and annual grass cover.

As indicated earlier, some research has been conducted on habitat management strategies in the Jepson Prairie Preserve. This research has not been conducted specifically for the delta green ground beetle, but instead is intended to help conserve a suite of native plant and animal species, including a number of rare ones. A primary goal of this research is the control of invasive exotic plant species (J. Meisler pers. comm.).

R. CONSERVANCY FAIRY SHRIMP *(BRANCHINECTA CONSERVATIO)*

1. Taxonomy, Description, and Identification

Taxonomy.—The Conservancy fairy shrimp (*Branchinecta conservatio*) was described by Eng, Belk, and Eriksen (Eng *et al.* 1990). The type specimens were collected in 1982 at Olcott Lake, Solano County, California. The species name was chosen to honor The Nature Conservancy, an organization responsible for protecting and managing a number of vernal pool ecosystems in California, including several that support populations of this species.

Description and Identification.—Conservancy fairy shrimp look similar to other fairy shrimp species (**Box 1**- Appearance and Identification of Vernal Pool Crustaceans). Conservancy fairy shrimp are characterized by the distal segment of the male's second antennae, which is about 30 percent shorter than the basal segment, and its tip is bent medially about 90 degrees (Eng *et al.* 1990). The female brood pouch is fusiform (tapered at each end), typically extends to abdominal segment eight, and has a terminal opening (Eng *et al.* 1990). Males

Box 1. Appearance and Identification of Vernal Pool Crustaceans

Most of the vernal pool crustacean species discussed in this draft recovery plan are similar in their general physiology and appearance. All five species of fairy shrimp, the *Conservancy fairy shrimp, longhorn fairy shrimp, vernal pool fairy shrimp, midvalley fairy shrimp,* and *California fairy shrimp*, have delicate elongate bodies, large stalked compound eyes, and 11 pairs of phyllopods, or swimming legs. Phyllopods (phyllo = leaf, poda = feet) also function as gills, absorbing dissolved oxygen as they are moved through the water (branchio = gill, poda = feet). Fairy shrimp use their phyllopods to swim or glide upside-down by means of complex, wavelike beating movements. Fairy shrimp do not have a hard shell, a characteristic of animals in the Order Anostraca **(**an = without, ostraca = hard plate or shell).

Distinguishing one fairy shrimp species from another is difficult. Fairy shrimp identification is based upon recognition of tiny physical characteristics, many of which can only be seen with a microscope. Species generally are identified by characteristics of the male's antennae, and by the size and shape of the female's brood pouch. Eriksen and Belk (1999) developed a key to identify fairy shrimp species found in California. Although we describe some of the identifying characteristics of different fairy shrimp species in this draft recovery plan, successful identification generally requires formal training.

The *vernal pool tadpole shrimp* is quite different in appearance from the fairy shrimp. This species is a member of the **Order Notostraca** (noto = back; ostraca = shell), and possesses a hard shell. The shell is large, flattened, and arched over the back of the tadpole shrimp in a shield-like manner. This structure gives the tadpole shrimp its unique, tadpole-like appearance, which easily distinguishes it from the fairy shrimp.

may be from 14 to 27 millimeters (0.6 to 1.1 inch) in length, and females have been measured between 14.5 and 23 millimeters (0.6 and 0.9 inch) long.

Conservancy fairy shrimp can be distinguished from the similar looking midvalley fairy shrimp (*Branchinecta mesovallensis*) by the shape of two humps on the distal segment of the male's second antennae (Belk and Fugate 2000). The midvalley fairy shrimp's antennae is bent such that the larger of the two humps is anterior (towards the head), whereas this same hump in the Conservancy fairy shrimp is posterior (towards the tail). Females of these two species differ in the shape of their brood pouches. The brood pouch of the midvalley fairy shrimp is pyriform and extends to below abdominal segments three and four, as opposed to segment eight in Conservancy fairy shrimp (Belk and Fugate 2000).

2. Historical and Current Distribution

Historical Distribution.—The historical distribution of the Conservancy fairy shrimp is not known. However, the distribution of vernal pool habitats in the areas where the Conservancy fairy shrimp is now known to occur were once more continuous and larger in area than they are today (Holland 1998). It is likely the Conservancy fairy shrimp once occupied suitable vernal pool habitats throughout a large portion of the Central Valley and southern coastal regions of California.

Current Distribution.—The Conservancy fairy shrimp is known from a few isolated populations distributed over a large portion of California's Central Valley and in southern California (**Figure II-42**). In the Northeastern Sacramento Valley Vernal Pool Region (Keeler-Wolf *et al*. 1995), Conservancy fairy shrimp populations are clustered around the Vina Plains area in Tehama and Butte Counties. Conservancy fairy shrimp populations are also found in the Solano-Colusa Vernal Pool Region on the greater Jepson Prairie area in Solano County and at the Sacramento National Wildlife Refuge in Glenn County. A new occurrence of Conservancy fairy shrimp has been recorded in the Tule Ranch unit of the California Department of Fish and Game Yolo Basin Wildlife Area, in Yolo County. In the San Joaquin Valley Vernal Pool Region, Conservancy fairy shrimp are found in the Grasslands Ecological Area in Merced County, and at a single location in Stanislaus County. In the Southern Sierra Foothills Vernal Pool Region, the species is known from the Flying M Ranch, the Ichord Ranch, and the Virginia Smith Trust lands in eastern Merced County. The Conservancy fairy shrimp is found outside the Santa Barbara Vernal Pool Region at two locations on the Los Padres National Forest in Ventura County.

3. Life History and Habitat

Life History.—Like other species discussed in this draft recovery plan, the life history of the Conservancy fairy shrimp is uniquely adapted to the ephemeral conditions of its vernal pool habitat. Helm (1998) found that the life span and maturation rate of the Conservancy fairy shrimp did not differ significantly from other fairy shrimp species under the conditions he observed. Helm (1998) found that Conservancy fairy shrimp reached maturity in an average of 46 days, and lived for as long as 154 days. However, aquatic invertebrate growth rates are largely controlled by water temperature and can vary greatly (Eriksen and Brown 1980, Helm 1998). Conservancy fairy shrimp produce one large cohort of offspring each wet season (Eriksen and Belk 1999).

Habitat.—The Conservancy fairy shrimp occurs in vernal pools found on several different landforms, geologic formations and soil types. At the Vina Plains in Tehama County, the species occurs in pools formed on Peters Clay soil on the volcanic Tuscan Formation. At Jepson Prairie, the Conservancy fairy shrimp is found in large playa like depressions on deep alluvial soils of Pescadero Clay Loam on Basin Rim landforms. Vernal pools that contain Conservancy fairy shrimp in the Los Padres National Forest tend to occupy atypical habitat settings that are located under a pine forest canopy instead of an annual grassland. They have been observed in vernal pools ranging in size from 30 to 356,253 square meters (323 to 3,834,675 square feet) (Helm 1998). Observations suggest this species often is found in pools that are relatively large, and turbid (King *et al.* 1996, Helm 1998, Eriksen and Belk 1999). Helm (1998) found the mean size of pools supporting this species to be 27,865 square meters (299,936 square feet), much larger than the average mean size of all other species he observed. Syrdahl (1993) found positive correlations between Conservancy fairy shrimp occurrence and large pool surface areas. The species has been found at sites that are low in alkalinity (16 to 47 parts per million) and total dissolved solids (20 to 60 parts per million), with pH near 7 (Barclay and Knight 1981, Syrdahl 1993, Eriksen and Belk 1999). Conservancy fairy shrimp have been found at elevations ranging from 5 to 1,700 meters (16 to 5,577 feet) (Eriksen and Belk 1999), and at water temperatures as high as 23 degrees Celsius (73 degrees Fahrenheit) (Syrdahl 1993).

Community Associations.—Conservancy fairy shrimp co-occur with several other vernal pool crustacean species addressed in this draft recovery plan, including the vernal pool fairy shrimp, the California fairy shrimp, and the vernal pool tadpole shrimp (King *et al.* 1996, Helm 1998, Eriksen and Belk 1999). These species may all be found in one general location, however, they rarely have been collected from the same pool at the same time (Eriksen and Belk 1999). In

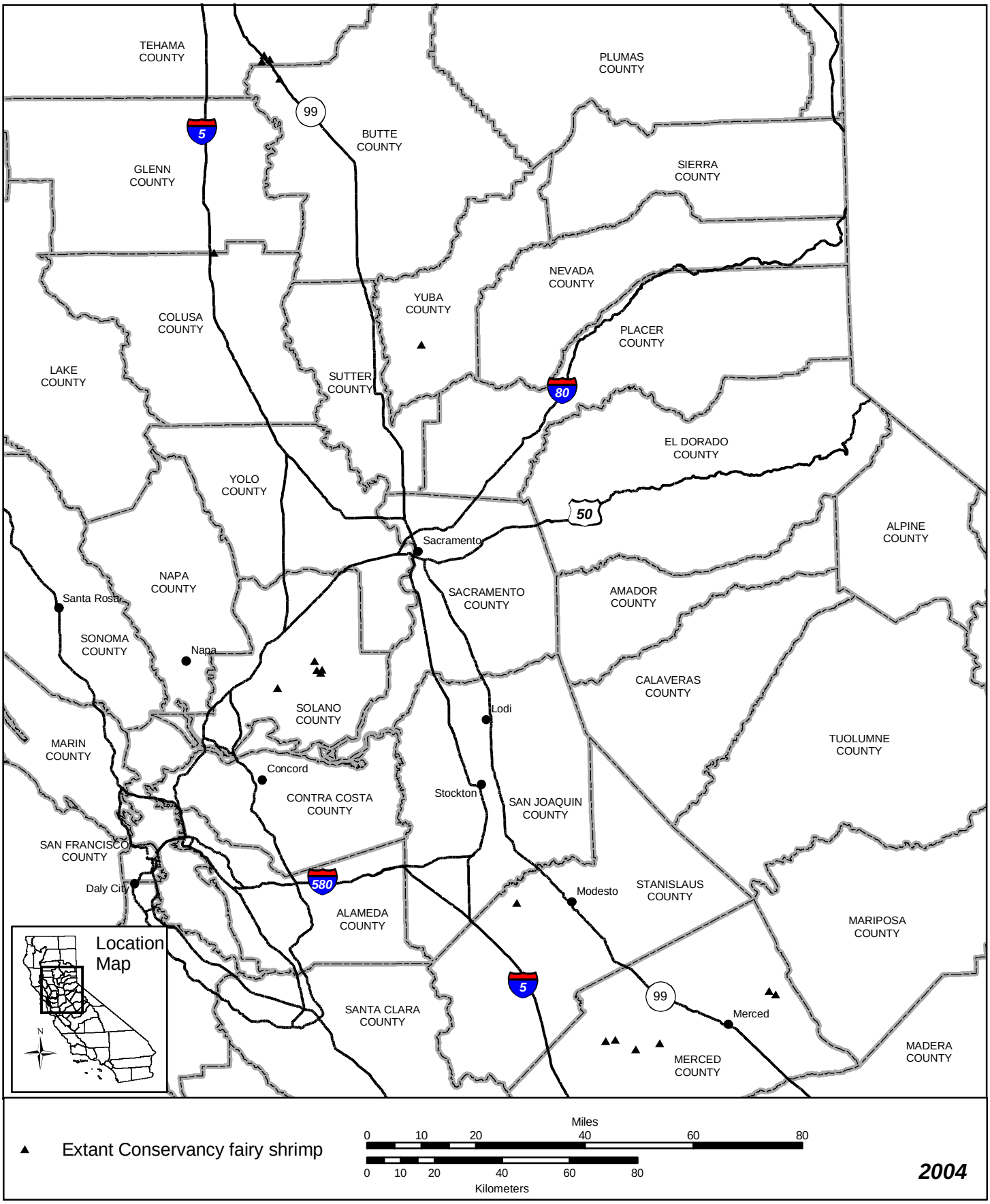

Figure II-42. Distribution of Conservancy fairy shrimp (*Branchinecta conservatio*).

general, Conservancy fairy shrimp have very large populations within a given pool, and is usually the most abundant fairy shrimp when more than one fairy shrimp species is present (Helm 1998, Eriksen and Belk 1999). Conservancy fairy shrimp is a prey species for the vernal pool tadpole shrimp (Alexander and Schlising 1997), as well as a variety of insect and vertebrate predator species. The species also co-occurs with several plants found in large vernal pools addressed in this draft recovery plan, including *Neostapfia colusana* and various *Orcuttia* species.

4. Reasons for Decline and Threats to Survival

Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to Conservancy fairy shrimp are described below.

In the Northeastern Sacramento Vernal Pool Region, Conservancy fairy shrimp are threatened by highway expansion on Caltrans land where they occur in Butte county. In the San Joaquin Vernal Pool Region, the Conservancy fairy shrimp is found only at the Grasslands Ecological area. Populations in this area may be threatened by inadequate management and monitoring (*e.g.*, regulatory mechanisms). In the Solano-Colusa region, Conservancy fairy shrimp populations are protected from development on some locations at the Jepson Prairie Preserve, however, specific management and monitoring for the species is not currently conducted at these sites. Additional occurrences of the species on private land in this region are threatened by development, particularly in the rapidly urbanizing areas of Fairfield and Vacaville. The species is also threatened by lack of management and monitoring at the Sacramento National Wildlife Refuge in Glenn County. In the Southern Sierra Foothills region, the species is known from the Flying M ranch, on University of California lands, and on the Ichord ranch where it is currently threatened by indirect and cumulative effects associated with the development of the University of California, Merced campus. On the Los Padres National Forest in Ventura County, the Conservancy fairy shrimp is potentially threatened by lack of pro-active management and monitoring.

5. Conservation Efforts

On September 19, 1994, the final rule to list the Conservancy fairy shrimp as endangered was published in the *Federal Register* (U.S. Fish and Wildlife Service 1994*a)*. In 2003, critical habitat was designated for Conservancy fairy shrimp

and several other vernal pool species in *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon* (U.S. Fish and Wildlife Service 2003).

Within the Northeastern Sacramento Vernal Pool Region, the Conservancy fairy shrimp is protected at the Vina Plains preserve owned by the Nature Conservancy. In the Solano-Colusa Vernal Pool Region the Conservancy fairy shrimp is protected on lands within the Jepson Prairie Ecosystem, including the Burke Ranch and the Jepson Prairie Preserve owned by the Solano County Open Space and Farmland Conservancy and jointly managed by the University of California Reserve System. In the San Joaquin Vernal Pool Region, Conservancy fairy shrimp populations are protected at Grasslands Ecological Area on State and federally owned lands.

S. LONGHORN FAIRY SHRIMP (*BRANCHINECTA LONGIANTENNA*)

1. Taxonomy, Description, and Identification

Taxonomy.—The longhorn fairy shrimp (*Branchinecta longiantenna*) was first collected in 1937, but was not formally described until 1990 (Eng *et al.* 1990). The longhorn fairy shrimp is named for its relatively long antennae. The type specimen was collected from a sandstone outcrop pool on the Souza Ranch in Contra Costa County, California.

Description and Identification.—Although longhorn fairy shrimp generally look similar to other fairy shrimp species (see **Box 1**- Appearance and Identification of Vernal Pool Crustaceans), this species is easily identified by the male's very long second antennae, which is about twice as long, relative to its body, as the second antennae of other species of *Branchinecta.* Longhorn fairy shrimp antennae range from 6.7 to 10.4 millimeters (0.3 to 0.4 inch) in length (Eriksen and Belk 1999). Females can be recognized by their cylindrical brood pouch, which extends to below abdominal segments six or seven. Mature males have been measured between 12 and 21 millimeters (0.5 to 0.8 inch) in length, and females range from 13.3 to19.8 millimeters (0.5 to 0.8 inch) in length (Eng *et al.* 1990).

Longhorn fairy shrimp are easily distinguished from other fairy shrimp by the male’s extremely long second antennae (Eng *et al.* 1990). Female longhorn fairy shrimp may be confused with alkali fairy shrimp (*Branchinecta mackini*), but there are no dorsal outgrowths on the thoracic segments of longhorn fairy shrimp females; while these structures are present in alkali fairy shrimp females (Eng *et al.* 1990).

2. Historical and Current Distribution

Historical Distribution.—The distribution of the longhorn fairy shrimp may never have extended into the northern portion of the Central Valley or into southern California. Extensive surveying of vernal pool habitats in southern California have never revealed populations of longhorn fairy shrimp. There is some evidence that temperatures may not be warm enough for the species to mature in the northern portions of the Central Valley. However, it is likely the longhorn fairy shrimp was once more widespread in the regions where it is currently known to occur, and in adjacent areas such as the San Joaquin and Southern Sierra Foothill Vernal Pool Regions, where habitat loss has been extensive.

Current Distribution.—Longhorn fairy shrimp are extremely rare. The longhorn fairy shrimp is known from only a small number of widely separated populations (**Figure II-43**). Sugnet (1993) found only three occurrences of the longhorn fairy shrimp out of 3,092 locations surveyed, and Helm (1998) found longhorn fairy shrimp in only nine of 4,008 wetlands sampled. Longhorn fairy shrimp are currently found in alkaline pools around Soda Lake in the Carrizo Vernal Pool Region, in a series of sandstone outcrop pools in the Livermore Vernal Pool Region, and from alkaline grassland vernal pools at the Kesterson National Wildlife Refuge and a roadside ditch located two miles north of Los Banos in the San Joaquin Vernal Pool Region. Lack of surveys throughout much of the San Joaquin valley and in areas between the Carrizo and the Livermore vernal pool regions suggests there may be additional, undiscovered populations of this species. Until research addressing the tolerance of longhorn fairy shrimp to cooler temperatures has been conducted, its presence in northern Central Valley vernal pool regions cannot be ruled out.

3. Life History and Habitat

Life History.—The longhorn fairy shrimp is highly adapted to the unpredictable conditions of vernal pool ecosystems. Longhorn fairy shrimp required a minimum of 23 days, but averaged 43 days, to reach maturity in artificial pools described by Helm (1998). However, Helm (1998) found no significant differences between the life span or reproductive rate of the longhorn fairy shrimp and other species of fairy shrimp he studied.

Habitat.—Although the longhorn fairy shrimp is only known from a few locations, these sites contain very different types of vernal pool habitats. Longhorn fairy shrimp in the Livermore Vernal Pool Region in Contra Costa and Alameda Counties live in small, clear, sandstone outcrop vernal pools. These

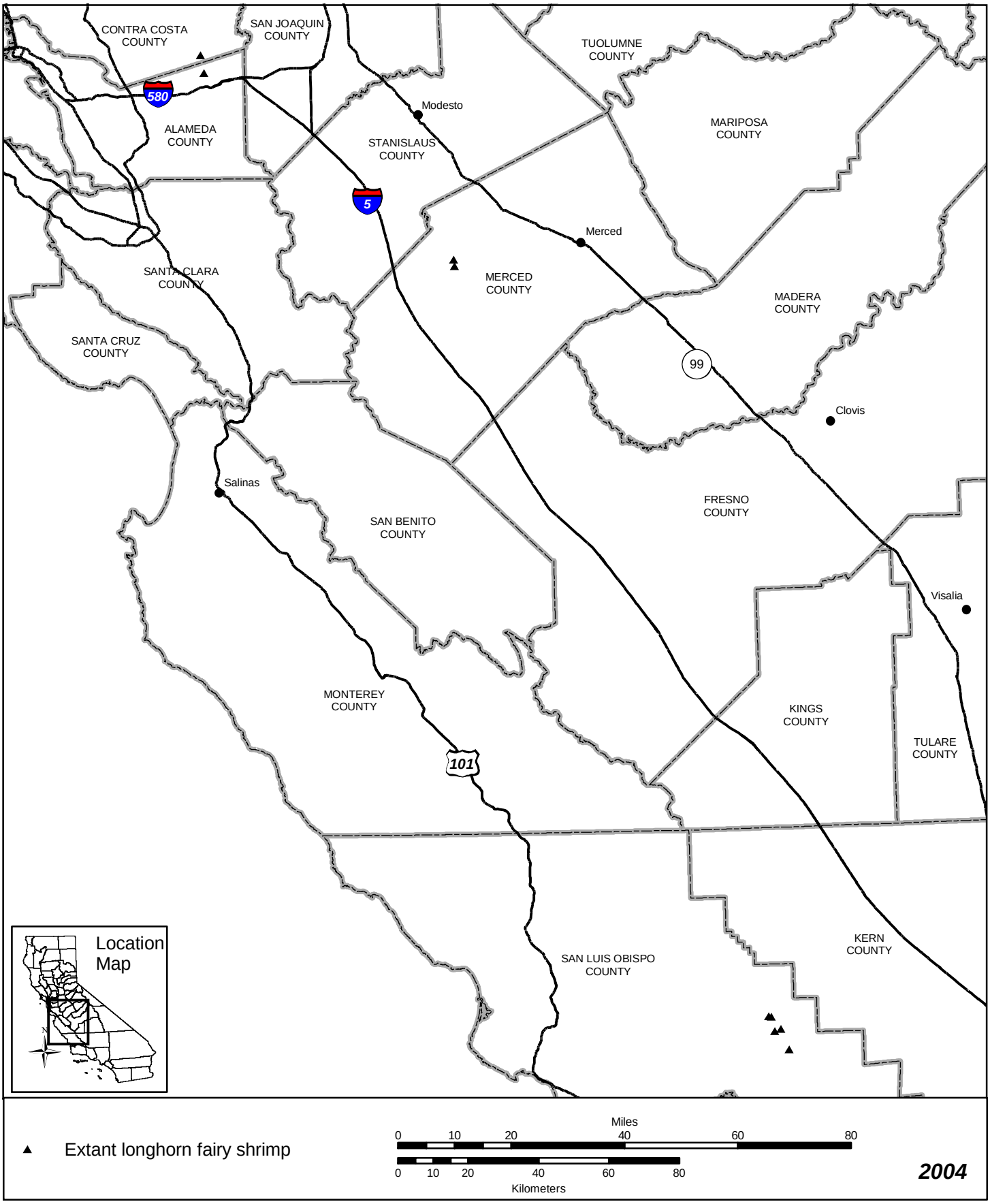

Figure II-43. Illustration of longhorn fairy shrimp (*Branchinecta longiantenna*).

sandstone pools are sometimes no larger than 1 meter (3.3 feet) in diameter (Eng *et al.* 1990), have a pH near neutral, and very low alkalinity and conductivity (Eriksen and Belk 1999). Water temperatures in these vernal pools have been measured between 10 and 18 degrees Celsius (50 and 64 degrees Fahrenheit). In both the San Joaquin and Carrizo vernal pool regions, the longhorn fairy shrimp is found in turbid, alkaline, grassland pools (Helm 1998, Eriksen and Belk 1999).

These grassland pools may be as large as 62 meters (203.4 feet) in diameter (Eng *et al.* 1990). Water temperatures in the grassland vernal pools are also warmer, between 10 and 28 degrees Celsius (50 to 82 degrees Fahrenheit). The species was most recently observed in a disturbed roadside ditch two miles north of Los Banos (California Natural Diversity Data Base 2003). Longhorn fairy shrimp have been found at elevations ranging from 23 meters (75.5 feet) in the San Joaquin Vernal Pool Region to 880 meters (2,887 feet) in the Carrizo Vernal Pool Region.

Community Associations.—The longhorn fairy shrimp has been found in the same general area as the Conservancy fairy shrimp, vernal pool fairy shrimp, and California fairy shrimp at different locations (Eng *et al.* 1990, Eriksen and Belk 1999). However, active adult longhorn fairy shrimp have rarely been collected from the same vernal pool as other fairy shrimp species.

4. Reasons for Decline and Threats to Survival

Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to longhorn fairy shrimp are described below.

In the Carrizo Vernal Pool Region, longhorn fairy shrimp habitat near Soda Lake is threatened by proposed subdivision development of “ranchettes” and road construction. In the Livermore Vernal Pool Region, longhorn fairy shrimp occurrences in the Altamont Pass area in Contra Costa and Alameda Counties may be threatened by ongoing and future wind energy developments (Eng *et al.* 1990). The Souza Ranch area in Contra Costa County is also threatened by wind energy and water storage projects (Eng *et al.* 1990). In the San Joaquin Vernal Pool Region, the longhorn fairy shrimp is protected from development on the Kesterson Unit of San Luis National Wildlife Refuge, however, there are no management guidelines explicitly addressing management of longhorn fairy shrimp at the refuge.

5. Conservation Efforts

On September 19, 1994, the final rule to list the longhorn fairy shrimp as endangered was published in the *Federal Register* (U.S. Fish and Wildlife Service 1994*a)*. In 2003, critical habitat was designated for longhorn fairy shrimp and several other vernal pool species in *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon* (U.S. Fish and Wildlife Service 2003).

Although there has been a significant amount of research addressing vernal pool habitats, few studies have addressed longhorn fairy shrimp specifically. The longhorn fairy shrimp is difficult to study because of its rarity. Most of what is known about the species is described in Helm (1998), Eriksen and Belk (1999), and Eng *et al.* (1990). Factors that limit the distribution of this species have been suggested in the literature, but have yet to be tested.

In the Carrizo Vernal Pool Region, vernal pool habitat supporting the longhorn fairy shrimp has been protected on the Carrizo National Monument. Longhorn fairy shrimp populations are periodically monitored by Bureau of Land Management staff. In the San Joaquin Vernal Pool Region, vernal pool habitats occupied by the longhorn fairy shrimp are protected at the Kesterson National Wildlife Refuge.

T. VERNAL POOL FAIRY SHRIMP (*BRANCHINECTA LYNCHI*)

1. Taxonomy, Description, and Identification

Taxonomy.—The vernal pool fairy shrimp (*Branchinecta lynchi*) was first described by Eng, Belk and Eriksen (Eng *et al.* 1990). The species was named in honor of James B. Lynch, a systematist of North American fairy shrimp. The type specimen was collected in 1982 at Souza Ranch, Contra Costa County, California. Although not yet described, the vernal pool fairy shrimp had been collected as early as 1941, when it was identified as the Colorado fairy shrimp by Linder (1941).

Description and Identification.—Although most species of fairy shrimp look generally similar (see **Box 1-** Appearance and Identification of Vernal Pool Crustaceans), vernal pool fairy shrimp are characterized by the presence and size of several mounds (see identification section below) on the male's second antennae, and by the female's short, pyriform or pear shaped, brood pouch. Vernal pool fairy shrimp vary in size, ranging from 11 to 25 millimeters (0.4 to 1.0 inch) in length (Eng *et al.* 1990). Vernal pool fairy shrimp closely resemble

Colorado fairy shrimp (*Branchinecta coloradensis*) (Eng *et al.* 1990). However, there are differences in the shape of a small mound-like feature located at the base of the male's antennae, called the pulvillus. The Colorado fairy shrimp has a round pulvillus, while the vernal pool fairy shrimp's pulvillus is elongate. The vernal pool fairy shrimp can also be identified by the shape of a bulge on the distal, or more distant end, of the antennae. This bulge is smaller and less spiny on the vernal pool fairy shrimp. The female Colorado fairy shrimp's brood pouch is longer and more cylindrical than the vernal pool fairy shrimp's. Female vernal pool fairy shrimp also closely resemble female midvalley fairy shrimp. These two species can be distinguished by the number and placement of lobes on their backs, called dorsolateral thoracic protuberances. Vernal pool fairy shrimp have paired dorsolateral thoracic protuberances on the third thoracic segment that are lacking in the midvalley fairy shrimp (Belk and Fugate 2000).

2. Historical and Current Distribution

Historical Distribution.—The vernal pool fairy shrimp was identified relatively recently, in 1990, and there is little information on the historical range of the species. However, the vernal pool fairy shrimp is currently known to occur in a wide range of vernal pool habitats in the southern and Central Valley areas of California, and in two vernal pool habitats within the “Agate Desert” area of Jackson County, Oregon. The vegetation and land use in its Oregon range are similar to those of northern California’s inland valleys.

It is likely the historical distribution of this species coincides with the historical distribution of vernal pools in California’s Central Valley and southern Oregon (**Figure II-44**). Holland (1978) estimated that roughly 1,618,700 hectares (4,000,000 acres) of vernal pool habitat existed in the Central Valley prior to the widespread agricultural development that began in the mid-1800's. He found that although the current and historical distribution of vernal pools is similar, vernal pools are now far more fragmented and isolated from each other than during historical times and currently occupy only about 25 percent of their former land area (Holland 1998). The current distribution of the vernal pool fairy shrimp in the Central Valley may be similar to its historical distribution in extent, but remaining populations are now considerably more fragmented and isolated than in pre-agricultural times.

The historical distribution of the vernal pool fairy shrimp in the Central Coast, Carrizo, and Santa Barbara vernal pool regions is not known. The historical distribution of the vernal pool fairy shrimp in Southern California may also have been similar to the historic distribution of its vernal pool habitat. Unlike the Central Valley, where vernal pool habitats where historically widespread, vernal

Figure II-44. Distribution of vernal pool fairy shrimp (*Branchinecta lynchi*)

pools in Southern California were probably always limited in area and extent. However, vernal pool habitats were once far more extensive than they are today (Bauder and McMillan 1998, Mattoni and Longcore 1998). In Los Angeles County, the coastal prairie and associated vernal pools may have historically occupied as much as 9,308 hectares (23,000 acres) (Mattoni *et al.* 1997). Vernal pools in San Diego County probably covered 51,800 hectares (128,000 acres) prior to intensive agriculture and urbanization (Bauder and McMillan 1998). The vernal pool fairy shrimp was likely historically present in available vernal pool habitats in Riverside, Los Angeles, Ventura, and Orange Counties. However, vernal pool fairy shrimp are currently absent from San Diego County, despite the presence of vernal pool habitats there. It is possible the vernal pool fairy shrimp is absent from the San Diego Vernal Pool Region as a result of competition with other species, such as the San Diego fairy shrimp. However, this hypothesis has not been formally tested.

Vernal pool habitats in the Agate Desert of southern Oregon historically occupied approximately 12,950 hectares (32,000 acres) (Oregon Natural Heritage Program 1997). The Agate Desert is located in the Rogue/Illinois River Valley region of the Klamath Mountains ecoregion. This area may have also constituted the historic range of the vernal pool fairy shrimp in this region. However, because the presence of vernal pool fairy shrimp was first documented in 1998, it is possible that additional locations for the species will be found in Oregon in the future.

Current Distribution.—The vernal pool fairy shrimp is currently found in 27 counties across the Central Valley and coast ranges of California, and in Jackson County of southern Oregon. The species occupies a variety of vernal pool habitats, and occurs in 11 of the 17 vernal pool regions identified in California (by Keeler-Wolf *et.al*. (1998)). Although the vernal pool fairy shrimp is distributed more widely than most other fairy shrimp species covered in this recovery plan, it is generally uncommon throughout its range, and rarely abundant where it does occur (Eng *et al.* 1990, Eriksen and Belk 1999). Helm (1998) found vernal pool fairy shrimp in only 16 percent of pools sampled across 27 counties, and Sugnet (1993) found this species in only 5 percent of 3,092 locations sampled.

The Agate Desert of southern Oregon comprises the northern extent of the range of the vernal pool fairy shrimp. Here, vernal pool fairy shrimp are known from the vernal pools within the Agate-Winlo soils of the Agate Desert landform and the Randcore-Shoat soils underlain by lava bedrock on top of Upper and Lower Table Rocks (Helm and Fields 1998). In California, the vernal pool fairy shrimp occurs on the Thomes Creek Ecological Reserve and the Stillwater Plains

preservation bank in Tehama County, and at isolated locations in Glenn and Shasta Counties in the Northwestern Sacramento Valley Vernal Pool Region. In the Northeastern Sacramento Valley Vernal Pool Region, the species occurs in the vicinity of Vina plains and the City of Chico in Tehama and Butte Counties, respectively. The greatest number of known occurrences of the vernal pool fairy shrimp are found in the Southeastern Sacramento Vernal Pool Region, where it is found in scattered vernal pool habitats in Placer, Sacramento, and San Joaquin Counties, in the vicinity of Beale Air Force Base in Yuba County, and at a single location in El Dorado County. In the Solano-Colusa Vernal Pool Region, the vernal pool fairy shrimp is known from the vicinity of Jepson Prairie, and the cities of Vacaville and Dixon in Solano County. In the San Joaquin Valley Vernal Pool Region, the vernal pool fairy shrimp is found at the Grasslands Ecological Area in Merced County, at the Pixley National Wildlife Refuge in Tulare County, and at isolated locations in Kings and Stanislaus Counties. In the Southern Sierra Foothills Vernal Pool Region, the vernal pool fairy shrimp is known from the Stone Corral Ecological Reserve and the Hogwallow Preserve in Tulare County and from scattered locations on private land in Stanislaus, San Joaquin, Fresno, Madera, and Merced Counties.

The vernal pool fairy shrimp is also found in isolated patches along the central and southern Coast Range of California. In the Livermore Vernal Pool Region, the vernal pool fairy shrimp has been found in the Springtown area and in the vicinity of Byron Airport in Alameda and Contra Costa Counties respectively. In the Central Coast region the species has been found in a minimum of 55 wetland pools at Fort Hunter Liggett in Monterey County; at two locations in San Benito County; and at one site 2.5 miles east of the city of Paso Robles. The vernal pool fairy shrimp occurs at a single location in Napa County in the Lake-Napa Vernal Pool Region. In the Carrizo Vernal Pool Region, the vernal pool fairy shrimp has been found in a minimum of 61 pools at Camp Roberts and in the vicinity of Soda Lake on the Carrizo plain in San Luis Obispo County. In the Santa Barbara Vernal Pool Region, the vernal pool fairy shrimp has been found in Cachuma Canyon in Santa Barbara County, in the Carlsberg vernal pools in Ventura County, and in the Cruzan Mesa vernal pools in Los Angeles County. Vernal pool fairy shrimp have also been found at two locations within the Los Padres National Forest in Ventura County, outside the Santa Barbara Vernal Pool Region. In the Western Riverside County Vernal Pool Region, the species is known to occur at Skunk Hollow and on the Santa Rosa Plateau.

3. Life History and Habitat

Life History.—Vernal pool fairy shrimp are uniquely adapted to the environmental conditions of their ephemeral habitats. One adaptation is the

ability of the vernal pool fairy shrimp eggs, or cysts, to remain dormant in the soil when their vernal pool habitats are dry. Another important adaptation is that the vernal pool fairy shrimp has a relatively short life span, allowing it to hatch, mature to adulthood, and reproduce during the short time period when vernal pools contain water. The vernal pool fairy shrimp can reach sexual maturity in as few as 18 days at optimal conditions of 20 degrees Celsius (68 degrees Fahrenheit), and can complete its life cycle in as little as 9 weeks (Gallagher 1996, Helm 1998). However, maturation and reproduction rates of vernal pool crustaceans are controlled by water temperature and can vary greatly (Eriksen and Brown 1980, Helm 1998). Helm (1998) observed that vernal pool fairy shrimp did not reach maturity until 41 days at water temperatures of 15 degrees Celsius (59 degrees Fahrenheit). Helm (1998) observed six separate hatches of vernal pool fairy shrimp in a single pool within a single wet season, and Gallagher (1996) observed three separate hatches of vernal pool fairy shrimp in vernal pools in Butte County. Helm (1998) found the mean life span of the vernal pool fairy shrimp was significantly shorter than the California fairy shrimp, but not significantly different from midvalley, longhorn, or Conservancy fairy shrimp observed under the same conditions. In larger pools that hold water for longer durations, vernal pool fairy shrimp are capable of hatching multiple times if water temperatures drop to below 10 degrees Celsius (50 degrees Fahrenheit), a necessary environmental cue for vernal pool fairy shrimp cyst hatching (Gallagher 1996, Helm 1998). Helm (1998) observed vernal pool fairy shrimp living for as long as 147 days.

Habitat.—Vernal pool fairy shrimp exist only in vernal pools or vernal pool like habitats. Individuals have never been found in riverine, marine, or other permanent bodies of water. Vernal pool habitats form in depressions above an impervious soil layer or duripan. Due to local topography and geology, the depressions are part of an undulating landscape, where soil mounds are interspersed with basins, swales, and drainages. Water movement within complexes allows vernal pool fairy shrimp to move between individual pools. These movement patterns, as well as genetic evidence, indicate that vernal pool fairy shrimp populations exist within and are defined by entire vernal pool complexes, rather than individual vernal pools (Simovich *et al.* 1992, King, *et al.* 1996).

The vernal pool fairy shrimp occupies a variety of different vernal pool habitats, from small, clear, sandstone rock pools to large, turbid, alkaline, grassland valley floor pools (Eng *et al.* 1990, Helm 1998). Although the vernal pool fairy shrimp has been collected from large vernal pools, including one exceeding 10 hectares (25 acres) in area (Eriksen and Belk 1999), it tends to occur in smaller pools (Plantenkamp 1998), and is most frequently found in pools measuring less than

0.02 hectare (0.05 acre) in area (Gallagher 1996, Helm 1998). The vernal pool fairy shrimp typically occurs at elevations from 10 meters (33 feet) to 1,220 meters (4,003 feet) (Eng *et al.* 1990), although two sites in the Los Padres National Forest have been found to contain the species at an elevation of 1,700 meters (5,600 feet). The vernal pool fairy shrimp has been collected at water temperatures as low as 4.5 degrees Celsius (40 degrees Fahrenheit) (Eriksen and Belk 1999), however, the species has not been found in water temperatures above about 23 degrees Celsius (73 degrees Fahrenheit) (Helm 1998, Eriksen and Belk 1999). The species is typically found in pools with low to moderate amounts of salinity or total dissolved solids (Collie and Lathrop 1976, Keeley 1984, Syrdahl 1993). Vernal pools are mostly rain fed, resulting in low nutrient levels and dramatic daily fluctuations in pH, dissolved oxygen, and carbon dioxide (Keeley and Zedler 1998). Although there are many observations of the environmental conditions where vernal pool fairy shrimp have been found, there have been no experimental studies investigating the specific habitat requirements of this species. Plantenkamp (1998) found no significant differences in vernal pool fairy shrimp distribution between four different geomorphic surfaces studied at Beale Air Force Base.

In Oregon, the vernal pool fairy shrimp is found on two distinct vernal pool habitats (Helm and Fields 1998). The species occurs on alluvial fan terraces associated with Agate-Winlo soils on the Agate Desert, and in the Table Rocks area on Randcore-Shoat soils underlain by lava bedrock. These vernal pool habitats represent the northern extent of Mediterranean vernal pools addressed in this recovery plan, and the northern extent of the range of the vernal pool fairy shrimp.

In the Western Riverside County and Santa Barbara vernal pool regions, the vernal pool fairy shrimp occurs on inland mesas and valleys, on weak to strongly alkaline soils. In the Los Padres National Forest in Ventura County, the animal is known to occur in atypical habitats that consist of vernal pools that are located under a Jeffrey Pine canopy that does not possess a grass understory.

Community Associations.—The vernal pool fairy shrimp occupies the same vernal pool habitats as many of the other species addressed in this recovery plan. Plant species that have been found in the same vernal pool habitats as the vernal pool fairy shrimp include *Astragalus tener* var. *tener*, *Atriplex persistens*, *Castilleja campestris* ssp. *succulenta*, *Chamaesyce hooveri*, *Eryngium spinosepalum*, *Gratiola heterosepala*, *Legenere limosa*, *Limnanthes floccosa* ssp. *californica*, *Neostapfia colusana*, all of the *Orcuttia* species, and *Tuctoria greenei*. In Oregon, the vernal pool fairy shrimp is found in the same vernal pool habitats as two listed vernal pool plants, *Lomatium cookii* (Cook's lomatium) and

Limnanthes floccosa ssp. *grandiflora* (large-flowered meadowfoam). The vernal pool fairy shrimp occupies the same vernal pool habitats as the delta green ground beetle.

The vernal pool fairy shrimp has been found in the same vernal pool habitats as all of the other vernal pool crustaceans described in this recovery plan: the vernal pool tadpole shrimp, California fairy shrimp, the Conservancy fairy shrimp, the longhorn fairy shrimp, and the midvalley fairy shrimp. In Southern California, vernal pool fairy shrimp have been found to co-occur with the federally listed Riverside fairy shrimp (*Streptocephalus sealii*). However, the vernal pool fairy shrimp has rarely been collected from the same pools as other fairy shrimp species (Eng *et al.* 1990, Maeda-Martinez *et al.* 1997, Eriksen and Belk 1999). When coexistence does occur, it has been in longer lived pools, and the vernal pool fairy shrimp are often less abundant than other fairy shrimp species (Eng *et al.* 1990, Gallagher 1996, Eriksen and Belk 1999). Given the apparently wide distribution of this species and its tolerance for a wide range of conditions, it is possible that the absence of the vernal pool fairy shrimp in certain habitats is explained by competitive exclusion by other fairy shrimp (Helm 1998, Eriksen and Belk 1999). Vernal pool tadpole shrimp are predators of vernal pool fairy shrimp, whereas vernal pool fairy shrimp feed on algae, bacteria, protozoa, rotifers, and bits of detritus.

The vernal pool fairy shrimp occurs in the same vernal pool habitats as the California tiger salamander and the western spadefoot toad. Vernal pool fairy shrimp provide an important food source for a number of species, including the western spadefoot toad (Simovich *et al.* 1991). Vernal pool fairy shrimp are also a major prey item for waterfowl, such as ducks (Proctor *et al.* 1967, Krapu 1974, Swanson *et al.* 1974, Silveira 1996). In turn, waterfowl and other migratory birds are important dispersal agents for this and other vernal pool species.

4. Reasons for Decline and Threats to Survival

Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to vernal pool fairy shrimp are described below.

As the California Natural Diversity Database (2003) indicates, 92 occurrences (27 percent) of vernal pool fairy shrimp are threatened by development, and an additional 27 occurrences (7 percent) are threatened by agricultural conversion.

In the Carrizo Vernal Pool Region, vernal pool habitats known to contain the vernal pool fairy shrimp are currently located on Federal land at the Camp Roberts Military Base and at the Carrizo National Monument. Although these areas are not immediately threatened by development, they may be threatened by military activities that alter historical vernal pools characteristics and introduce nonnative plant species. In two of the three plots that were fenced to protect vernal pools from training activities on Camp Roberts, nonnative *Taeniatherum caput-medusae* became more prolific and threatened to diminish the pool area available to fairy shrimp because nonnative plants encroached on pool edges.

In the Central Coast region, the vernal pool fairy shrimp is known only from Federal land on the Fort Hunter Liggett Military Reservation. Training and maintenance activities on this military base also have the potential to degrade some historical wetland habitats that are inhabited by fairy shrimp. In the Livermore Vernal Pool Region, the vernal pool fairy shrimp is located primarily on private land, where it is threatened by development, including expansion of the Byron Airport.

In the Northeastern Sacramento Valley Vernal Pool Region, most of the known occurrences of the vernal pool fairy shrimp are located on Caltrans rights-of-way and are thus threatened by various future road improvement projects in this region, particularly the future expansion of Highway 99. Additional populations are threatened by commercial and residential development projects. In the Northwestern Sacramento Valley Vernal Pool Region, the vernal pool fairy shrimp may be threatened by lack of management and monitoring on the PG&E mitigation areas and at the Stillwater Plains mitigation bank. Additional occurrences on private land in this region may be threatened by agricultural conversion or development. In the Southeastern Sacramento Vernal Pool Region, the vernal pool fairy shrimp is threatened by urban development. Both Sacramento and Placer Counties are currently developing Habitat Conservation Plans to address growth in the region. Vernal pool fairy shrimp also occur on a number of private mitigation sites in the Southeastern Sacramento Vernal Pool Region, where they are threatened by a lack of management and monitoring.

In the San Joaquin Valley region, the vernal pool fairy shrimp is found primarily on private land where it is threatened by direct habitat loss, including urban development and agricultural conversion. On the San Joaquin National Wildlife Refuge the species is protected from development, however it may be threatened by lack of specific monitoring and management.

Refer to the Draft Santa Rosa Plains Recovery Plan (in development) for information regarding threats facing the vernal pool fairy shrimp in the Santa Rosa vernal pool region, as identified by Keeler-Wolf *et.al*. (1998).

In the Solano-Colusa region, the vernal pool fairy shrimp is threatened by development on the private property where it occurs. The species may also be threatened by lack of management and monitoring on protected properties such as Jepson Prairie, Travis Air Force Base, and at the Davis Communications Annex.

In the Southern Sierra Foothills region, the species is threatened by the proposed University of California, Merced campus, which will likely also contribute to significant growth in the region, resulting in additional loss of vernal pool crustacean habitat. Agricultural conversion and flood control projects on Bureau of Reclamation land also threaten the species in this region.

In the Western Riverside County region, vernal pool fairy shrimp populations are threatened by development where they occur on private land in Los Angeles, Ventura, and Riverside Counties. Although other populations in Riverside County are protected at the Santa Rosa Plateau managed by the Nature Conservancy, these habitats may be threatened by the development of adjacent lands (Chester 2000).

In Oregon, vernal pool fairy shrimp occurring on the Agate Desert are threatened by commercial and industrial development, agricultural conversion, and utility projects (Oregon Natural Heritage Program 1997). Over 40 percent of the vernal pool habitats remaining in Oregon have been degraded (Borgias and Patterson 1999). Vernal pool habitats that are protected on the Agate Desert by the Nature Conservancy are threatened by the indirect effects of adjacent land use, including alteration of hydrology (Evans 2000). Vernal pool fairy shrimp populations on the Table Rocks area managed by the Bureau of Land Management are also threatened by direct influences of *incompatible* land uses. Because the portion of the Table Rocks managed by the Bureau of Land Management is an Area of Critical Environmental Concern, the pools on Bureau of Land Management administered land are in an area that is not available for timber harvest and closed to Off-Highway-Vehicle use. Grazing is allowed for one month in the spring on Upper Table Rock only. The area is open to mineral entry. There is a single access road to the summit of each of the Table Rocks from adjacent private lands, and an old airplane landing strip is present on Lower Table Rock. The tops of the Table Rocks are closed to motorized vehicles, including aircraft. Threats to the vernal pools on the Table Rocks are primarily as a result of recreation use: human trampling in the wet areas near pools and potential change in subsurface or surface flow runoff patterns due to trail construction and/or improvement. The

Bureau of Land Management is scheduled to begin development of a management plan for Upper and Lower Table Rock in 2004.

5. Conservation Efforts

On September 19, 1994, the final rule to list the vernal pool fairy shrimp as threatened was published in the *Federal Register* (U.S. Fish and Wildlife Service 1994*a)*. In 2003, critical habitat was designated for vernal pool fairy shrimp and several other vernal pool species in *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon* (U.S. Fish and Wildlife Service 2003).

Conservation efforts for the vernal pool fairy shrimp are divided into five broad categories; regulatory and legal protections, education and outreach, research, conservation planning and habitat protection, and species specific management and monitoring. A brief description of each type of conservation action is provided below.

Regulatory and Legal protections. The vernal pool fairy shrimp is protected as a threatened species under the Endangered Species Act. The International Union for the Conservation of Nature listed the vernal pool fairy shrimp as vulnerable in the 1996 Red list.

Education and Outreach: The Inland Invertebrate Working group distributes Anostracan news, and works toward disseminating information about the species. In 1998, we published a recovery plan for the vernal pools of Southern California (U.S. Fish and Wildlife Service 1998b).

Research: Vernal pool habitats have been the focus of much research, and scientific interest in this unique habitat type has continued to grow. Although there are numerous anecdotal accounts of the habitat requirements of the vernal pool fairy shrimp, little specific information about the conservation needs of the vernal pool fairy shrimp has been accumulated.

Conservation Planning and Habitat Protection: Approximately 5,261 hectares (13,000 acres) of vernal pool habitats, including mitigation banks, have been set aside for the vernal pool fairy shrimp specifically as terms and conditions of section 7 consultations. These areas are scattered throughout the Central Valley and represent important building blocks toward recovery of the vernal pool fairy shrimp.

Vernal pool habitats supporting populations of vernal pool fairy shrimp have been protected through a variety of other means. Within the Carrizo Vernal Pool Region, some of the vernal pool fairy shrimp habitat is protected from training and maintenance activities on the Camp Roberts military base.

In the Central Coast region, some of the vernal pools inhabited by fairy shrimp are protected at the Fort Hunter Liggett Military Reservation. In the Livermore Vernal Pool Region, the species occurs on public land in Contra Costa County and in the City of Livermore.

In the Northeastern Sacramento Valley region, vernal pool fairy shrimp are protected on a private mitigation area and on land owned by the Nature Conservancy. Private mitigation lands, the Stillwater Preservation Bank, and the Thomes Creek Ecological Reserve protect the species from direct habitat loss in the Northwestern Sacramento Valley Vernal Pool Region.

In the San Joaquin Valley Vernal Pool Region, vernal pool fairy shrimp are protected at the Grasslands Ecological Area, including Federal and State wildlife refuges in Merced County. In the Solano-Colusa Vernal Pool Region, the vernal pool fairy shrimp is protected on several preserves in the Jepson Prairie area and at Travis Air Force Base in Solano County. Several Habitat Conservation Plans are developing vernal pool preserve plans in the region, including Solano and Yolo Counties.

In the Southeastern Sacramento Valley Vernal Pool Region, vernal pool fairy shrimp occurrences are protected from development at a number of private mitigation areas, mitigation banks, and on the Cosumnes River Preserve's Valensin Ranch property. They also occur on the Howard Ranch, owned by a private rancher but protected by a conservation easement (Marty, pers. comm. 2004). The species is also protected at Beale Air Force Base in Yuba County, where management and monitoring have recently been implemented (Jones and Stokes 1997). Several Habitat Conservation Plans are developing vernal pool preserve plans in the region, including Sacramento and Placer Counties.

In the Southern Sierra Foothills Vernal Pool Region, the species is protected at the Stone Corral Ecological Reserve.

In the Western Riverside County Vernal Pool Region, vernal pool fairy shrimp are protected at the Santa Rosa Plateau Preserve, managed by the Nature Conservancy. The Recovery Plan for Vernal pools of Southern California (U.S. Fish and Wildlife Service 1998b) includes vernal pool habitats containing vernal pool fairy shrimp populations as part of the Riverside Management Area, and

establishes recovery strategies and criteria for protecting these habitats. Some of these habitats are also protected through a Habitat Conservation Plan.

In the Santa Barbara Vernal Pool Region, the Recovery Plan for Vernal Pools of Southern California (U.S. Fish and Wildlife Service 1998b) includes habitats containing vernal pool fairy shrimp populations in Los Angeles and Ventura Counties in the Transverse Management area. The recovery plan develops recovery strategies and criteria for listed fairy shrimp species occurring in these habitats. The three known vernal pools that support fairy shrimp on the Los Angles National Forest receive some protection as a result of section 7 consultation requirements that are mandatory for Federal agencies, and additional survey efforts would likely result in local range extensions within the national forest.

In Oregon, vernal pool fairy shrimp populations are protected on the Nature Conservancy's Agate Desert and Whetstone Savanna preserves, containing approximately 78 hectares (197 acres) of vernal pool habitat. Habitat is also protected from development on property owned by the Bureau of Land Management (129 hectares [320 acres] of vernal pool habitat) and Bureau of Reclamation (60 hectares [150 acres] of vernal pool habitat). Bureau of Land Management is scheduled to begin development of a management plan for Upper and Lower Table Rock in 2004. The Bureau of Reclamation is scheduled to begin development of a management plan for vernal pool habitat in 2005. A Wetland Conservation Plan is currently being developed to protect vernal pool habitats in the White City region of the Agate Desert.

Site-specific details of the recovery actions for vernal pool fairy shrimp populations in Oregon will be identified as part of a recovery plan for species of the upper Rogue River Valley, which is currently in preparation at our Roseburg Field Office. The Rogue River Valley recovery plan will develop an integrated, ecosystem-based strategy for recovery of vernal pool fairy shrimp and two endangered plant species that are endemic to the area, within the context of the broader recovery strategy identified in this Vernal Pool Ecosystem Draft Recovery Plan.

U. VERNAL POOL TADPOLE SHRIMP *(LEPIDURUS PACKARDI)*

1. Taxonomy, Description, and Identification

Taxonomy.—The vernal pool tadpole shrimp *(Lepidurus packardi)* was initially described by Simon (1886), and named *Lepidurus packardi*. Linder (1952) maintained *L. packardi* as a valid species. However, in a review of the

Order Notostraca, Longhurst (1955) reduced this and 18 other species to subspecies of *L. apus* based primarily on the lack of apparent geographic boundaries between *L. apus* and *L. packardi* populations. Lynch (1972) resurrected *L. packardi* to full species status based on further examination of specimens. This is the currently accepted taxonomic status of the vernal pool tadpole shrimp. Recent genetic analysis indicates *L. packardi* is a valid species (King and Hanner 1998).

Description and Identification.—Vernal pool tadpole shrimp, like other members of the Order Notostraca, are known as living fossils because they have changed little in appearance over roughly the last 2 million years, and resemble species found in the fossil record (Longhurst 1955, King and Hanner 1998). Vernal pool tadpole shrimp are distinguished by a large, shield-like carapace, or shell, that covers the anterior half of their body. Vernal pool tadpole shrimp have 30 to 35 pairs of phyllopods, a segmented abdomen, paired cercopods or tail-like appendages, and fused eyes. Mature vernal pool tadpole shrimp range in size from 15 to 86 millimeters (0.6 to 3.3 inches) in length.

Vernal pool tadpole shrimp and other species in the Order Notostraca have remained generally similar in appearance for hundreds of millions of years (Longhurst 1955). However, individuals often vary greatly in appearance, making classification and identification of species difficult (King and Hanner 1998, Linder 1952, Longhurst 1955, Gurney 1924). Recent genetic studies (King and Hanner 1998) may provide the basis for relating genetically detected differences to morphological variation, potentially allowing for the development of a classification key to the genus. Species in the genus *Lepidurus* can be distinguished from members of the similar looking genus *Triops* by the presence of a supra-anal plate between their cercopods, which is lacking in *Triops*. Another species of *Lepidurus* found in California, the cryptic tadpole shrimp (*Lepidurus cryptus*), has recently been described (Rogers 2001). This species cannot be differentiated from the vernal pool tadpole shrimp by appearance, but the two species are genetically distinct (King and Hanner 1998, Rogers 2001). The cryptic tadpole shrimp occurs in Great Basin and intermountain regions of northern California and southern and eastern Oregon, whereas the vernal pool tadpole shrimp occurs in the Central Valley, Delta, and east San Francisco Bay area (Rogers 2001). The cryptic tadpole shrimp is not known to occur within the range of the vernal pool tadpole shrimp as described in the listing rule (U.S. Fish and Wildlife Service 1994*a)*. No other species of *Lepidurus* are known from California.

2. Historic and Current Distribution

Historic Distribution.—King *et al.* (1996) suggested vernal pool tadpole shrimp probably evolved in the Central Valley of California after colonizing large inland lakes during the Pliocene and Pleistocene, approximately 2 million years ago. From the end of the Pleistocene until the mid-1800's, the Central Valley still contained extensive seasonal wetlands, sometimes covering the entire valley (Oakeshott 1978). Holland (1978) estimated that roughly 1,600,000 hectares (4,000,000 acres) of vernal pool habitat existed in the Central Valley during pre-agricultural times. Historically the vernal pool tadpole shrimp was probably distributed over most of these vernal pool habitats. However, surveys in southern portions of California have never revealed vernal pool tadpole shrimp populations, and the species probably did not occur historically outside of the Central Valley and Central Coast regions **(Figure II-45**).

Current Distribution.—The vernal pool tadpole shrimp is currently distributed across the Central Valley of California and in the San Francisco Bay area. The species distribution has been greatly reduced from historic times as a result of widespread destruction and degradation of its vernal pool habitat. Vernal pool habitats in the Central Valley now represent only about 25 percent of their former area, and remaining habitats are considerably more fragmented and isolated than during historic times (Holland 1998). Vernal pool tadpole shrimp are uncommon even where vernal pool habitats occur. Helm (1998) found vernal pool tadpole shrimp in only 17 percent of vernal pools sampled across 27 counties, and Sugnet (1993) found this species at only 11 percent of 3,092 locations. In the Northwestern Sacramento Vernal Pool Region, vernal pool tadpole shrimp are found at the Stillwater Plains and in the vicinity of Redding in Shasta County. In the Northeastern Sacramento Vernal Pool Region, vernal pool tadpole shrimp have been documented on private land in the vicinity of Chico in Butte County and at the Vina Plains Preserve, the Dales Lake Ecological Reserve, and Caltrans land in Tehama County. The largest concentration of vernal pool tadpole shrimp occurrences are found in the Southeastern Sacramento Vernal Pool Region, where the species occurs on a number of public and private lands in Sacramento County. Vernal pool tadpole shrimp are also known from a few locations in Yuba and Placer Counties, including Beale Air Force Base. In the Solano-Colusa Vernal Pool Region the vernal pool tadpole shrimp occurs in the vicinity of Jepson Prairie , Travis Air Force Base, and near Montezuma in Solano County and on the Sacramento National Wildlife Refuge in Glenn County. In the San Joaquin Vernal Pool Region, vernal pool tadpole shrimp are known from the Grasslands Ecological

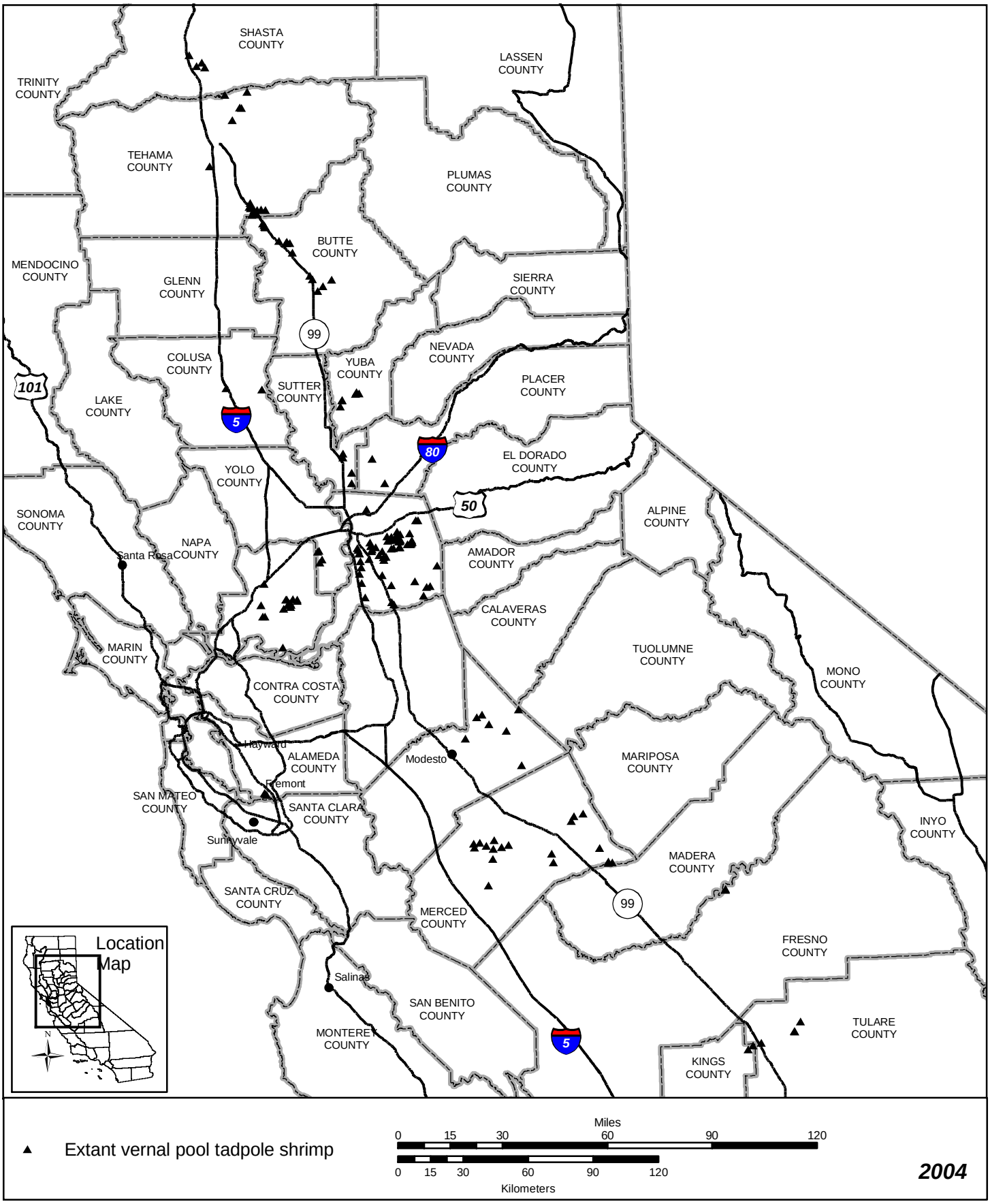

Figure II-45. Distribution of vernal pool tadpole shrimp (*Lepidurus packardi*)

Area and private land in Merced County and from single locations in Tulare and Kings Counties. In the Southern Sierra Foothills region, the species occurs at the Stone Corral Ecological Preserve in Tulare County, on ranchlands in eastern Merced County, at the Big Table Mountain Ecological Reserve in Fresno County, and at a few locations in Stanislaus County. In the Central Coast Vernal Pool Region, the vernal pool tadpole shrimp is found on the San Francisco National Wildlife Refuge and private land in Alameda County.

3. Life History and Habitat

Life History.—Although the vernal pool tadpole shrimp is adapted to survive in seasonally available habitat, the species has a relatively long life span compared to other vernal pool crustaceans. Helm (1998) found that the vernal pool tadpole shrimp lived significantly longer than any other species observed under the same conditions except the California fairy shrimp. Vernal pool tadpole shrimp continue growing throughout their lives, periodically molting their shells. These shells can often be found in vernal pools where vernal pool tadpole shrimp occur. Helm (1998) found that vernal pool tadpole shrimp took a minimum of 25 days to mature and the mean age at first reproduction was 54 days. Other researchers have observed that vernal pool tadpole shrimp generally takes between 3 and 4 weeks to mature (Ahl 1991, King *et al.*1996). Ahl (1991) found that reproduction did not begin until individuals were larger than 10 millimeters (0.4 inch) carapace length. Variation in growth and maturation rates may be a result of differences in water temperature, which strongly influences the growth rates of aquatic invertebrates.

Vernal pool tadpole shrimp have relatively high reproductive rates. Ahl (1991) found that fecundity increases with body size. Large females, greater than 20 millimeters (0.8 inch) carapace length, could deposit as many as 6 clutches, averaging 32 to 61 eggs per clutch, in a single wet season. Vernal pool tadpole shrimp may be hermaphroditic (Longhurst 1955, Lynch 1966, Rogers *in litt.* 2001), and sex ratios can vary (Ahl 1991, Sassaman 1991), perhaps in response to changes in water temperature.

After winter rains fill their vernal pool habitats, dormant vernal pool tadpole shrimp cysts may hatch in as little as 4 days (Ahl 1991, Rogers *in litt*. 2001). Additional cysts produced by adult tadpole shrimp during the wet season may hatch without going through a dormant period (Ahl 1991). Vernal pool tadpole shrimp emerge from their cysts as metanauplii, a stage which lasts for 1.5 to 2 hours. Then they molt into a larval form resembling the adult. Multiple hatching within the same wet season allows vernal pool tadpole shrimp to persist within vernal pools as long as these habitats remain inundated, sometimes for 6

months or more (Ahl 1991, Gallagher 1996, Helm 1998). Vernal pool tadpole shrimp hatching is temperature dependent. Optimal hatching occurs between 10 to 15 degrees Celsius (50 to 59 degrees Fahrenheit), with hatching rates becoming significantly lower at temperatures above 20 degrees Celsius (68 degrees Fahrenheit) (Ahl 1991).

Habitat.—Vernal pool tadpole shrimp occur in a wide variety of ephemeral wetland habitats (Helm 1998). The species has been collected in vernal pools ranging from 2 to 356,253 square meters (6.5 square feet to 88 acres) in surface area (Helm 1998). Some of these vernal pools may be too small to remain inundated for the entire life cycle of the tadpole shrimp, but the vernal pool tadpole shrimp may be able tolerate temporary drying conditions (Helm 1998). Vernal pool tadpole shrimp have been found in pools with water temperatures ranging from 10 degrees Celsius (50 degrees Fahrenheit) to 29 degrees Celsius (84 degrees Fahrenheit) and pH ranging from 6.2 to 8.5 (King 1996, Syrdahl 1993). However, vernal pools exhibit daily and seasonal fluctuations in pH, temperature, dissolved oxygen, and other water chemistry characteristics (Syrdahl 1993, Scholnick 1995, Wiggins 1995, Keeley 1998). Determining the vernal pool tadpole shrimp's habitat requirements is not possible based on anecdotal evidence, and the tolerances of this species to specific environmental conditions have yet to be determined. Although the vernal pool tadpole shrimp is found on a variety of geologic formations and soil types, Helm (1998) found that over 50 percent of vernal pool tadpole shrimp occurrences were on High Terrace landforms and Redding and Corning soils. Plantenkamp (1998) found that vernal pool tadpole shrimp presence differed significantly between geomorphic surfaces at Beale Air Force Base, and was most likely to be found on Riverbank formation.

Population Structure.—King *et al.* (1996) studied genetic variation among vernal pool tadpole shrimp populations at 20 different sites in the Central Valley. She found that 96 percent of the genetic variation measured was due to differences between sites. This result corresponds with the findings of other researchers that vernal pool crustaceans have low rates of gene flow between separated sites, between 0.02 and 2.61 individuals between sites per generation. The low rate of exchange between vernal pool tadpole shrimp populations is probably as a result of the spatial isolation of their habitats and their reliance on passive dispersal mechanisms. However, King *et al.* (1996) also found that gene flow between pools within the same vernal pool complex is much higher, between 0.5 and 14.4 individuals per generation. This finding indicates that vernal pool tadpole shrimp populations, like most vernal pool crustacean populations, are defined by vernal pool complexes and not by individual vernal pools.

Based on genetic differences, King *et al.* (1996) separated vernal pool tadpole shrimp populations into two distinct groups. One group comprised 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 *et al.* (1996) concluded that these two groups may have diverged because cyst dispersal by overland flooding recently connected these populations on the valley floor. Populations on the eastern margin of the valley likely experienced less frequent dispersal events, probably through different mechanisms such as migratory birds. King (1996) also found that populations in eastern Merced County, in the vicinity of the Flying M Ranch and the proposed University of California Merced campus, were very different from all other populations studied. She concluded, particularly because it is found on very ancient soils, that this group may have been isolated from other populations very early. She suggested this population may be a separate species.

4. Reasons for Decline and Threats to Survival

Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to vernal pool tadpole shrimp are described below.

The California Natural Diversity Database (2003) lists 17 occurrences of vernal pool tadpole shrimp as threatened by development. An additional 16 occurrences are reported as threatened by various agricultural conversions. The species is threatened by the encroachment of nonnative annual grasses on the San Francisco Bay National Wildlife Refuge in the Central Coast region, and by urban development where it is known to occur on private land in Alameda County. In the Northeastern Sacramento Valley region, most of the known occurrences of the vernal pool fairy shrimp are on Caltrans rights of way where they continue to be threatened by road improvement projects related to general urban growth. In addition, the species is threatened by lack of management and monitoring on the Dales Lake Ecological Reserve and the Vina Plains preserve where it is known to occur; also the species is known to have been parasitized by flukes (Trematoda) of an undetermined species at the Vina Plains, Tehama County (Ahl 1991). The gonads of both sexes were greatly reduced in size and their body cavities were filled with many young flukes (metacercariae). Ahl (1991) thus concluded that parasitic castration was the major limiting factor affecting reproduction of the vernal pool tadpole shrimp at the Vina Plains. In the Northwestern Sacramento Valley Vernal Pool Region, the vernal pool tadpole shrimp is threatened by development on the few sites on private land where it is known to occur and by

lack of monitoring and management on the Stillwater Plains preservation bank. In the Southeastern Sacramento Vernal Pool Region, extant populations of vernal pool tadpole shrimp are threatened by continued extensive urban development and by lack of management and monitoring on mitigation areas and other protected lands where it is known to occur in Sacramento, Placer, and Yuba Counties.

In the San Joaquin Vernal Pool Region, the species is threatened by lack of management and monitoring at the Grasslands Ecological Area, and by development on private land. In the Solano-Colusa region, the species is threatened by lack of species specific management and monitoring on the Sacramento National Wildlife Refuge in Glenn County and at the Jepson Prairie Preserve in Solano County, and by urbanization on private lands.

In the Southern Sierra Foothills Vernal Pool Region, the species is threatened by development of the proposed University of California, Merced campus, which will likely contribute to significant growth in the region, resulting in additional loss of vernal pool crustacean habitat. Populations on the Stone Corral Ecological Reserve may be threatened by inadequate monitoring and management and by pesticide drift from adjacent farmlands.

5. Conservation Efforts

On September 19, 1994, the final rule to list the vernal pool tadpole shrimp as endangered was published in the *Federal Register* (U.S. Fish and Wildlife Service 1994*a*). In 2003, critical habitat was designated for vernal pool tadpole shrimp and several other vernal pool species in *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon* (U.S. Fish and Wildlife Service 2003).

Although conservation efforts have been taken for vernal pool ecosystems in general, very few actions have been taken specifically to benefit the vernal pool tadpole shrimp.

V. Animal Species of Concern

1. Midvalley Fairy Shrimp (*Branchinecta mesovallensis*)

Taxonomy.—The midvalley fairy shrimp (*Branchinecta mesovallensis*) was described by Belk and Fugate (2000). The species was named for its limited range in the Central Valley of California. The type locality is on the Virginia

Smith Trust land in Merced County, California (Belk and Fugate 2000). Midvalley fairy shrimp specimens had been collected as early as 1989.

Description and Identification.— The midvalley fairy shrimp is characterized by relatively simple male antennae, lacking spines or protuberances. Female midvalley fairy shrimp possess pyriform brood pouches, opening terminally and extending to below abdominal segments 3 or 4. Male midvalley fairy shrimp range in length from 12 to 20 millimeters (0.5 to 0.8 inch), and females range from 7 to 20 millimeters (0.3 to 0.8 inch), measured from the front of the head to the tip of the cercopods (Belk and Fugate 2000).

Male midvalley fairy shrimp are most similar in appearance to the Conservancy fairy shrimp (Belk and Fugate 2000). These species are distinguished by the shape of the tip of their antennae. The midvalley fairy shrimp's antennae are bent such that the larger hump of two humps possessed by both species is anterior, whereas this same hump is posterior in the Conservancy fairy shrimp. Females of these two species differ in the shape of their brood pouches. The brood pouch of the midvalley fairy shrimp is pyriform and extends to below segments 3 and 4. The brood pouch of the Conservancy fairy shrimp is fusiform and extends to below segments 5 and 7. Midvalley fairy shrimp females also closely resemble the vernal pool fairy shrimp, except that vernal pool fairy shrimp females have a pair of dorsolateral processes on each side of thoracic segment 3, whereas the midvalley fairy shrimp does not have any dorsolateral processes on this thoracic segment.

Historic Distribution.—Although the historic distribution of the midvalley fairy shrimp is unknown, vernal pool habitats in the regions where it is currently known to occur have been dramatically reduced since pre-agricultural times (Holland 1998). The habitat of the midvalley fairy shrimp may have been even more severely reduced than other vernal pool habitats since it can occur in swales and short lived pools that may escape detection in dry years or during the dry season (Helm 1999, Belk and Fugate 2000).

Current Distribution.—The midvalley fairy shrimp is endemic to a small portion of California's Central Valley (**Figure II-46**). Helm (1998) found midvalley fairy shrimp in less than 0.5 percent of the vernal pools he examined. Based on the few known occurrences, the species distribution is limited to the Southeastern Sacramento, Southern Sierra Foothill, San Joaquin, and Solano-Colusa vernal pool regions. In the Southeastern Sacramento region, most occurrences are clustered around the City of Sacramento and Mather Air Force Base in Sacramento County. In the Southern Sierra Foothills and San Joaquin vernal pool regions, the midvalley fairy shrimp has been documented in the

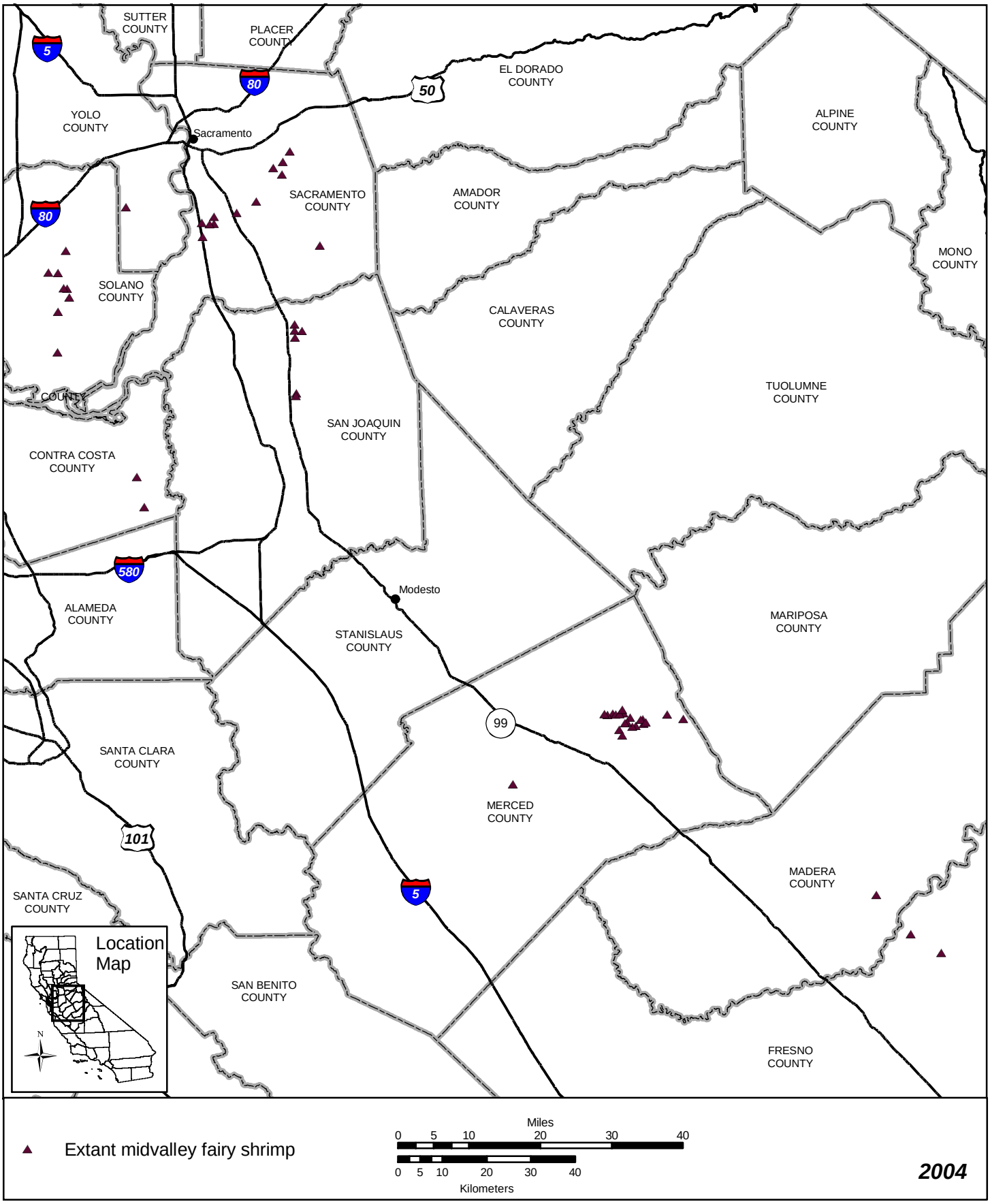

Figure II-46. Distribution of midvalley fairy shrimp (*Branchinecta mesovallensis*).

vicinity of the Virginia Smith Trust property in Merced County and from isolated occurrences in San Joaquin, Madera, and Fresno Counties. However, because this species was described only recently, it is likely additional occurrences will be found in the future.

Life History.—The life cycle of the midvalley fairy shrimp is well suited to the unpredictable conditions of vernal pool habitats. The midvalley fairy shrimp can mature and reproduce very rapidly; it has been observed to reach maturity in as little as eight days and reproduction was observed in as few as 16 days after hatching (Helm 1998). Under the culturing conditions described in Helm (1998), the midvalley fairy shrimp lived for 147 days, about as long as other Central Valley species observed. Multiple hatchings of the midvalley fairy shrimp have been observed in a single rainy season as its vernal pool habitat repeatedly fills and dries. Helm (1998) found the midvalley fairy shrimp to be very tolerant of warm water, occurring in pools with water temperatures ranging from 5 to 32 degrees Celsius (41 to 89 degrees Fahrenheit). This temperature is higher than that measured for any other Central Valley fairy shrimp collection except for the California fairy shrimp. Little is known about the midvalley fairy shrimp's tolerance to variations in water chemistry, but it has been found in some relatively alkaline pools (Helm 1998).

Habitat.—The midvalley fairy shrimp has been found in small, short-lived vernal pools and grass-bottomed swales ranging from 4 to 663 feet squared in area and averaging less than 4 inches in depth (Helm 1998). The species has been collected from pools on a volcanic mudflow landform of the Merhten Formation in Pentz Gravelly Loam and Raynor Clay soils. The midvalley fairy shrimp has also been found on San Joaquin Silt Loam soils on the Riverbank formation on Low Terrace landforms. At the time the type specimens were collected, the dominant macrophytes in the pool were the wetland grasses *Lolium multiflorum*, *Hordeum maximum gussoneanum* and *Deschampsia danthanoides*, species that are characteristic of extremely short lived pools and swales.

Community Associations.—The midvalley fairy shrimp has only been collected with one other fairy shrimp, the vernal pool fairy shrimp (Eriksen and Belk 1999). It may occupy habitats that are not inundated long enough for other species to inhabit.

Reasons for Decline and Threats to Survival.—Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft

recovery plan. Additional, specific threats to midvalley fairy shrimp are described below.

Continued conversion of the grassland-vernal pool ecosystem matrix to urban or agricultural uses, and associated hydrological changes, is the largest threat to survival of the midvalley fairy shrimp. The small depressions in which midvalley fairy shrimp typically reside require less preparation prior to conversion to urban or agricultural uses because they are already relatively level, and thus may be more attractive to developers. During the wet season, they may not contain water continuously, even when nearby larger pools are full. Under these conditions, midvalley fairy shrimp pools may not be surveyed at all, and conversion may proceed without the required regulatory review.

Although the Act affords incidental protection to midvalley fairy shrimp where they co-exist with listed species, none of those listed species, except vernal pool fairy shrimp have been found to co-occur with midvalley fairy shrimp in the same vernal pools (Eriksen and Belk 1999). Additionally, the co-occurrence with vernal pool fairy shrimp is believed to be a result of overland flow in a heavy precipitation event and not as a result of overlapping habitat requirements. Biological surveys are often inadequate and project proponents may miss detection of midvalley fairy shrimp due to its ability to occur in shallow pools which are inundated for short periods. In instances where co-existence of listed species and midvalley fairy shrimp are documented in the same complex, there may be incidental protection, however, there is no consultation requirement to avoid take or minimize effects of the action on the midvalley fairy shrimp. The largest number of known locations are in Merced County and Sacramento County. The City of Sacramento is growing rapidly, thus threatening the continued existence of occurrences in the sphere of growth. Urban expansion in eastern Merced County also poses a threat to many midvalley fairy shrimp populations.

Conservation Efforts.—Of the 53 midvalley fairy shrimp occurrences in the California Natural Diversity Data Base (2003), roughly 19 occurrences (36 percent) are directly threatened by proposed development projects, while 22 (41.5 percent) are on protected lands. The protected lands include two National Wildlife Refuges, several vernal pool mitigation banks, a California Department of Fish and Game ecological reserve, and several Nature Conservancy conservation easements. Sacramento and Merced Counties have the most threatened occurrences, with seven and five, respectively. Threats in Sacramento County mostly involve urban development projects, while the primary threat in Merced County is construction of the proposed University of California (UC) Merced campus. Merced County also has the highest number of protected

occurrences, however, with a total of 14 occurrences located on lands that have been set aside for the conservation of vernal pool species. These lands are intended to function as conservation areas to off-set the direct, indirect, and cumulative effects of the UC. Three ranches containing conservation easements held by The Nature Conservancy (totaling about 9,900 hectares [24,500 acres]) contain known midvalley fairy shrimp sightings. The easements are permanent, will generally be managed by The Nature Conservancy, and cannot be extinguished by selling the land to a new owner (J. Single, California Department of Fish and Game, *in litt*. 2003; U.S. Fish and Wildlife Service, *in litt*. 2003).

2. California Fairy Shrimp (*Linderiella occidentalis*)

Taxonomy.—The California fairy shrimp *(Linderiella occidentalis)* was first described as *Branchinecta occidentalis* by Dodds (1923) from specimens collected at Stanford University, Santa Clara County, California. Linder (1941) moved this species into the genus *Pristicephalus*, but discussed the possibility that the genus *Pristicephalus* should be absorbed into the genus *Eubranchipus*. However, he did not have the specimens necessary to make that determination. Pennak (1953) assigned California fairy shrimp specimens to the genus *Eubranchipus*. Brtek (1964) erected the family Linderiellidae, and placed the California fairy shrimp in the genus *Linderiella*. This taxonomic placement is still recognized (Belk and Brtek 1995). The California fairy shrimp was the only recorded species in the Family Linderiellidae in North America until 1994, when the Santa Rosa fairy shrimp *(Linderiella santarosae*) was collected and described from southern California by Thiery and Fugate (1994).

Description and Identification.—Unlike the other fairy shrimp addressed in this recovery plan, the California fairy shrimp is a member of the family Linderiellidae. It is smaller than fairy shrimp in the family Branchinectidae, and has red eyes, and conical, horn-like antennae appendages. Male California fairy shrimp are approximately 9 millimeters long (0.4 inch), females are about 10 millimeters (0.4 inch) in length (Dodds 1923).

The California fairy shrimp is one of two species of *Linderiella* described in North America. Both the California fairy shrimp and the Santa Rosa fairy shrimp are endemic to California (Eng *et al.* 1990, Thiery and Fugate 1994). These two species can be identified by the male's second antennae, and by their cysts. The male California fairy shrimp has a thinner, straighter second antennae than the Santa Rosa fairy shrimp. The cysts of the California fairy shrimp have sharper and longer spines than the Santa Rosa fairy shrimp, whose cysts have more tulip-shaped spines (Thiery and Fugate 1994).

The California fairy shrimp may also be confused with species of *Branchinecta* or *Eubranchipus*, as evidenced by its being placed in both these genera in the past (Dodds 1923, Pennak 1953). However, *Eubranchipus* has an obvious frontal appendage, while the California fairy shrimp has no frontal appendage. In California, *Linderiella* and *Eubranchipus* have completely separate distributions as well. The California fairy shrimp can be differentiated from species of *Branchinecta* by its red eyes and smaller size. The second antennae of the California fairy shrimp are also simpler than those of *Branchinecta* species, lacking outgrowths or protuberances (Belk 1975, Eng *et al.* 1990, Eriksen and Belk 1999).

Historical Distribution.—The California fairy shrimp was identified relatively recently, in 1990, and there is little information on the historic range of the species. However, the California fairy shrimp is currently known to occur in a wide range of vernal pool habitats in the Central Valley of California. It is likely the historic distribution of this species coincides with the historic distribution of Central Valley vernal pools. Holland (1978) estimated that roughly 1,600,000 hectares (4,000,000 acres) of vernal pool habitat existed in the Central Valley during pre-agricultural times. He found that although the current distribution of vernal pools is similar to their historic distribution in extent, Central Valley vernal pools are now far more fragmented and isolated from each other than during historic times. Central Valley vernal pools currently occupy only about 25 percent of their former land area (Holland 1998).

The historic distribution of the California fairy shrimp in Southern California may also have been similar to the historic distribution of its vernal pool habitat. Unlike the Central Valley, where vernal pool habitats where historically widespread, vernal pools in Southern California were probably always limited in area and extent. However, vernal pool habitats were once far more extensive than they are today (Bauder and McMillan 1998, Mattoni and Longcore 1998). In Los Angeles County, the coastal prairie and associated vernal pools may have historically occupied as much as 9,308 hectares (23,000 acres) (Mattoni *et al.* 1997). Vernal pools in San Diego County probably covered 51,800 hectares (128,000 acres) prior to intensive agriculture and urbanization (Bauder and McMillan 1998). The California fairy shrimp was likely historically present in available vernal pool habitats in Riverside, Los Angeles, Ventura, and Orange Counties. The historic distribution of the California fairy shrimp in the Central Coast, Carrizo, and Santa Barbara vernal pool regions is not known.

Current Distribution.—The current distribution of the California fairy shrimp in the Central Valley may be similar to its historic distribution in extent, but remaining populations are now considerably more fragmented and isolated

than during pre-agricultural times. The California fairy shrimp is currently known from the Central Valley and Coast ranges of California (**Figure II-47**). There are currently 212 reported occurrences of California fairy shrimp in the California Natural Diversity Data Base (2003). In the Northwestern Sacramento Valley Vernal Pool Region the California fairy shrimp is found in the vicinity of Redding on the Stillwater Plains in Shasta County and at a single occurrence in Tehama County. In the Northeastern Sacramento Valley Vernal Pool Region the species is known from the vicinity of Vina Plains and the Dales Lake Ecological Reserve in Tehama County and from a single occurrence in Butte County. In the Southeastern Sacramento Valley Vernal Pool Region the California fairy shrimp is found at Beale Air Force Base in Yuba County, at scattered locations in western Placer County, at McClellan Air Force Base and other locations in Sacramento County, and at a single location in San Joaquin County. In the Santa Rosa vernal pool region (as identified by Keeler-Wolf *et.al*. 1998), the California fairy shrimp is known from the vicinity of the cities of Healdsburg, Santa Rosa, and Sebastopol in Sonoma County (refer to the Draft Santa Rosa Plains Recovery Plan (in development) regarding these populations). The California fairy shrimp is also known from a single occurrence in the Livermore Vernal Pool Region in Alameda County. The California fairy shrimp occurs in the vicinity of Jepson Prairie in the Solano-Colusa Vernal Pool Region. In the Central Coast Vernal Pool Region the California fairy shrimp occurs on private property and at Fort Ord and Fort Hunter Liggett in Monterey and San Benito Counties. In the San Joaquin Vernal Pool Region the California fairy shrimp is known from the Grasslands Ecological Area in Merced County and from a single occurrence in Stanislaus County. In the Southern Sierra Foothill Vernal Pool Region the species is known from the Big Table Mountain preserve and private land in Fresno county, from Bureau of Reclamation and private lands in Madera County, and from a few scattered locations on private land in Merced, and Stanislaus Counties. The California fairy shrimp is also known from isolated occurrences in Santa Barbara and Ventura Counties in the Santa Barbara Vernal Pool Region.

Life History.—The California fairy shrimp is uniquely adapted to the astatic conditions of vernal pool habitats. This species has been found to live longer than the California fairy shrimp, however, its mean reproduction rate and life span does not differ significantly from other species addressed in this plan (Helm 1998). Helm (1998) found that the California fairy shrimp required a minimum of 31 days and an average of 43 days to reproduce, and was observed to live as long as 168 days. California fairy shrimp eggs can hatch when temperatures drop below 20 degrees Celsius (68 degrees Fahrenheit), although optimum hatching may occur at 10 degrees Celsius (50 degrees Fahrenheit) (Eriksen and Belk 1999). The California fairy shrimp may have relatively small clutch sizes. Dodds (1923) reported that brood pouches he examined never

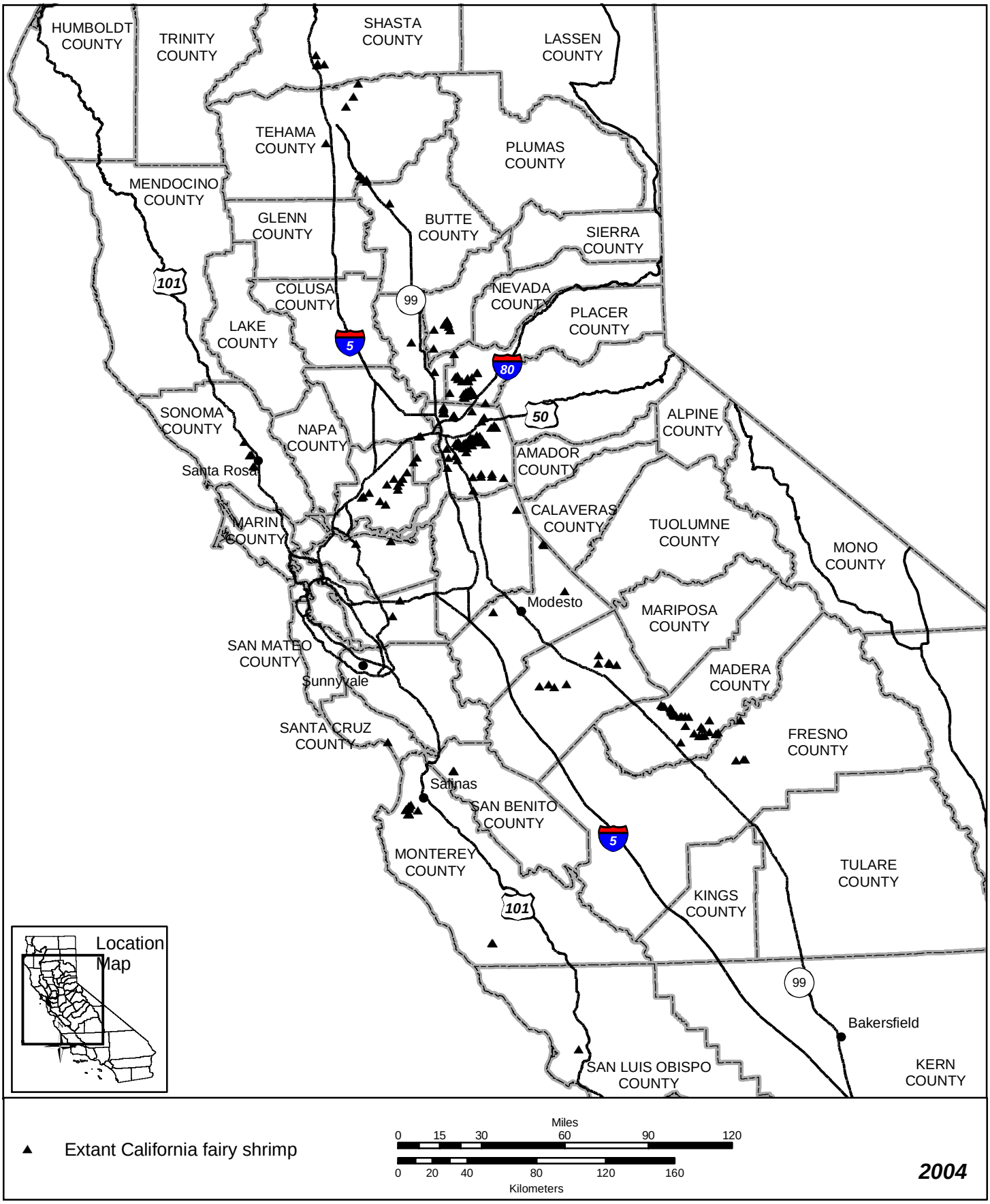

Figure II-47. Distribution of California fairy shrimp (*Linderiella occidentalis*)

contained more than six eggs. California fairy shrimp have been observed in pools with 4- to 16-week durations, and mortality was caused by pool drying (Gallagher 1996). When pools almost dried, Gallagher (1996) observed California fairy shrimp surviving in the pool bottoms, suggesting it may be tolerant of high temperatures and low levels of dissolved oxygen.

Habitat.—The California fairy shrimp is the most widely distributed fairy shrimp in California. The California fairy shrimp has been documented on most land forms, geologic formations, and soil types supporting vernal pools in California. Helm (1998) found the California fairy shrimp in pools ranging in size from 1 to 52,500 m^2. Other studies have also documented California fairy shrimp in vernal pools ranging widely in size (Syrdahl 1993, Alexander and Schlising 1997). However, the California fairy shrimp tends to be in deeper pools (Plantenkamp 1998). The California fairy shrimp is tolerant of a wide range of water temperatures, and has been found in pools with temperatures from 5 to 29.5 degrees Celsius (41 to 85 degrees Fahrenheit) (Syrdahl 1993). California fairy shrimp are often found in pools with clear to turbid water with pH ranging from 6.1 to 8.5, low (13 to 170 parts per million) alkalinity and low (33-273 parts per million) total dissolved solids (Eng *et al.* 1990, Syrdahl 1993, Eriksen and Belk 1999). California fairy shrimp have been found in vernal pools ranging from 10 to 1,159 meters (30 to 3,800 feet) above sea level (Eriksen and Belk 1999).

Community Associations.--The range of the California fairy shrimp overlaps the range of most other large branchiopods that occur in the Central Valley of California. The California fairy shrimp is frequently collected from the same pools as the California fairy shrimp, where it is usually numerically dominant (Eriksen and Belk 1999).

Reasons for Decline and Threats to Survival.—Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to California fairy shrimp are described below.

According to the California Natural Diversity Database (2000), 42 occurrences of California fairy shrimp are threatened by development, and 13 occurrences are threatened by agricultural conversion.

In the Northwestern Sacramento Valley Vernal Pool Region the California fairy shrimp is subjected to many threats. On private mitigation areas in Shasta County this species is threatened by inadequate management and monitoring. On private

lands in Shasta and Tehama Counties, it is threatened by development. In the Northeastern Sacramento Valley Vernal Pool Region the species is threatened by lack of management at the Vina Plains and the Dales Lake Ecological Reserve in Tehama County, and by development on private land in Butte County. In the Southeastern Sacramento Valley Vernal Pool Region the California fairy shrimp is threatened by lack of management and monitoring at Beale Air Force Base in Yuba County, McClellan Air Force Base and private mitigation areas in Sacramento and Placer County. The California fairy shrimp is also threatened by development on private land in this region.

The California fairy shrimp is threatened by development in Alameda County in the Livermore Vernal Pool Region. The California fairy shrimp is threatened by development where it occurs on private land in Solano County in the Solano-Colusa Vernal Pool Region. In the Central Coast Vernal Pool Region the California fairy shrimp is threatened by lack of management and monitoring at Fort Ord and Fort Hunter Liggett in San Benito County, and by development on private land in Monterey County.

In the San Joaquin Vernal Pool Region the California fairy shrimp is threatened by lack of management and monitoring at the Grasslands Ecological Area in Merced County and by development on private land in Stanislaus County.

In the Southern Sierra Foothill Vernal Pool Region the species is threatened by lack of management and monitoring at the Big Table Mountain preserve. The species is also threatened by development and incompatible land uses on Bureau of Reclamation land in Madera County, and on private land in Madera, Merced, and Stanislaus Counties.

Refer to the Draft Santa Rosa Plains Recovery Plan (in development) for information regarding threats facing the California fairy shrimp in the Santa Rosa vernal pool region, as identified by Keeler-Wolf *et.al*. (1998). The California fairy shrimp is also threatened by development in Santa Barbara and Ventura Counties in the Santa Barbara Vernal Pool Region. This species is threatened by lack of management and monitoring on the Santa Rosa Plateau in Riverside County in the Western Riverside County Vernal Pool Region.

Conservation Efforts.—While no actions have been taken specifically to conserve California fairy shrimp, a number of populations occur on protected lands. There are currently 212 reported occurrences of California fairy shrimp in the California Natural Diversity Data Base (2003). Approximately 33 percent of the documented populations are on private land without protection and ownership is unknown for 18 percent (California Natural Diversity Data Base 2003). Of

these occurrences, 25 are within existing reserves or mitigation sites: 17 private reserves or mitigation sites, 4 State-owned reserves, and 4 federally-owned reserves (California Natural Diversity Data Base 1997). The California fairy shrimp is protected from direct habitat loss at the Stillwater Plains in Shasta County in the Northwestern Sacramento Valley Vernal Pool Region. In the Northeastern Sacramento Valley Vernal Pool Region the species is protected at the Vina Plains and the Dales Lake Ecological Reserve in Tehama County. In the Southeastern Sacramento Valley Vernal Pool Region the California fairy shrimp is protected from development at Beale Air Force Base in Yuba County, McClellan Air Force Base in Sacramento County, and on a variety of private mitigation areas throughout the region. In the Central Coast Vernal Pool Region the California fairy shrimp is protected from direct habitat loss at Fort Ord and Fort Hunter Liggett in San Benito County. In the San Joaquin Vernal Pool Region the California fairy shrimp is protected from direct habitat loss at the Grasslands Ecological Area in Merced County. In the Southern Sierra Foothill Vernal Pool Region the species is protected from direct habitat loss at the Big Table Mountain preserve in Fresno county. The California fairy shrimp is also protected on the Santa Rosa Plateau in Riverside County in the Western Riverside County Vernal Pool Region.

3. Western Spadefoot Toad (*Spea hammondii*)

Taxonomy.—Spadefoot toads are members of the family Pelobatidae. Two closely related genera of spadefoot toads have been recognized within this family: *Scaphiopus* and *Spea* (Cannatella 1985, Weins and Titus 1991). We will collectively refer to members of this family in this document as spadefoot toads unless otherwise stated. Western spadefoot toads are officially recognized within the genus *Spea* (Weins and Titus 1991) although many literature sources reference *Scaphiopus* as the genus. Species relationships within *Spea* have been difficult to define due to morphological homogeneity among species. At least four species currently are recognized (Weins and Titus 1991). Named by Baird in 1859, *Spea hammondii* was regarded as having a broad geographic range from California to western Texas and Oklahoma with a distributional gap in the Mojave Desert of California (Storer 1925, Stebbins 1966). However, Brown (1976) identified morphological, vocalization, and reproductive differences between eastern (Arizona eastward) and western (California) populations, justifying species recognition for each. The California populations retained the name *Spea hammondii* while the eastern populations were designated as *Spea multiplicata*. This distinction was further supported by electrophoretic analyses conducted by Sattler (1980) and by allozymic and morphological analyses conducted by Weins and Titus (1991). Genetic variation across the range of *Spea hammondii* has not been studied to date.

Description and Identification.—Spadefoot toads are distinguished from the true toads (genus *Bufo*) by their cat-like eyes (their pupils are vertically elliptical in bright light but are round at night), the single black sharp-edged "spade" on each hind foot, teeth in the upper jaw, and rather smooth skin (Stebbins 1985) (**Figure II-48**). The parotid glands (large swellings on the side of the head and behind the eye) are absent or indistinct on spadefoot toads. Males may have a dusky throat and dark nuptial pads on the innermost front toes (*i.e.*, thumb).

The western spadefoot toad ranges in size from 3.7 to 6.2 centimeters (1.5 to 2.5 inches) snout-vent length. They are dusky green or gray above and often have four irregular light-colored stripes on their back, with the central pair of stripes sometimes distinguished by a dark, hourglass-shaped area. The skin tubercles (small, rounded protuberances) are sometimes tipped with orange or are reddish in color, particularly among young individuals (Storer 1925, Stebbins 1985). The iris of the eye is usually a pale gold. The abdomen is whitish without any markings. Spadefoot toads have a wedge-shaped, glossy black "spade" on each hind foot. The call of western spadefoot toads is hoarse and snore-like, and lasts between 0.5 and 1.0 second (Stebbins 1985).

The eggs of western spadefoot toads are pigmented and are found in irregular cylindrical clusters of about 10 to 42 eggs attached to plant stems and other submerged objects in temporary pools (Stebbins 1985). Spadefoot toad larvae (tadpoles) can reach 7 centimeters (2.5 inches) in length. They have oral papillae (small nipple-like projections that encircle the mouth), and their eyes are set close together. Their body is broadest just behind the eyes (Storer 1925).

Western spadefoot toads and southern spadefoot toads (*Spea multiplicata*) lack a cranial boss (a ridge between the eyes). This trait distinguishes these species from the plains (*Spea bombifrons)* and the Great Basin (*Spea intermontanus*) spadefoot toads, which each have a cranial boss. Compared to western spadefoot toads, southern spadefoot toads have a more elongate spade, are brownish above, and have a copper-colored iris.

Western spadefoot toad larvae are similar in appearance to other spadefoot toad larvae. The larvae have oral papillae, and their eyes are set close together and situated well inside the outline of the head as viewed from above. Western spadefoot toad larvae resemble those of the plains spadefoot toad in that their body is broadest just behind the eyes and they are light to medium gray or brown above. Western spadefoot toad larvae have an upper mandible that is beaked and a lower mandible that is notched. These larvae grow to around 7 centimeters (2.8 inches) (Storer 1925).

Figure II-48. Photograph of western spadefoot toad *(Spea hammondii).* Reprint from William Flaxington with permission.

Historical Distribution.—The western spadefoot toad is nearly endemic to California, and historically ranged from the vicinity of Redding in Shasta County southward to Mesa de San Carlos in northwestern Baja California, Mexico (Stebbins 1985). In California, western spadefoot toads ranged throughout the Central Valley, and throughout the Coast Ranges and the coastal lowlands from San Francisco Bay southward to Mexico (Jennings and Hayes 1994).

Current Distribution.—The western spadefoot toad has been extirpated throughout most of the lowlands of southern California (Stebbins 1985) and from many historic locations within the Central Valley (Jennings and Hayes 1994, Fisher and Shaffer 1996) (**Figure II-49**). According to Fisher and Shaffer (1996), western spadefoot toads have suffered a severe decline with virtually complete extirpation from the Sacramento Valley, and a reduced density of populations in the eastern San Joaquin Valley. Declines in abundance have been more modest in the Coast Ranges. This species occurs mostly below 900 meters (3,000 feet) (Stebbins 1985), but can occur up to 1,363 meters (4,500 feet) (Morey 1988). However, the average elevation of sites where the species still occurs is significantly higher than the average elevation for historical sites suggesting that declines have been more pronounced in lowlands.

Three relatively recent sources of data have presented information regarding the current status and distribution of the western spadefoot toad. Jennings and Hayes (1994) examined 832 museum and sighting records from 346 locations and concluded that western spadefoot toads occurred in 18 California counties, and has been extirpated from six counties. Fisher and Shaffer (1996) conducted field surveys of 315 sites in the Sacramento Valley, San Joaquin Valley, and Coast Ranges from 1990 to 1992. These surveys confirmed the presence of western spadefoot toads in 13 counties and failed to detect the species in an additional eight counties. The California Natural Diversity Data Base (2000) lists 174 records of western spadefoot toads from 24 counties. These records range from 1978 to 2000 and do not represent a systematic survey. The status of most of the sites where western spadefoot toads were observed is unknown. Many sites may no longer exist due to subsequent development, and indeed, some of the records were submitted by biological consultants who were conducting surveys on sites that were about to be developed. **Table II-1** below summarizes the collective findings of these three cited sources.

Western spadefoot toads have been recorded in 11 of the 17 vernal pool regions described by Keeler-Wolf *et al.* (1997). The species has been documented to co-occur with several other rare species, some of which are federally protected. Among the 174 locations for western spadefoot toads in the California Natural

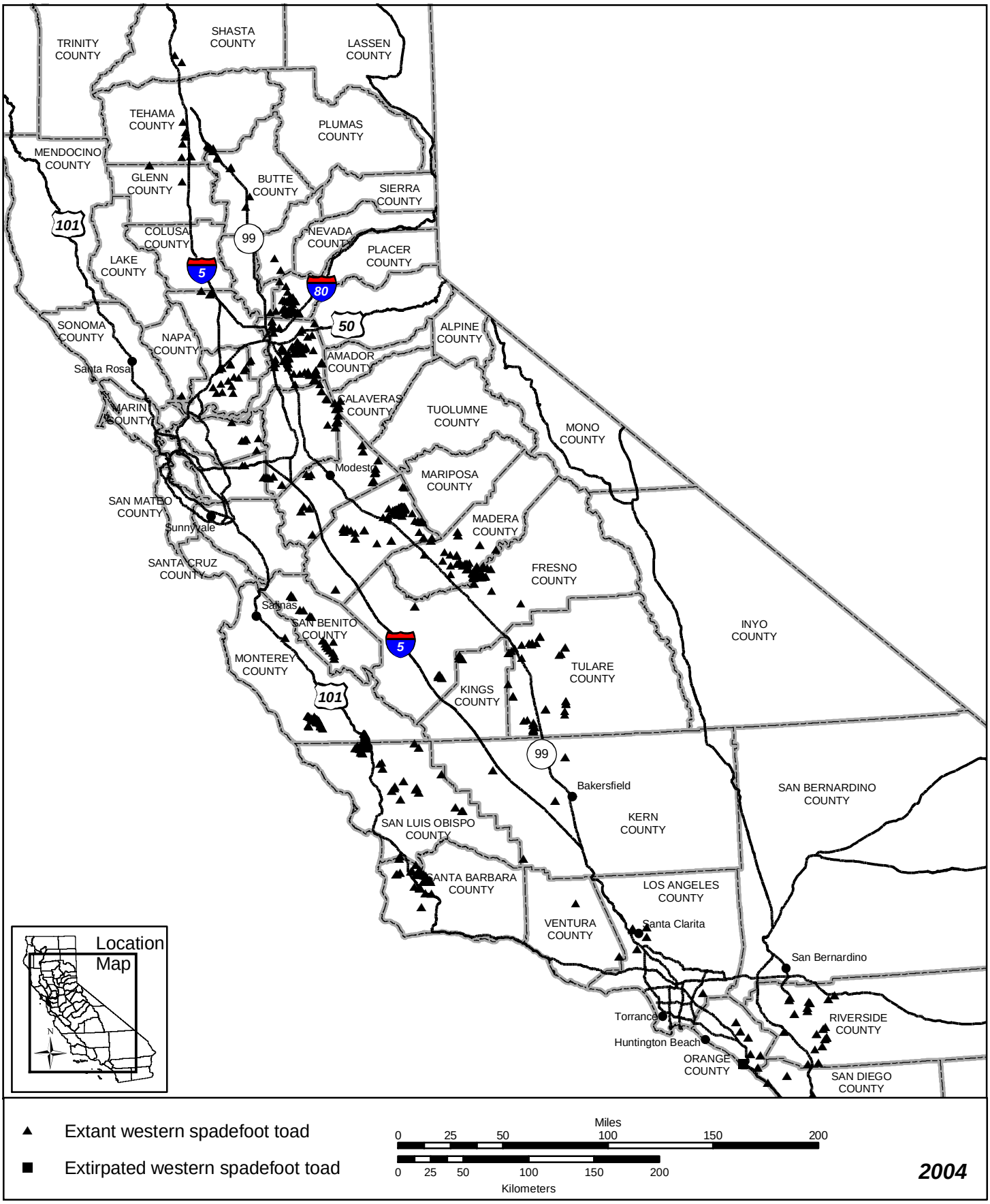

Figure II-49. Distribution of western spadefoot toad (*Spea hammondii*).

Table II-1. Western Spadefoot Toad Count Occurrence Information

County	Jennings and Hayes (1994)	Fisher and Shaffer (1996)	California Natural Diversity Data Base (2000)
Alameda	Extant	Extant	Extant
Amador	Extant	No Detection	No Data
Butte	Extant	No Detection	Extant
Calaveras	Extirpated	Extant	Extant
Fresno	Extirpated	No Detection	Extant
Glenn	No Data	Extant	No Data
Kern	Extant	Extant	Extant
Kings	No Data	No Data	Extant
Los Angeles	Extirpated	No Data	Extant
Madera	Extant	Extant	Extant
Mariposa	Extant	No Data	No Data
Merced	No Data	Extant	Extant
Monterey	Extant	Extant	Extant
Orange	Extant	No Data	Extant
Placer	No Data	No Data	Extant
Riverside	Extant	No Data	Extant
Sacramento	Extant	Extant	Extant
San Benito	Extant	Extant	Extant
San Bernardino	Extirpated	No Data	No Data
San Diego	Extant	No Data	Extant
San Joaquin	Extant	No Detection	Extant
San Luis Obispo	Extant	Extant	Extant
Santa Barbara	Extant	Extant	Extant
Shasta	Extirpated	No Detection	No Data
Stanislaus	Extant	Extant	Extant
Tehama	Extant	No Detection	Extant
Tulare	Extant	Extant	Extant
Ventura	No Data	No Data	Extant
Yolo	Extirpated	No Detection	Extant

Diversity Data Base (2000), the following special status animals have been documented to co-occur (number of occurrences denoted by number in parenthesis): California tiger salamanders (*Ambystoma californiense*) (17), California red-legged frogs (*Rana aurora draytonii*) (4), vernal pool tadpole shrimp (*Lepidurus packardi*) (3), vernal pool fairy shrimp (*Branchinecta lynchi*) (8), California fairy shrimp (*Linderiella occidentalis*) (7). Rare plants have been observed at 1 location each and include *Orcuttia inaequalis*, *Orcuttia pilosa*, *Castilleja campestris* ssp. *succulenta*, *Neostapfia colusana*, and *Chamaesyce hooveri*. Such co-occurrences provide an opportunity to conserve multiple species at one location.

Food and Foraging.—Typical of toads, adult western spadefoot toads will forage on a variety of insects, worms, and other invertebrates. Morey and Guinn (1992) examined the stomach contents of 14 western spadefoot toads and found 11 different food items including grasshoppers (Order Orthoptera: Family Gryllacrididae), true bugs (Order Hemiptera), moths (Order Lepidoptera: Family Noctuidae and unidentified moths), ground beetles (Order Coleoptera: Family Carabidae), predaceous diving beetles (Order Coleoptera: Family Dytiscidae), ladybird beetles (Order Coleoptera: Family Coccinellidae), click beetles (Order Coleoptera: Family Elateridae), flies (Order Diptera: Family Heleomyzidae), ants (Order Hymenoptera: Family Formicidae), and earthworms (Order Haplotaxida). Adult toads can consume 11 percent of their body mass during a single feeding bout, and Dimmit and Ruibal (1980) speculated that in only a few weeks, adults may be able to acquire sufficient energy for their long dormancy period (8 to 9 months).

The specific food habits of western spadefoot toad larvae are unknown. However, the larvae of southern and plains spadefoot toads consume planktonic organisms and algae, and also will scavenge dead organisms, including other spadefoot toad larvae (Bragg 1964). Also, larvae of plains spadefoot toads reportedly will prey on fairy shrimp (*e.g.*, *Branchinecta* spp.) (Bragg 1962). Both adult and larval western spadefoot toads consume food items that also are used by other co-occurring amphibians (*e.g.*, Pacific tree frog [*Pseudacris* (*Hyla*) *regilla*], California tiger salamander, and western toad [*Bufo boreas*]) (Morey and Guinn 1992). Thus, some degree of resource competition may occur, depending upon the abundance of food resources.

Reproduction and Demography.—Western spadefoot toads breed from January to May in temporary pools and drainages that form following winter or spring rains. Water temperatures in these pools must be between 9 degrees Celsius (48 degrees Fahrenheit) and 30 degrees Celsius (86 degrees Fahrenheit) for western spadefoot toads to reproduce (Brown 1966, 1967). Oviposition (egg

laying) does not occur until water temperatures reach the required minimum of 9 degrees Celsius (48 degrees Fahrenheit) (Jennings and Hayes 1994). Depending on the temperature regime and annual rainfall, oviposition may occur between late February and late May (Storer 1925, Burgess 1950, Feaver 1971, Stebbins 1985). During breeding, highly vocal aggregations of more than 1,000 individuals may form (Jennings and Hayes 1994). Breeding calls are audible at great distances and serves to bring individuals together at suitable breeding sites (Stebbins 1985). Amplexus, the copulatory embrace by males, is pelvic (Stebbins 1985). Females deposit their eggs in numerous small irregularly cylindrical clusters of 10 to 42 eggs (average is 24) (Storer 1925), and may lay more than 500 eggs in one season (Stebbins 1951). Eggs are deposited on plant stems or pieces of detritus in temporary rain pools, or sometimes pools in ephemeral stream courses (Storer 1925, Stebbins 1985).

Eggs hatch in 0.6 to 6 days depending on temperature (Brown 1967). At relatively high water temperatures (*e.g.*, 21 degrees Celsius [70 degrees Fahrenheit]), Storer (1925) noted that about half of the western spadefoot toad eggs failed to develop, possibly due to a fungus that thrives in warmer water and invades toad eggs. Larval development can be completed in 3 to 11 weeks (Burgess 1950, Feaver 1971) depending on food resources and temperature but must be completed before pools dry. In 8 vernal pools examined by Morey (1998), the average duration to complete larval development (hatching to metamorphosis) was 58 days (range 30 to 79 days). Metamorphosing larvae may leave the water while their tails are still relatively long (greater than 1 centimeter [0.4 inch]) (Storer 1925). Longer periods of larval development were associated with larger size at metamorphosis. Pools that persist for longer periods would permit longer larval development resulting in larger juveniles with great fat reserves at metamorphosis (Morey 1998). These larger individuals have a higher fitness level and survivorship (Pfennig 1992). Annual reproductive success probably varies with precipitation levels with success being lower in drier years (Fisher and Shaffer 1996). Recently metamorphosed juveniles emerge from water and seek refuge in the immediate vicinity of natal ponds. They spend several hours to several days near ponds before dispersing. Weintraub (1979) reported that toadlets of plains spadefoot toads seek refuge in drying mud cracks, under boards, and under other surface objects including decomposing cow manure. Age at sexual maturity is unknown, but considering the relatively long period of subterranean dormancy (8 to 9 months), individuals may require at least 2 years to mature (Jennings and Hayes 1994).

Virtually no data are available on demographic values for western spadefoot toads. Long-term population dynamics, survival rates, reproductive success, and dispersal rates for western spadefoot toads are unknown. It is assumed that

connectivity corridors between populations is essential for conservation of metapopulations. Morey and Guinn (1992) reported that western spadefoot toad abundance appeared to remain stable from 1982 to 1986 at a vernal pool complex in Stanislaus County, California. Based on systematic collections of road-killed western spadefoot toads at this same site, the proportions of adults and juveniles were 70 percent and 30 percent, respectively, and the proportions of adult males and females were about equal.

Behavior and Species Interactions.—Western spadefoot toads are almost completely terrestrial and enter water only to breed (Dimmitt and Ruibal 1980). However, typical of amphibians, western spadefoot toads require a certain level of moisture to avoid desiccation, which can be a challenge in the arid habitats occupied by the species. Spadefoot toads have behavioral and physiological adaptations that facilitate moisture retention.

During dry periods, spadefoot toads construct and occupy burrows that may be up to 0.9 meter (3 feet) in depth (Ruibal *et al.* 1969). Individuals may remain in these burrows for 9 to10 months. While in these burrows, individuals are completely surrounded by soil, and they appear to enter a state of torpor. Like all amphibians, western spadefoot toads have very permeable skin that allows them to absorb moisture from the surrounding soil. Spadefoot toads may retain urea to increase the osmotic pressure within their bodies, which prevents water loss to the surrounding soil and even facilitates water absorption from soils with relatively high moisture tensions (Ruibal *et al.* 1969, Shoemaker *et al.* 1969). Spadefoot toads appear to construct burrows in soils that are relatively sandy and friable as these soil attributes facilitate both digging and water absorption (Ruibal *et al.* 1969).

Spadefoot toads emerge from burrows to forage and breed following rains in the winter and spring. The factors that stimulate emergence are not well understood. In Arizona, spadefoot toads emerged after as little as 0.25 centimeters (0.1 inch) of precipitation, which barely wet the soil surface and obviously did not soak down to burrows (Ruibal *et al.* 1969). Sound or vibration from rain striking the ground appears to be the primary emergence cue used by spadefoot toads, and even the vibrations of a motor can cause toads to emerge (Dimmitt and Ruibal 1980). Spadefoot toads may move closer to the surface prior to precipitation and may even emerge to forage on nights with adequate humidity. Most surface activity is nocturnal. Morey and Guinn (1992) report that surface activity is related to both moisture and cooler temperatures following storms. Surface activity has been observed in all months from October to May (Morey 1988, Morey and Guinn 1992).

Above-ground activity is primarily nocturnal, presumably to reduce water loss. Even when exposed to artificial light, spadefoot toads will immediately move away or begin burrowing underground (Storer 1925, Ruibal *et al.* 1969). During the day, spadefoot toads dig and occupy relatively shallow burrows 2 to 5 centimeters (0.5 to 2 inches) in depth (Ruibal *et al.* 1969), and may even use small mammal burrows. In addition to breeding during periods of above-ground activity, spadefoot toads must acquire sufficient energy resources prior to reentering dormancy (Seymour 1973).

The role of predation on the population dynamics of western spadefoot toads is unclear. The extended dormancy period of adult and juvenile toads reduces their exposure to predators. Also, toxic secretions from dermal glands provide a significant deterrent to predators. Predators pose a much greater threat to larval western spadefoot toads. Larval toads are preyed upon by a variety of native predators including waterbirds, garter snakes (*Thamnophis* spp.), and raccoons (*Procyon lotor*) (Childs 1953, Feaver 1971). According to Feaver (1971), western spadefoot toad larvae were preyed upon by California tiger salamander larvae whenever the two species co-existed in the same pools and the California tiger salamander larvae matured first. However, if western spadefoot toad and California tiger salamander larvae are the same size, no predation may occur (Anderson 1968).

Nonnative predators introduced within the range of western spadefoot toads include crayfish (Order Decapoda), fish, and bullfrogs (*Rana catesbeiana*) (Hayes and Warner 1985, Hayes and Jennings 1986, Morey and Guinn 1992, Jennings and Hayes 1994, Fisher and Shaffer 1996). Nonnative fish, many of which are predatory, have been introduced for sportfishing and other purposes. These fish negatively affect native amphibians by preying upon eggs and larvae (Jennings 1988). In some locations, mosquito fish (*Gambusia affinis*) purposely introduced to control mosquitos also prey on western spadefoot toad eggs and larvae (Grubb 1972, Jennings and Hayes 1994, Fisher and Shaffer 1996). Nonnative species may also compete for resources with western spadefoot toads, thus potentially limiting their foraging success.

Introduced bullfrogs have been implicated in the declines of native amphibians (Moyle 1973, Hayes and Jennings 1986). Bullfrogs may not be significant predators of adult western spadefoot toads, although western spadefoot toads have been found in the stomachs of bullfrogs on at least two occasions (Hayes and Warner 1985, Morey and Guinn 1992). Bullfrogs may present more of a threat to larval western spadefoot toads. During dispersal between permanent water sources, juvenile bullfrogs will use temporary water sources (*e.g.*, vernal pools) as resting and feeding areas, which increases the potential for predation on western

spadefoot toad larvae (Morey and Guinn 1992). Thus, bullfrogs are of concern regarding the conservation of western spadefoot toads.

Some significant ecological differences exist that may minimize interactions between bullfrogs and western spadefoot toads. Some spatial segregation may exist because bullfrogs may occur less frequently in the temporary wetlands (*e.g.*, vernal pools) used by western spadefoot toads. Also, western spadefoot toads increase activity in response to moisture and low temperatures following storms whereas bullfrogs increase activity in response to warmer temperatures prior to storms (Morey and Guinn 1992). Thus, some temporal segregation may occur as well. However, some studies indicate that declining population trends may be associated with introduced predators including bullfrogs (see general threats discussion in the Introduction section). At a site in Stanislaus County, California, western spadefoot toad abundance remained stable during 1982 to 1986 despite dramatic increases in bullfrog abundance during this same period (Morey and Guinn 1992).

Habitat and Community Associations.—Western spadefoot toads are primarily a species of lowland habitats such as washes, floodplains of rivers, alluvial fans, playas, and alkali flats (Stebbins 1985). However, they also occur in the foothills and mountains. Western spadefoot toads prefer areas of open vegetation and short grasses, where the soil is sandy or gravelly. They are found in the valley and foothill grasslands, open chaparral, and pine-oak woodlands.

Western spadefoot toads require two distinct habitat components in order to meet life history requirements, and these habitats probably need to be in close proximity. Spadefoot toads are primarily terrestrial, and require upland habitats for feeding and for constructing burrows for their long dry-season dormancy. However, little is known regarding the distance from aquatic resources western spadefoot toads range for dispersal and estivation. As further discussed in the conservation strategy section, current research on amphibian conservation suggests average habitat utilization falls within 368 meters (1,207 feet) from aquatic habitats (Semlitsch and Brodie 2003). Typical of amphibians, wetland habitats are required for reproduction. Western spadefoot toad eggs and larvae have been observed in a variety of permanent and temporary wetlands including rivers, creeks, pools in intermittent streams, vernal pools, and temporary rain pools (California Natural Diversity Database 2000), indicating a degree of ecological plasticity. However, it appears that vernal pools and other temporary wetlands may be optimal for breeding due to the absence or reduced abundance of both native and nonnative predators, many of which require more permanent wetlands.

Western spadefoot toads also have exhibited a capacity to breed in altered wetlands as well as man-made wetlands. Western spadefoot toads, including eggs and larvae, have been observed in vernal pools that have been disturbed by activities such as earthmoving, disking, intensive livestock use, and off-road vehicle use. Western spadefoot toads, again including eggs and larvae, also have been observed in artificial ponds, livestock ponds, sedimentation and flood control ponds, irrigation and roadside ditches, roadside puddles, tire ruts, and borrow pits (Fisher and Shaffer 1996, California Natural Diversity Database 2000). This behavior again indicates a degree of ecological plasticity and adaptability. However, although western spadefoot toads have been observed to inhabit and breed in wetlands altered or created by man, survival and reproductive success in these pools have not been evaluated relative to that in unaltered natural pools. In addition, at this time, our knowledge of which land surface types can be crossed by western spadefoot toads is incomplete.

Based on calculations from upland habitat use data analyzed by Semlitsch and Brodie (2003), a minimum conservation area to preserve ecological processes required for conservation of amphibians may fall within an area of approximately 368 meters (1207 feet) from suitable breeding wetlands. Given a square preserve surrounding a single breeding pond, this estimate would suggest a minimum preserve size of approximately 54.2 hectares (134 acres). In any given western spadefoot toad metapopulation, we expect that some subpopulations will disappear, but the habitat they occupied will eventually be recolonized if it remains acceptable. To enable natural recolonization of unoccupied habitat, and to allow for gene flow that is vital for preventing inbreeding, opportunities for dispersal and interbreeding among subpopulations of the western spadefoot toad must be maintained. Where possible, habitat corridors between breeding sites should be protected and maintained.

Reasons for Decline and Threats to Survival.—Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this draft recovery plan. Additional, specific threats to western spadefoot toad are described below.

Most habitat of the western spadefoot toad is not protected and those areas that are protected are relatively small and therefore still highly subject to external threats. This species likely suffered dramatic reductions in the mid to late 1900's when urban and agricultural development were rapidly destroying natural habitats in the Central Valley and southern California (Jennings and Hayes 1994). According to Jennings and Hayes (1994), over 80 percent of the habitat once

known to be occupied by the western spadefoot toad in southern California (from the Santa Clara River Valley in Los Angeles and Ventura Counties southward) has been developed or converted to uses that are incompatible with successful reproduction and recruitment. In northern and central California, loss of habitat has been less severe, but nevertheless significant; it is estimated that over 30 percent of the habitat once occupied by western spadefoot toads has been developed or converted (Jennings and Hayes 1994). Regions that have been severely affected include the lower two-thirds of the Salinas River system, and much of the areas east of Sacramento, Fresno, and Bakersfield. Many of the remaining suitable rainpool or vernal habitats, which are concentrated on valley terraces along the edges of the Central Valley floor, have disappeared or been fragmented (Jennings and Hayes 1994).

Changes in vernal pool hydrology may adversely affect spadefoot toad populations. In particular, grazing may play an important role in maintaining vernal pool hydrology by decreasing the abundance of vegetation and therefore evapotranspiration from the pools during the spring. In a study conducted in pools inhabited by spadefoot toads, Marty (2004) found that removal of grazing led to a reduction in the inundation period of the pools below the amount of time required by the toads to successfully metamorphose.

Another reason for the population decline of the western spadefoot toad is the introduction of nonnative predators, specifically bullfrogs, crayfishes (*e.g.*, *Procambarus clarkii*), and fishes (*e.g.*, mosquito fish) (Hayes and Warner 1985, Hayes and Jennings 1986, Fisher and Shaffer 1996). All of these were introduced into California in the late 1800's and early 1900's, and through range expansions, additional introductions, and transplants, these exotics have become established throughout most of California. Fisher and Shaffer (1996) reported an inverse relationship between the presence of western spadefoot toads and that of nonnative predators. Additionally, nonnative predators may have displaced western spadefoot toads at lower elevations, resulting in the toads being found primarily at higher elevation sites where these predators apparently are less abundant (Fisher and Shaffer 1996). Fisher and Shaffer (1996) assessed native amphibian populations in the Coast Ranges, Sierra foothills, and Central Valley. They predicted that widespread declines of western spadefoot toads would occur if nonnative species continued to spread into low-elevation Coast Range habitats. However, in the San Joaquin Valley they found that relatively few nonnative predators were present, but native amphibians still had declined significantly. The San Joaquin Valley was the most intensively farmed and most modified of the three regions examined. It has been subject to extensive habitat loss, degradation, and fragmentation (U.S. Fish and Wildlife Service 1998*a*). Adverse impacts from these activities as well as isolation from other western spadefoot

toad populations may have caused the observed declines. Disking the soil as a part of row-cropping and other forms of intensive agriculture are likely to cause mortality of western spadefoot toads in their underground burrows.

Roads represent and additional threat to the western spadefoot toad. Road construction can result in direct mortality of the western spadefoot toad, and can cause direct loss and fragmentation of habitat. Roads can also cause indirect loss of habitat by facilitating transportation. They also facilitate urban development (a major cause of habitat loss for the western spadefoot toad). Mortality of western spadefoot toads from motor vehicle strikes has been observed by multiple researchers (Morey and Guinn 1992, Jennings 1998, California Natural Diversity Database 2000), and appears to be both widespread and frequent. For instance, Jennings (1998) reported road mortality at all seven sites that he surveyed in Kings and Alameda Counties. The impact of motor vehicle-caused mortality on populations of western spadefoot toads is unknown. Roads can be a barrier to movements and effectively isolate populations. Roads are significant barriers to gene flow among common frogs (*Rana temporaria*) in Germany, which has resulted in genetic differentiation among populations separated by roads (Reh and Seitz 1990). Similarly, Kuhn (1987, in Reh and Seitz 1990) determined that approximately 24 to 40 cars per hour on a given road resulted in mortality of 50 percent of common toads (*Bufo bufo*) individuals attempting to migrate across the road. Heine (1987, in Reh and Seitz 1990) identified that 26 cars per hour effectively reduced toad survival at road crossings to zero.

Amphibians typically have complex life cycles and thus more opportunities for exposure to chemicals and more potential routes of exposure than other vertebrates. The western spadefoot toad is exposed to a variety of toxins throughout its range, but the sensitivity of this species to pesticides, heavy metals, air pollutants, and other contaminants is largely unknown. Each year, millions of kilograms (millions of pounds) of fertilizer, insecticides, herbicides, and fungicides are used on crops, forests, rights of way, and landscape plants in California. Some of these chemicals are extremely toxic to aquatic organisms such as amphibians and their prey. Industrial facilities and motor vehicles also release contaminants that may harm the western spadefoot toad. Contaminants from road materials, leaks, and spills also could adversely affect western spadefoot toads by contaminating the water in wetlands. Refer to Appendix E for a list of chemicals most likely to be harmful to the western spadefoot toad.

Activities that produce low frequency noise and vibration, such as grading for development and seismic exploration for natural gas, in or near habitat for western spadefoot toads may be detrimental to the species. Dimmitt and Ruibal (1980) determined that spadefoot toads were extremely sensitive to such stimuli

and would break dormancy and emerge from their burrows in response to these disturbances. Disturbances that cause spadefoot toads to emerge at inappropriate times could result in detrimental effects such as mortality or reduced fitness.

Conservation Efforts.—The western spadefoot toad was a Category 2 candidate for listing in 1994 (U. S. Fish and Wildlife Service 1994*b*). Due to a change in policy regarding candidate species (U.S. Fish and Wildlife Service 1996*c*), western spadefoot toads are now considered a *species of concern*. Species of Concern are sensitive species that have not been listed, proposed for listing nor placed in candidate status. "Species of concern" is an informal term used by some but not all U.S. Fish and Wildlife Service offices. Species of concern receive no legal protection and the use of the term does not necessarily mean that the species will eventually be proposed for listing as a threatened or endangered species. The western spadefoot toad was designated a species of special concern by the State of California in 1994 (Jennings and Hayes 1994, California Department of Fish and Game 1998).

A number of sites with suitable habitat for western spadefoot toads already are being protected by national wildlife refuges, state parks, state ecological reserves, private preserves, mitigation banks, and conservation easements. Specific protected sites where the presence of western spadefoot toads has been confirmed include the Kesterson Unit of the San Luis National Wildlife Refuge (Merced County), the Arena Plains Unit of the Merced National Wildlife Refuge (Merced County), a reserve for the endangered Stephens' kangaroo rats (*Dipodomys stephensi*) at March Air Force Base (Riverside County), Corral Hollow State Ecological Reserve (San Joaquin County), Allensworth State Ecological Reserve (Tulare County), Stone Corral State Ecological Reserve (Tulare County), the Center for Natural Land Management's Pixley Vernal Pool Preserve (Tulare County), The Nature Conservancy's Simon-Newman Ranch (Stanislaus County), Mather Regional Park (Sacramento County), the Howard Ranch protected with a conservation easement (Sacramento County), Casper Regional Park (Orange County), two Caltrans mitigation sites (Madera County), and at private habitat mitigation sites in Sacramento, Placer, and Merced Counties. Western spadefoot toad observations also have been reported from Camp Roberts and Fort Hunter Liggett Military Reservations (San Luis Obispo and Monterey Counties), Naval Air Station Lemoore (Kings County), and a site owned by the California State University - Fresno (California Natural Diversity Database 2000). These locations on public lands present conservation opportunities for the species. Some conservation measures have already been implemented at Camp Roberts and Fort Hunter Liggett. The western spadefoot toad is also included for conservation under several habitat conservation plans currently in existence or under development. Additionally, 23 vernal pool species are now federally

protected including 18 plants and 5 animals. This protection will result in habitat conservation and management efforts that will contribute to the conservation of western spadefoot toads.

III. RECOVERY

A. GOALS

The overall goals of this draft recovery plan are to:

Achieve and protect in perpetuity self-sustaining populations throughout the full ecological, geographical, and genetic range of each listed species by ameliorating or eliminating the threats that caused the species to be listed.

- Delist the endangered *Eryngium constancei* (Loch Lomond button-celery), *Lasthenia conjugens* (Contra Costa goldfields), *Limnanthes floccosa* ssp. *californica* (Butte County meadowfoam), *Navarretia leucocephala* ssp. *pauciflora* (few-flowered navarretia), *Navarretia leucocephala* ssp. *plieantha* (many-flowered navarretia), *Orcuttia pilosa* (hairy Orcutt grass), *Orcuttia viscida* (Sacramento Orcutt grass), *Parvisedum leiocarpum* (Lake County stonecrop), *Tuctoria greenei* (Greene's tuctoria), *Tuctoria mucronata* (Solano grass), Conservancy fairy shrimp (*Branchinecta conservatio*), longhorn fairy shrimp (*Branchinecta longiantenna*), and vernal pool tadpole shrimp (*Lepidurus packardi*) and the threatened *Castilleja campestris* ssp. *succulenta* (fleshy owl's clover), *Chamaesyce hooveri* (Hoover's spurge), *Neostapfia colusana* (Colusa grass), *Orcuttia inaequalis* (San Joaquin Valley Orcutt grass), and *Orcuttia tenuis* (slender Orcutt grass), vernal pool fairy shrimp (*Branchinecta lynchi*), and delta green ground beetle (*Elaphrus viridis*).

- Ensure the long-term conservation of the species of concern *Astragalus tener* var. *ferrisiae* (Ferris' milk vetch), *Astragalus tener* var. *tener* (alkali milk vetch), *Atriplex persistens* (vernal pool smallscale), *Eryngium spinosepalum* (spiny-sepaled button-celery), *Gratiola heterosepala* (Boggs Lake hedge-hyssop), *Juncus leiospermus* var. *ahartii* (Ahart's dwarf rush), *Legenere limosa* (legenere), *Myosurus minimus* var. *apus* (little mousetail), *Navarretia myersii* ssp. *deminuta* (small pincushion navarretia), *Plagiobothrys hystriculus* (bearded popcorn flower), mid-valley fairy shrimp (*Branchinecta mesovalliensis*), California fairy shrimp (*Linderiella occidentalis*), and western spadefoot toad (*Spea hammondii*).

The interim goals of this draft recovery plan are to:

- Stabilize and protect populations so further decline in species status and range are prevented.

- Conduct research necessary to refine reclassification (*i.e.*, downlisting) and recovery criteria.

- Reclassify to threatened (*i.e.*, downlist) those taxa currently federally listed as endangered. Reclassification will be appropriate when each taxon is no longer in danger of extinction throughout a significant portion of its range. Because data upon which to base decisions about reclassification and recovery are mostly lacking, downlisting and recovery criteria in this draft recovery plan are necessarily preliminary and may be revised as necessary data is obtained.

B. OBJECTIVES

The overall objectives of this draft recovery plan are to:

- Ameliorate or eliminate the threats that caused the species to be listed as endangered or threatened and ameliorate any other newly identified threats in order to be able to delist these species.

- Ameliorate or eliminate the threats that affect the species of concern and ameliorate any other newly identified threats in order to conserve these species.

- Confirm the status of the *Plagiobothrys hystriculus*, currently presumed extinct. If extant populations are discovered, the ultimate goal would be to ensure the long-term conservation of this species.

- Promote natural ecosystem processes and functions by protecting and conserving intact vernal pools and vernal pool complexes within the recovery planning area to maintain viable populations of listed species and species of concern, and prevent additional threats from emerging over time. By doing so other vernal pool species that may be considered common today, and additional species that have not yet been identified or described, will be adequately conserved so that they will never need the protection of the Endangered Species Act.

C. STRATEGY

Habitat loss and fragmentation is the single largest threat to the survival and recovery of the listed species and species of concern addressed in this draft recovery plan. The continued existence of these species, and the prevention of future listing of species, would be ensured when populations and sub-populations of these species are protected in perpetuity from future habitat loss and fragmentation. Additionally, all other threats to the survival of these species need to be ameliorated or eliminated prior to delisting.

Most species addressed in this draft recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. The primary threats that have lead to the decline of the species are outlined in the Introduction section.

To meet the goal of delisting 20 species and ensuring the long-term conservation of 13 other species, habitat that represents the suite of vernal pool communities in California is necessary. This "ecosystem-level" strategy is shaped by (1) the existing conditions of vernal pool communities, (2) available information on biology, distribution, and population status of vernal pool species, and (3) the current and anticipated processes that will affect both natural and human-altered landscapes.

Recovery and long-term conservation actions contributing to the recovery strategy emphasized in this draft recovery plan are (1) habitat protection, (2) adaptive habitat management and monitoring, (3) status surveys, (4) research, and (5) public participation and outreach. Specifics of each strategy are provided in this chapter and in the Stepdown Narrative of this document. This draft recovery plan focuses on a large number of listed species and species of concern. Whenever possible, emphasis is placed on specific strategies that will benefit several species covered in this draft recovery plan (*e.g.*, an ecosystem approach). Since many of these species co-occur, this approach is most feasible. Where species do not co-occur, recovery and long-term conservation strategies will focus on single species.

All species addressed in this draft recovery plan are threatened by habitat loss and fragmentation. Therefore, areas currently, historically, or potentially occupied by the species are recommended for habitat protection, as appropriate. Areas for habitat protection are of two general types: (1) areas currently occupied by, or providing potential habitat for, several species, or areas contributing significantly to the protection of ecologically, geographically, or genetically distinct populations or sub-populations, and (2) areas that are currently occupied by, or

providing potential habitat for, a single species covered in this draft recovery plan. Areas to be protected for single species include those areas occupied by populations or sub-populations considered important within the species range (*e.g.*, populations or sub-populations at the edge of the species range or populations or sub-populations that help maintain genetic diversity). Factors influencing the choice of sites for protection also include habitat size, quality, connectivity, ease or feasibility of protection, ability to maintain and/or implement effective management, and overall cost of protection or long-term management. Wherever possible, protection of habitat needs to focus on larger blocks of land (*e.g.*, public land) to provide for greater species and physical diversities, less vulnerability of the species populations to outside influences, connectivity through land with natural habitat or compatible uses that allows for movement of species between vernal pool complexes, and minimize edge effects between natural and developed land. Cooperation of private landowners on some smaller parcels will be necessary to ensure recovery of the listed species and the long-term conservation of the species of concern. Cooperative efforts with private landowners will need to utilize tools such as fee title acquisition, conservation easements, or participation in voluntary programs (*e.g.*, our Partners for Fish and Wildlife program) to maintain or enhance habitat values for vernal pool species and their habitat while continuing certain types of land uses (*e.g.*, appropriate levels of grazing).

Ultimately, habitat management plans will need to be developed and implemented for all protected lands. Without effective plans, a lack of management or inappropriate management will continue to threaten the survival and recovery of the species in otherwise suitable habitat. In many cases, effective habitat management and restoration techniques have not been developed for species covered in this draft recovery plan. Therefore, management at any scale must be "adaptive", or flexible, based on currently available scientific data, on-going research, or observed outcomes of on-going management activities. For example, control of invasive species is a high priority for many protected sites. Studies of the various strategies to control individual species need to be conducted, and in some cases, management for one species may conflict with management techniques for other species. Thus an ecosystem approach to management should be undertaken when possible, and further research is needed.

1. Individual Elements of the Recovery Strategy

a. Habitat Protection

All habitat occupied by featured taxa is important for recovery or conservation for two reasons: (1) vernal pool species are primarily threatened with extinction due

to habitat loss and fragmentation, so additional habitat loss is counterproductive to recovery; and (2) genetic diversity within each taxon must be retained to increase a species likelihood of persistence through unpredictable events (*e.g.*, drought, climate change). Genetic composition has not been investigated for most of the featured taxa, so protection of remaining populations is prudent. By retaining the full range of site diversity and, thus, genetic diversity, in which a taxon currently or historically occurred, the likelihood of genetic persistence under unpredictable future environmental conditions is maximized. Habitat protection includes the preservation of the geographic, topographic, and edaphic features that support aggregations or systems of hydrologically interconnected vernal pools, vernal pool swales, and other ephemeral wetlands and depressions within a matrix of surrounding uplands that together form hydrologically and ecologically functional vernal pool complexes. The Stepdown Narrative includes actions to identify and protect larger vernal pool conservation areas as well as a series of research actions to characterize, maintain, and restore functional vernal pool ecosystems.

Although habitat protection of remaining vernal pools and vernal pool complexes in the vernal pool regions is a long-term goal, the core areas identified herein should be the initial focus of protection measures. Core areas are the specific sites that are necessary to recover these endangered or threatened species or to conserve the species of concern addressed in this draft recovery plan. Higher recovery priorities are 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) to those populations or species representing unique ecological conditions and genotypes. Habitat protection can be achieved in a number of ways including land acquisition, purchase of conservation easements, and conservation agreements. In all cases, a management plan to control nonnative species and maintain critical inundation periods is essential. Appendix F describes numerous tools available to assist in the protection of habitat for vernal pool species.

b. Adaptive Habitat Management, Restoration, and Monitoring

The most effective habitat management, restoration, and monitoring techniques for a vernal pool ecosystem are not yet fully understood, although some research and management is in progress. Until site- and species-specific research is completed, management strategies must remain “adaptive” (*i.e.*, flexible) and must be tied to population trends of featured species. Where populations are currently stable or increasing, existing habitat management including grazing management should be continued, and species monitoring should be instituted. If such populations begin to decline, changes in management may be indicated. For

populations that are declining, other habitat management techniques should be attempted, based on the best available scientific data, on-going research, or observed outcomes of on-going management from similar situations.

Although threats vary among core areas, habitat management foci are likely to include: (1) promoting population stability of listed species and species of concern; (2) maintaining the hydrology of the vernal pools or vernal pool complexes; (3) controlling invasive nonnative and native plants (*e.g.*, through appropriate levels of burning or grazing); (4) promoting appropriate grazing regimes to reduce invasive species, maintain hydrologic function to support listed species and species of concern, and maintain recruitment of target species; and (5) providing suitable upland habitat buffers to protect pollinators of vernal pool plants, dispersal of vernal pool plants and animals, and local watersheds, and sustain important predators of herbivores such as rodents and rabbits (*e.g.*, hawks). One of the many challenges will be coordinating management for the various species, whose needs may differ.

The recommended management actions are necessary to eliminate or ameliorate threats to vernal pool species, including loss, fragmentation, degradation, and alteration of habitat; competition/predation from both native and nonnative species, and other manmade factors such as disturbance of vernal pool habitats by recreational activities and contamination by urban and agriculture activities.

In addition to specific management recommendations to ameliorate or eliminate threats, the stepdown narrative and recovery strategy include several recovery actions to develop mechanisms to ensure that management actions continue in perpetuity so that threats remain neutralized. These actions include:
1) establishing a range-wide recovery implementation team; 2) establishing working groups and developing participation plans for each vernal pool region; 3) developing and implementing management plans that include provisions for adaptive management on publicly owned lands; 4) assisting local governments in developing habitat conservation plans and developing land use protection measures; 5) assisting private landowners in developing landowner agreements; 6) acquiring habitat, where necessary; and 7) ensuring mechanisms are in place to provide for the perpetual management and monitoring of core areas, vernal pool regions, or for each management unit within a vernal pool region, as appropriate. A key component of these efforts includes education and outreach to inform partners and the public about recovery needs and opportunities for vernal pool ecosystems.

Vernal pool complexes have been degraded, either by direct disturbance of the vernal pools (*e.g.*, due to inappropriate grazing), invasion of nonnative species, or

by alteration of hydrological patterns (*e.g.*, due to construction of roads through vernal pool complexes). Habitat restoration may be necessary in many instances to achieve proper functioning of a vernal pool ecosystem. This restoration may include diverting excess surface runoff (*e.g.*, in the form of siltation or contamination from agriculture or urbanization), reconstructing the impermeable layer and characteristic depth of the overlying soil beneath a vernal pool (*e.g.*, from damage due to off-road vehicle use), managing grazing at appropriate levels, or removing competing species. Creation of vernal pools may be necessary when all natural vernal pools representing certain ecological conditions have been destroyed. Creation of vernal pools within a vernal pool complex of existing pools is not recommended because it may alter the hydrology of the existing system.

In all cases practicable, existing pools should be used as a model for new creation. In doing so, it is important to consider the natural geographic, topographic and edaphic characteristics of the site where the pool or complex is to be created. Size and depth of pools to be constructed, hydrologic connections within complexes, and upland-area to pool-area ratios are all important factors to consider before creating vernal pools. Appropriate upland buffer size surrounding vernal pools can be a highly disputed issue among professional wetland scientists. Research may be necessary to help define an appropriate relationship between uplands and vernal pools so a species self-sustainability and recovery potential is maximized. In all cases where vernal pool creation is an alternative, success criteria should be established before the vernal pool is created. These criteria should be capable of modification and improvement as new information becomes available.

Especially in core areas, a species population size must remain stable or increase in size over the long term to contribute to recovery. Declines in species populations must be halted, and likely reversed, if populations are to be self-sustaining. Demographic monitoring, which includes trend analysis and factor resolution (Pavlik 1994), is one method for predicting plant population trends and focusing efforts on the causes of population decline at a particular site. Unlike traditional monitoring methods, the concurrent evaluation of several indicators (*e.g.*, survivorship, seed production per plant, and the density of ungerminated seeds in the soil) during demographic monitoring allows for predictions of population stability to be made in a shorter time frame (*e.g.*, 2 to 4 years versus 5 to 15 years, depending on climatic conditions) and is applicable to both annual and perennial plants. Demographic monitoring has its uses in endangered species recovery; however, it does not address the threats that caused the species to be listed. Therefore, it is not the only monitoring tool that should be used; it is one

practical approach to monitoring plants and should be considered on a case by case basis.

Animal species monitoring requirements may vary depending on species composition and environmental factors (*e.g.*, habitat location, seasonal timing of rainfall, cattle grazing, fires, *etc.*). In general, monitoring should be done for multiple years and should involve conducting standardized species and habitat surveys and assessments. Surveys may be more intensive at first to determine whether the objectives are being met (*e.g.*, are restored/created pools holding water? are animal species populating the vernal pools?). If a protected area is surrounded by numerous threats, standardized surveys may be required more frequently. If a location is highly protected (*i.e.*, strictly a preserve) then animal species monitoring requirements may not be as stringent. Ultimately, monitoring should always include assessment of the existing threats.

Recovery is the process by which the decline of a listed species is arrested or reversed, and the threats to its survival are ameliorated or eliminated so that its long-term survival is assured. Therefore, in order to delist a species, we must determine that the species is protected from, and no longer subjected to, the threats that caused it to be listed. Therefore, each threat discussed previously also must be monitored to ensure recovery goals and criteria are being met. Delisting will not be appropriate until the threats to population stability have been completely ameliorated or eliminated.

Habitat management should be conducted, in many instances, in an experimental context to determine the effects of various factors independently and jointly, and should be linked with monitoring or other determination of population trends. Once appropriate results have been obtained, they should be applied and adaptive management implemented. Based on results of monitoring and research described below, existing habitat management plans should be revised or new plans developed to maximize the value of protected habitat for featured species.

c. Status Surveys

A status survey is a detailed process beginning with a literature review and examination of herbarium or museum specimens. All historical localities of a species are identified and historical management and land use of the site should be noted. Additional sites where the species may occur are predicted based on distributional and ecological data and management history. All of the historical and predicted sites are visited at the appropriate time of year to evaluate if the species has persisted, population size and threats at those sites are evaluated, and recommendations for conservation are made. The purpose of the status survey for

recovery purposes is to determine how a species is doing on a range wide basis, assess whether it may warrant reclassification or delisting, and identify locations within appropriate habitat that could be suitable for introduction or reintroduction efforts. Additionally, status surveys can be used to identify additional sites for protection and to identify additional management actions necessary to ameliorate or eliminate remaining threats to the species. Status surveys are needed for all taxa featured in this draft recovery plan. Although status surveys were conducted in the past for certain taxa, such as members of the Orcuttieae, for example, the data are more than a decade old and must be updated to aid in recovery efforts. Moreover, many known sites have not been visited in recent years, so the number of occurrences that are actually extant and the current threats to those occurrences are not documented. Periodic status surveys can eliminate these data shortfalls and ultimately are essential to the recovery process.

d. Research

Research to further understand the effects of threats and the effectiveness of our measures to ameliorate or eliminate those threats are needed to recover and conserve the taxa featured in this draft recovery plan. This research includes studies related to habitat protection (*e.g.*, appropriate preserve size and location), habitat management and restoration techniques (*e.g.*, appropriate levels of burning, grazing, mowing, or rest), and species ecology and biology (*e.g.*, genetic relatedness, tolerances to environmental contaminants, and species interactions). The breeding systems and patterns of gene flow are not known for most species; therefore, management plans to protect genetic diversity cannot be fully developed or implemented without further research. The most effective habitat management techniques for vernal pool ecosystems also are not yet fully understood. Therefore, management plans cannot be fully developed or implemented, and therefore species recovered, until research is conducted.

e. Participation and Outreach

Participation and outreach are critical to the survival and recovery of the listed species and species of concern addressed in this draft recovery. Vernal pool species occur on many parcels of property owned and/or managed by dozens of different stakeholders (private landowners, Federal agencies, State agencies, and local governments). Early ownership in the recovery implementation process requires that landowners and land managers be informed so they can become effective participants in the recovery process. Many private landowners, and local agencies, are willing participants in recovery implementation efforts, but many do not have the information necessary to make informed decisions. Developing working relationships with all stakeholders, including public land

management agencies and private landowners to secure and recover vernal pool ecosystems is essential. Public land management agencies and private landowners should be informed of the presence or potential presence of vernal pool species and habitat on their property, the ecological requirements of the species, and incentives to compensate them for any efforts they take to help recover the species.

To enhance compliance with existing regulations and to better take advantage of opportunities within existing Federal, State, and local laws, regulations, and policies to conserve vernal pool resources, outreach and educational programs should be developed and implemented. We are recommending the formation of a single recovery implementation team with multiple vernal pool region-level working groups tiered off of it to implement effective outreach and education. Appendix G details outreach tools and strategies that can be used to facilitate effective public participation in the vernal pool recovery process.

Education will be a key component in increasing the public's general awareness of vernal pool ecosystems and garnering support for conservation of habitat for the covered species. Materials should be developed and distributed through existing outreach mechanisms such as newsletters, the Internet, and meetings. Specialized educational programs should be developed to educate target audiences such as school groups, landowners, and other stakeholders. A program of regular communications with public and private stakeholders is necessary to ensure mutual understanding, as well as compliance with Federal and State laws regulating vernal pool resources. Regulations to stem the destruction or adverse modification of habitat for the covered species must be improved, which can be done through effective participation and outreach with governing agencies. For example, it is essential to coordinate closely with local and county permitting agencies as well as State, Federal, and private interests to ensure that they understand where the covered species occur and where potential habitat exists. Outreach in the form of workshops/meetings with city and county planning staff will help stakeholders understand Federal laws, regulations, and policies concerning management of listed species and be aware of incentive programs that can assist them in protecting listed species and their habitats. Education should emphasize the benefits of vernal pool ecosystems, the compatibility of vernal pool management and managed grazing practices, and how conservation easements can benefit both landowners and the covered species.

2. Species-specific Recovery and Conservation Strategies

a. Plants

Several plant species require interim monitoring at multiple locations because they are small populations and are the only representatives from a given vernal pool region or vernal pool type. Monitoring and subsequent protection of these populations prior to completion of other recovery actions for those species is necessary to ensure the species distributions throughout their range.

To prevent the decline of *Castilleja campestris* ssp. *succulenta*, *Chamaesyce hooveri*, *Eryngium constancei*, *Lasthenia conjugens*, *Limnanthes floccosa* ssp. *californica*, *Navarretia leucocephala* ssp. *pauciflora*, *Navarretia leucocephala* ssp. *plieantha*, *Parvisedum leiocarpum*, *Astragalus tener* var. *ferrisiae*, *Astragalus tener* var. *tener*, *Atriplex persistens*, *Eryngium spinosepalum*, *Legenere limosa*, *Myosurus minimus* var. *apus*, and *Navarretia myersii* ssp. *deminuta* due to loss of pollinators, research is needed to determine whether each of them is insect-pollinated. If insects are found to be important to pollination, and therefore to seed production, their habitat must be protected in each core area to contribute to the recovery of each species.

Seed banking, although by no means meant to replace conservation of wild populations in their natural habitat, can increase the survival prospects of imperiled plant species by preventing unique genotypes from disappearing altogether. Seed banking can effectively document, preserve, and maintain viable seeds of vernal pool plants in long-term storage, thereby reducing the possibility of extinction and contributing to recovery. Seed bank collection is recommended for all plant species covered in this draft recovery plan.

Biosystematic research, including DNA analysis, is needed for several taxa as a whole or for certain populations. The lack of certainty concerning the distribution of several taxa of concern has precluded the possibility of listing them as endangered or threatened. Some uncertainty also remains among listed taxa, particularly those for which populations intermediate in morphology are known. This knowledge is critical in order to preserve the ecological and genetic diversity of each taxon. Biosystematic research is recommended for *Limnanthes floccosa* ssp. *californica*, *Astragalus tener* var. *ferrisiae*, *Astragalus tener* var. *tener*, *Eryngium spinosepalum*, *Myosurus minimus* var. *apus*, *Navarretia leucocephala* ssp. *pauciflora*, and *Navarretia leucocephala* ssp. *plieantha*.

Although Federal regulations require status reviews of listed species every 5 years, status reviews of *Tuctoria mucronata*, *Navarretia myersii* ssp. *deminuta* ,

and *Plagiobothrys hystriculus* are recommended 3 years after approval of this recovery plan due to their extremely low numbers. Knowledge of these species' distribution is critical to determine whether *Navarretia myersii* ssp. *deminuta* and *Plagiobothrys hystriculus* warrant listing as an endangered or threatened species and to provide immediate protection for these species and *Tuctoria mucronata* in order to help ensure their recovery or conservation.

b. Delta Green Ground Beetle

Due to the limited amount of delta green ground beetle habitat remaining and the threat posed to much of that habitat, the most important strategy for recovering the delta green ground beetle is to protect, in perpetuity, remaining suitable grassland/vernal pool habitat in the greater Jepson Prairie area, particularly designated critical habitat outside of the Jepson Prairie Preserve on the Wilcox Ranch property owned by the Nature Conservancy and Solano County. With so little habitat for the delta green ground beetle remaining, even small patches of habitat may be of benefit to the species. No specific management actions for the delta green ground beetle are included in the latest Jepson Prairie Preserve grazing plan (R. Reiner pers. comm., C. Witham pers. comm.). This oversight should be corrected, so that grazing can be used as an effective tool to manage habitat of the delta green ground beetle.

The delta green ground beetle population at the Jepson Prairie Preserve is unlikely to be able to serve as a source of individuals for an introduction effort, based on the relatively few sightings of delta green ground beetles at the Preserve since 1974. The removal of a smaller number of individuals for a captive breeding effort may be necessary to maintain the population. Therefore, concurrent with research to identify suitable habitat conditions and surveys to find potential introduction sites, a captive population of delta green ground beetles should be established to produce progeny to be used for reintroduction efforts. Goulet (1983) and Kavanaugh (pers. comm.) already have had some success in propagating the delta green ground beetle in captivity, but additional research is necessary to refine techniques for maintaining and breeding delta green ground beetles in captivity.

The paucity of information on the delta green ground beetle reduces the options available to conserve and recover this species. Managing habitat of the current population and establishing new populations will only be successful after critical information needs are addressed. Many aspects of the biology and ecology of the delta green ground beetle should be investigated including: (1) sources and rates of mortality for adults, pupae, larvae, and eggs; (2) productivity; (3) dispersal; (4) preferred habitat conditions for larvae and adults; (5) preferred sites for

oviposition; (6) activity cycles, both daily and annual; and (7) timing of life-cycle stages.

c. Vernal Pool Fairy Shrimp

In the Western Riverside County vernal pool region, the recovery strategy for the vernal pool fairy shrimp builds on the strategy developed for the Riverside fairy shrimp developed in the Recovery Plan for Vernal Pools of Southern California (U.S. Fish and Wildlife Service 1998b). The strategy includes securing existing vernal pool habitats and their associated watersheds, reestablishing vernal pool habitat to its historical structure, and managing and monitoring habitat and listed species.

In the Santa Barbara vernal pool region, the recovery strategy for the vernal pool fairy shrimp includes actions for the Transverse Management area identified by the Recovery Plan for Vernal Pools of Southern California (U.S. Fish and Wildlife Service 1998b). The strategy includes protecting habitats containing vernal pool fairy shrimp populations in Los Angeles and Ventura Counties.

A site-specific recovery strategy for vernal pool fairy shrimp in the Klamath Mountains vernal pool region (consistent with the general recovery strategy identified in this document) will be developed within a recovery plan for species of the upper Rogue River Valley, which is currently in preparation at our Roseburg Field Office.

d. Western Spadefoot Toad

Where agricultural activities must coincide with the conservation of western spadefoot toad, appropriately grazed pastures will provide better habitat than intensively farmed lands subject to discing, planting, harvesting and other activities that could kill aestivating western spadefoot toads. Providing incentives to private landowners to maintain pasture (rather than converting it to row-crops) or to convert intensively-farmed land to pasture will help to maintain or increase the amount of upland habitat available to the western spadefoot toad.

Dimmitt and Ruibal (1980) found that western spadefoot toads were extremely sensitive to low frequency noises and vibrations. These disturbances caused western spadefoot toads to break dormancy and emerge from their burrows. Such disturbances pose a threat if they cause western spadefoot toads to emerge at inappropriate times, which may in turn result in mortality or reduced productivity. More data are needed to determine the significance of this threat, but efforts to protect habitat for this species should take Dimmitt and Ruibal's (1980) findings

into account. When choosing sites to protect essential habitat features such as breeding ponds, sufficient upland habitat for estivation, and dispersal corridors, it may be important to consider the current and potential presence of objects or activities that create low-frequency noise. It also may be wise to protect additional habitat that can serve as a buffer against low-frequency noise around these essential habitat features.

Throughout the world, evidence is mounting that many local extirpations of amphibians are due to disease outbreaks. Small or fragmented populations may not be able to survive a disease outbreak. Ironically, some amphibian disease vectors can be carried accidentally by conservation biologists who are working to conserve amphibians. To counter this problem, researchers should follow guidelines for minimizing disease transmission when they are conducting field work with the western spadefoot toad. A suggested procedure for minimizing the potential transmission of disease and pathogens between aquatic resources is available in Appendix H.

An extremely important issue is the suitability of altered and man-made wetlands for successful reproduction by western spadefoot toads. Spadefoot toads appear to readily use such wetlands based on frequent observation of eggs and larvae. However, reproductive success has not been evaluated in these wetlands. If the characteristics of these wetlands (*e.g.*, water quality, presence of predators, longevity) permit successful reproduction by western spadefoot toads, then they potentially could contribute significantly to the conservation of this species and the creation of artificial wetlands could constitute a valuable mitigation and conservation strategy. However, it also is possible that spadefoot toads are attracted to such wetlands, but that reproductive success is poor compared to that in natural wetlands. In this situation, altered and man-made wetlands could constitute a significant threat to western spadefoot toads by acting as population "sinks." Thus, a critical need is an evaluation of the reproductive success of western spadefoot toads in such wetlands.

Some roads threaten the conservation of the western spadefoot toad by limiting their movement. Specifically, many western spadefoot toads are run over by motor vehicles on roads that do not allow them safe passage. One means to minimize this threat is to protect large expanses of habitat that have few roads or roads with limited vehicle use, and to limit road construction in these protected sites. When new roads are constructed within western spadefoot toad habitat, they should be designed with the welfare of this species in mind. Monitoring should be performed before road construction to find sites where western spadefoot toad dispersal routes would most likely intersect the proposed roadway. If possible, the path of the roadway should be altered to avoid these sites. If the

proposed roadway still threatens to place western spadefoot toads in danger, ecopassages (passageways designed to allow safe movement of wildlife under roads) should be constructed at the most dangerous sites. Many roads already exist within the range of the western spadefoot toad. Monitoring should be conducted to determine where road-caused obstruction of dispersal and motor-vehicle caused mortality occur most frequently. Portions of roadway that are most problematic for western spadefoot toads should be retrofitted with ecopassages so as to permit safe passage of this and other species of wildlife.

Additional data also are needed on the basic life history of the western spadefoot toad, particularly demographic parameters such as survival rates and sources of mortality (for both adults and larvae), longevity, recruitment rates, reproductive success, optimal juxtaposition of upland and aquatic habitats, optimal and tolerable characteristics of aquatic habitats for reproduction and larval development, optimal upland sites for burrows, acceptable soil characteristics for subterranean dormancy, dispersal rates, and dispersal distances. Also, the effects of annual variations in environmental conditions (*e.g.*, precipitation) should be investigated.

Changes in vernal pool hydrology may adversely impact spadefoot toad populations. In particular, grazing may play an important role in maintaining vernal pool hydrology by decreasing the abundance of vegetation and therefore evapotranspiration from the pools during the spring. In a study conducted in pools inhabited by spadefoot toads, Marty (2004) found that removal of grazing led to a reduction in the inundation period of the pools below the amount of time required by the toads to successfully metamorphose.

D. VERNAL POOL REGIONS

The vernal pool regions established in this draft recovery plan will assist in meeting the recovery and conservation objectives for each species addressed in this draft plan. Each designated region is based on the geography and/or ecology of one or more of the vernal pool species in this draft plan. Core areas, discussed further below, are distinct areas in each vernal pool region that provide the features necessary or populations of these species, important to the recovery of a species because they represent distinct geographic and/or genetic diversity. Based upon current information, other areas within the vernal pool regions may provide similar features and/or geographic/genetic distinctness; however, they are not, at this time, the focus of our recovery effort.

Vernal pool regions are individually important to the recovery and conservation of the listed species addressed in this draft recovery plan because each region

contains unique biotic and abiotic attributes of the species' range (such as genetic robustness, demographic robustness, important life history stages, or other features) and habitat within each region may contribute to future recovery efforts. These individual contributions from each region provide for the long-term sustainability (*i.e.*, recovery) of a species throughout its range. Each species is, however, listed based on its entire population, not as separate entities occurring in specific regions and, therefore, a species cannot be delisted by individual vernal pool region. Each species must be recovered in all of the vernal pool regions in which it occurs, and the threats that caused its listing must be ameliorated and eliminated, before it can be proposed for delisting (**Table III-1** lists the vernal pool regions designated for each species). Recovery of each listed species discussed in this draft recovery plan depends upon satisfying the recovery criteria for the given species. The designated vernal pool regions do not represent distinct population segments nor do they reflect designated critical habitat for any of the species covered in this draft recovery plan. The respective status of each species' populations in each region is highly variable, as is their potential for recovery.

Maintaining populations distributed throughout the range of each species is necessary for the long-term recovery and conservation of the listed species covered in this draft recovery plan as many of these species rely on secondary dispersal mechanisms (*e.g.*, birds) to maintain their genetic diversity. Well-distributed populations help eliminate the possibility of species extinction due to further habitat loss or fragmentation and will ameliorate the vulnerability of a species to environmental fluctuations and catastrophes. To ensure that each taxon in this draft recovery plan can persist despite weather variations, climate change, or catastrophic events, the suite of populations in each vernal pool region represents the full range of environmental conditions in which the taxon occurred historically. Environmental conditions to be taken into consideration include the size and type of vernal pool, pool chemistry, underlying soils and landforms, elevations, and geographic distribution. The range of genetic variation also must be represented to allow for evolution and resilience to environmental change. Genetic diversity has not been investigated for most taxa addressed in this draft recovery plan, therefore, well-distributed populations across the species range and across ecological conditions is recommended as a surrogate means to preserving genetic diversity.

While a goal of the draft recovery plan is to protect the long-term viability of all existing populations within each vernal pool region, core areas within each vernal pool region have been identified where recovery actions will be focused (**Figure III-1** depicts a conceptual model of recovery with respect to areas within and

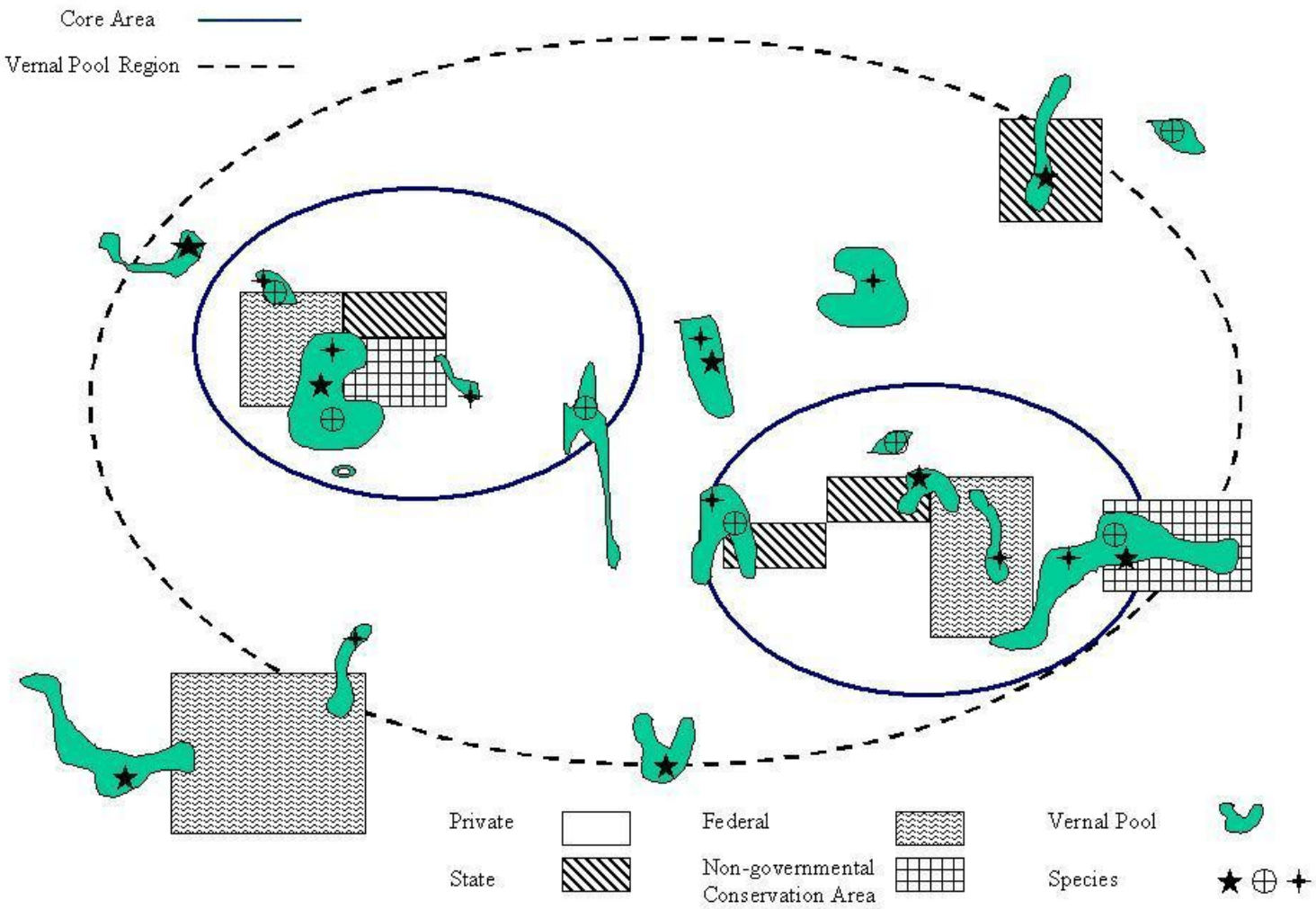

Figure III-1. Conceptual model for recovery of vernal pool ecosystem.

outside of vernal pool regions or core areas). The methodology for establishing core areas stems from the premise that those core areas represent viable populations (possibly even source populations for larger metapopulations) or will contribute to the connectivity of habitat and thus increase dispersal opportunities between populations. Establishment of core areas was based on existing data on species occurrences and data from the proposed critical habitat for vernal pool crustaceans and plants. From this data, representative sites were selected that are 1) representative of a given species range, or 2) support a high concentration of species per unit area. Generally, sites falling into these categories are within core areas. However, some sites meeting these criteria were not included in core areas due to factors such as relatively large numbers of occurrences already within established core areas which are representative of the species distribution throughout its range, or data that indicated the populations documented from a site were extirpated. In such cases, outlier occurrences were not considered, based on the available data, to be critical to the recovery and conservation of the given species. Future analysis through the implementation of this recovery plan may support the need to incorporate these populations into vernal pool regions or core areas. Core area boundaries have been established based on data from the representative distributions of species occurrence information, data layers for the proposed critical habitat for vernal pools, Holland (1998) data, watershed boundaries, other hydrographic boundaries, topographic features, roads and land use designations. Specific boundaries of core areas are mapped below in **Figures III-2 through III-17**.

Preservation and enhancement of each core area is important to maintain and possibly expand the distribution of the vernal pool species rangewide. Core areas will require long-term protection and management so that existing and reestablished populations remain viable. Recovery and delisting will be facilitated by meeting recovery criteria in all core areas. In most cases, core areas attempt, to the fullest extent possible, to represent the full range of vernal pool sizes and types, soils, and within species genetic diversity for each taxon. Thus, core areas should be refined, as appropriate, when new data becomes available. Core areas and critical habitat areas differ in that core areas have no legal mandate for protection under the Endangered Species Act and solely rely upon voluntary implementation. The designation of critical habitat requires Federal agencies to consult with the Service regarding any action that could destroy or adversely modify critical habitat.

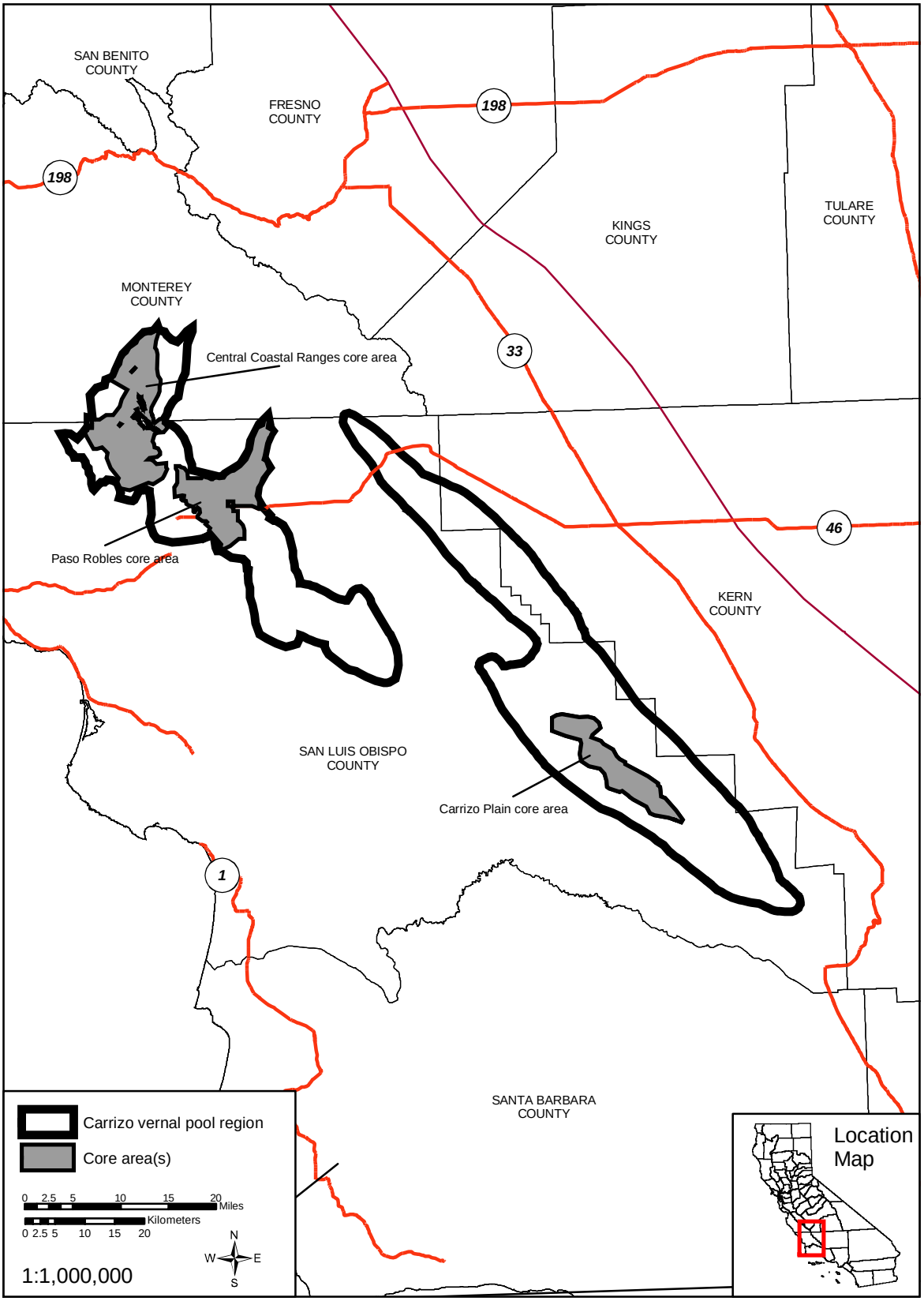

Figure III-2. Carrizo vernal pool region.

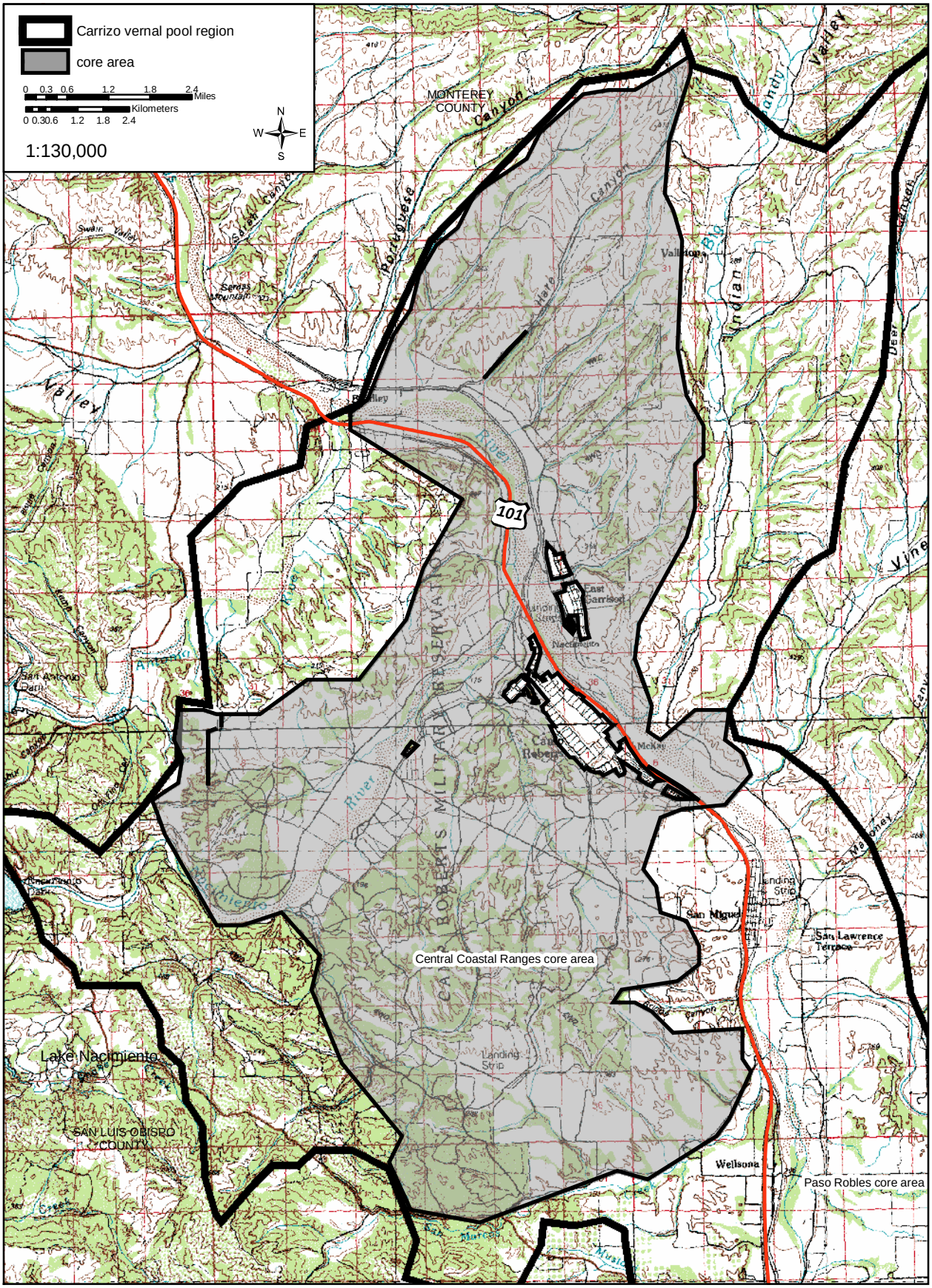

Figure III-2a. Central Coastal Ranges core area within the Carrizo vernal pool region.

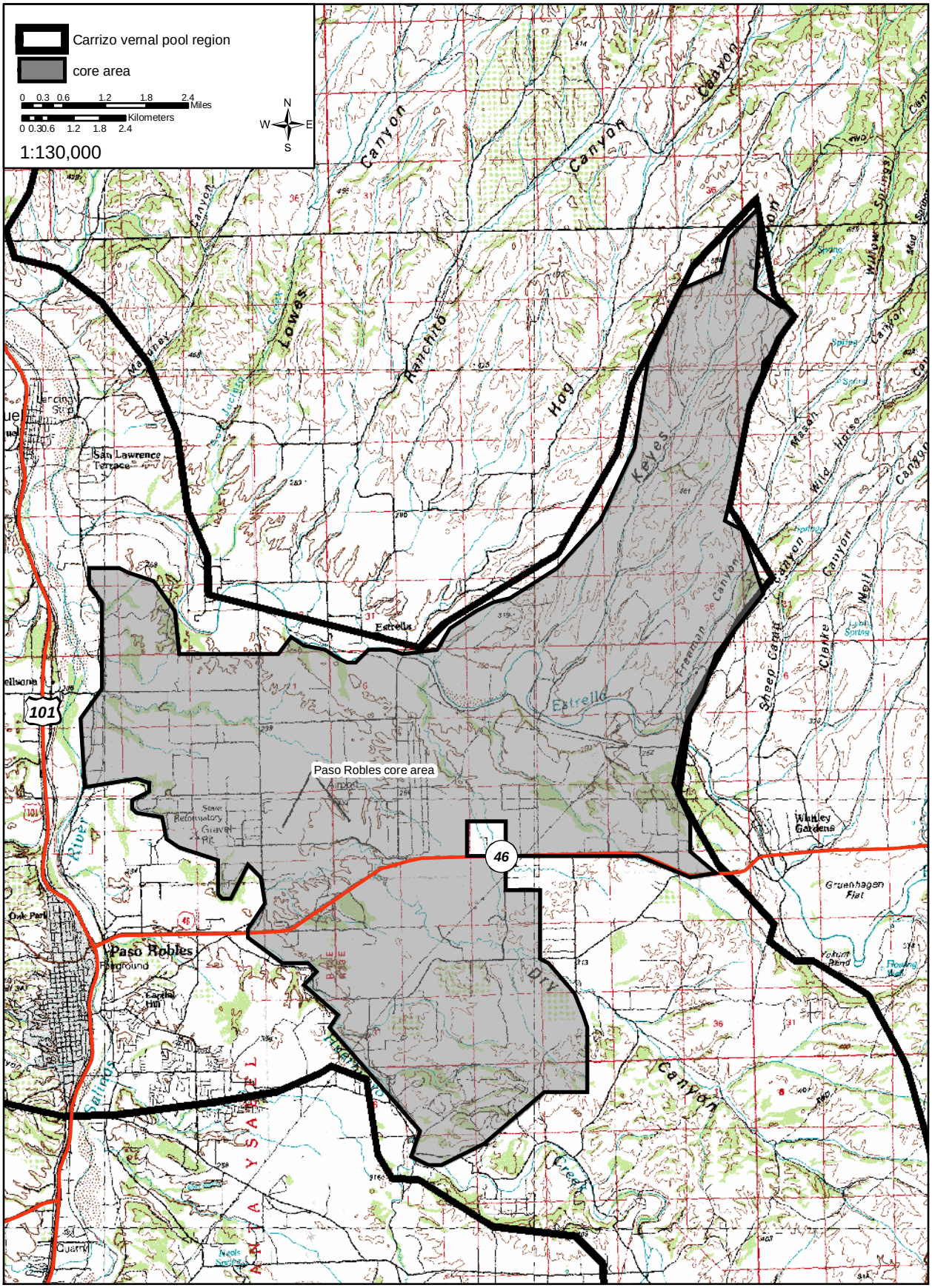

Figure III-2b. Paso Robles core area within the Carrizo vernal pool region.

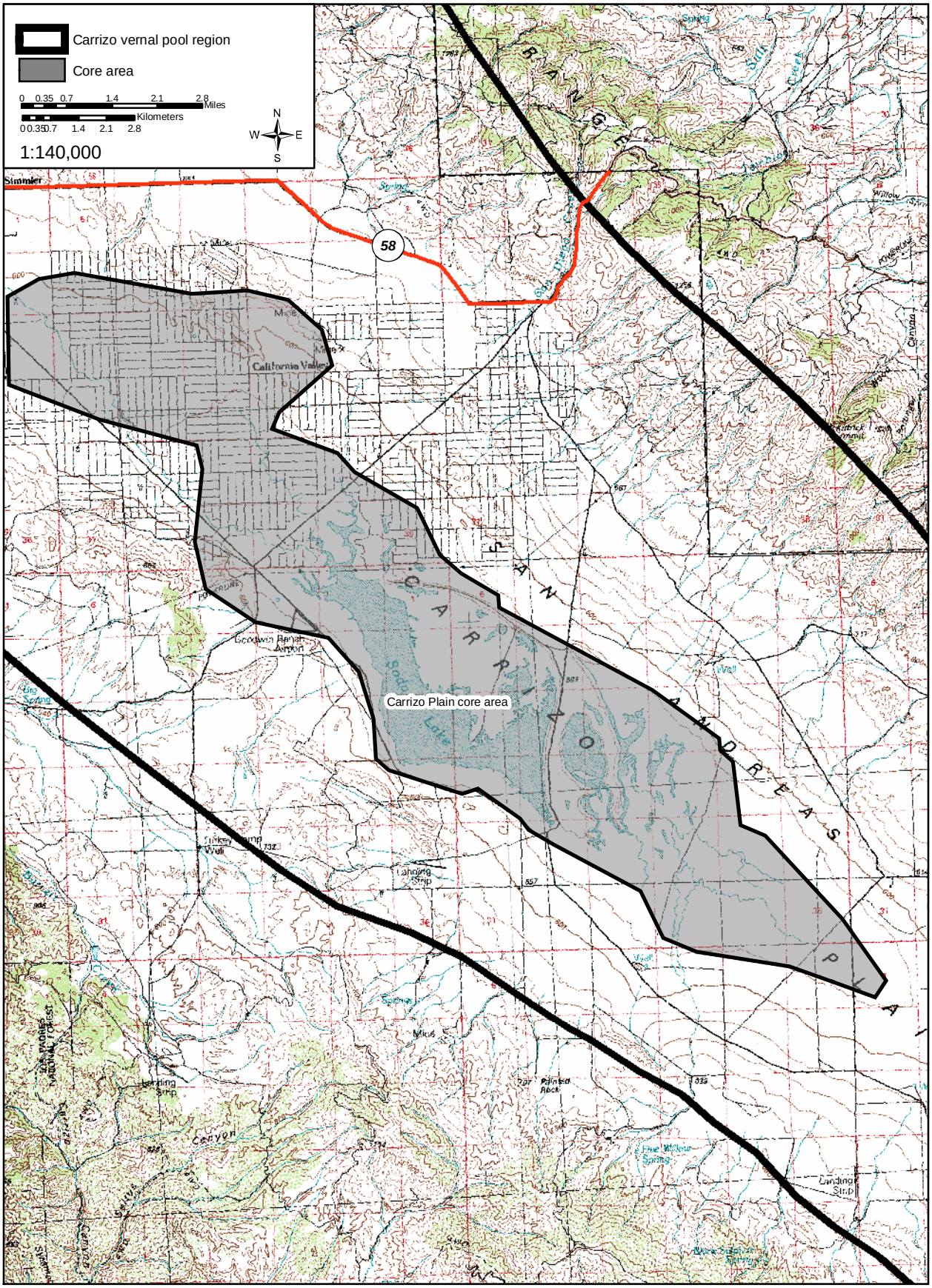

Figure III-2c. Carrizo Plain core area within the Carrizo vernal pool region.

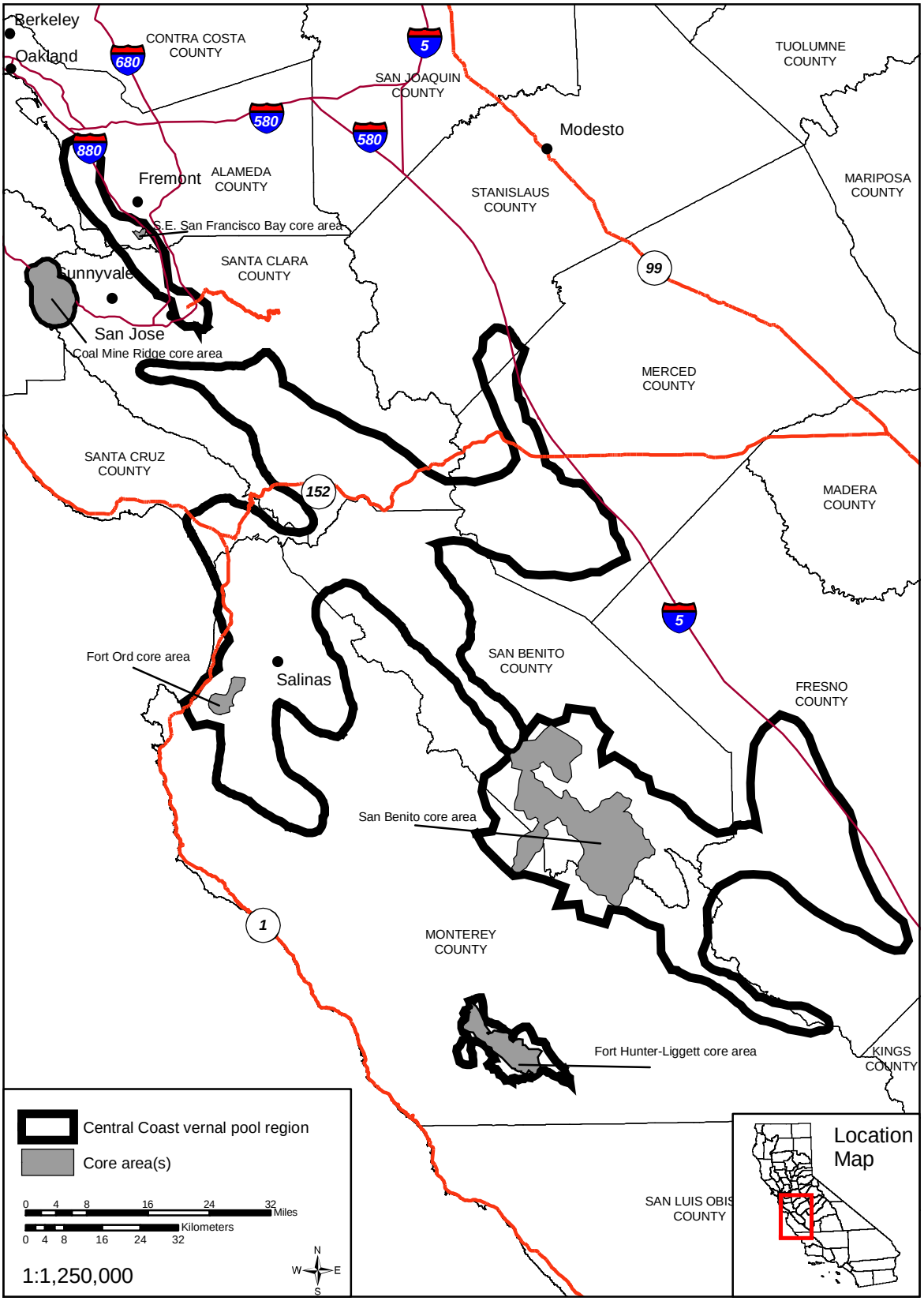

Figure III-3. Central Coast vernal pool region.

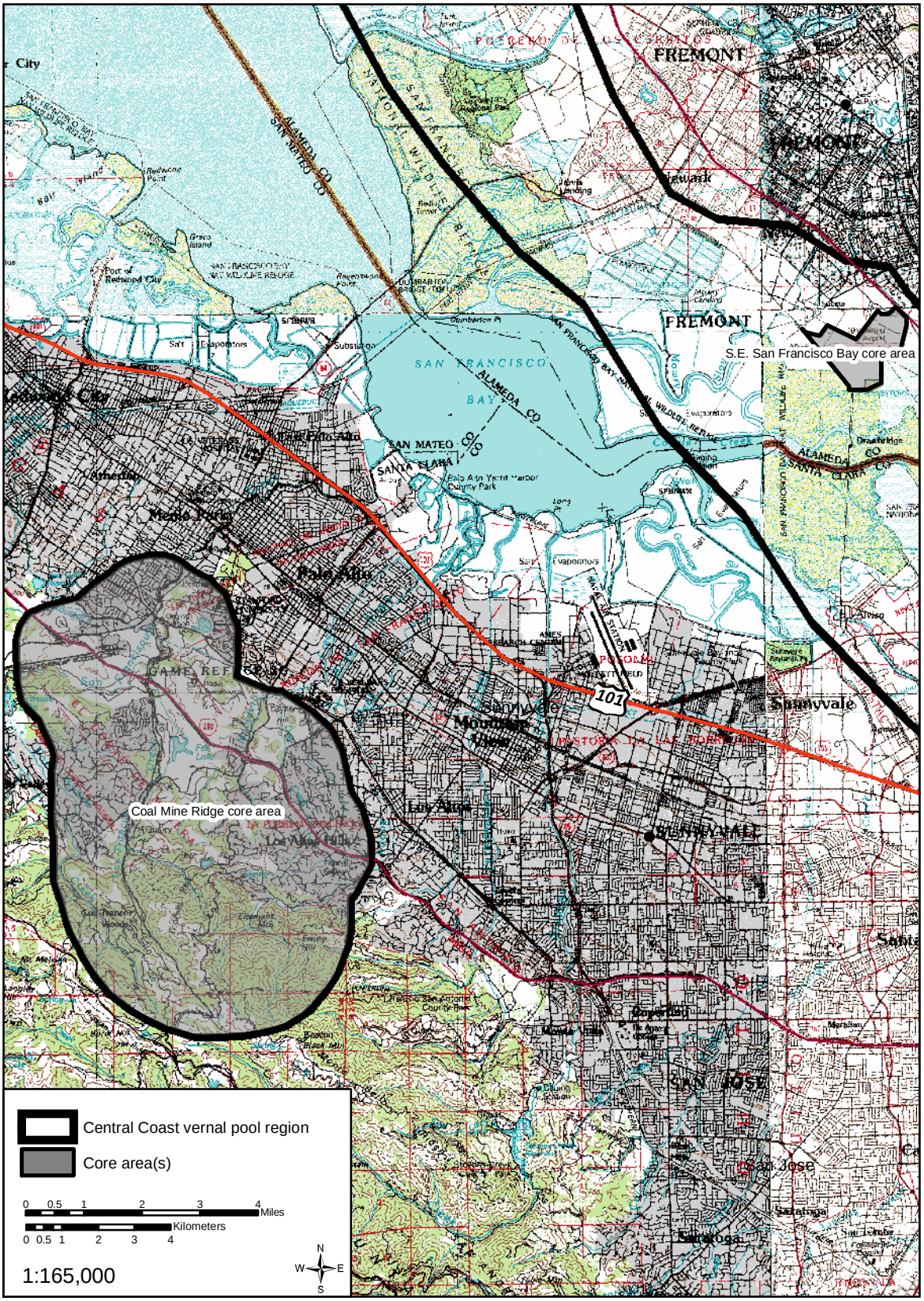

Figure III-3a. Coal Mine Ridge and S.E. San Francisco Bay core areas within the Central Coast vernal pool region.

Figure III-3b. Ford Ord core area within the Central Coast vernal pool region.

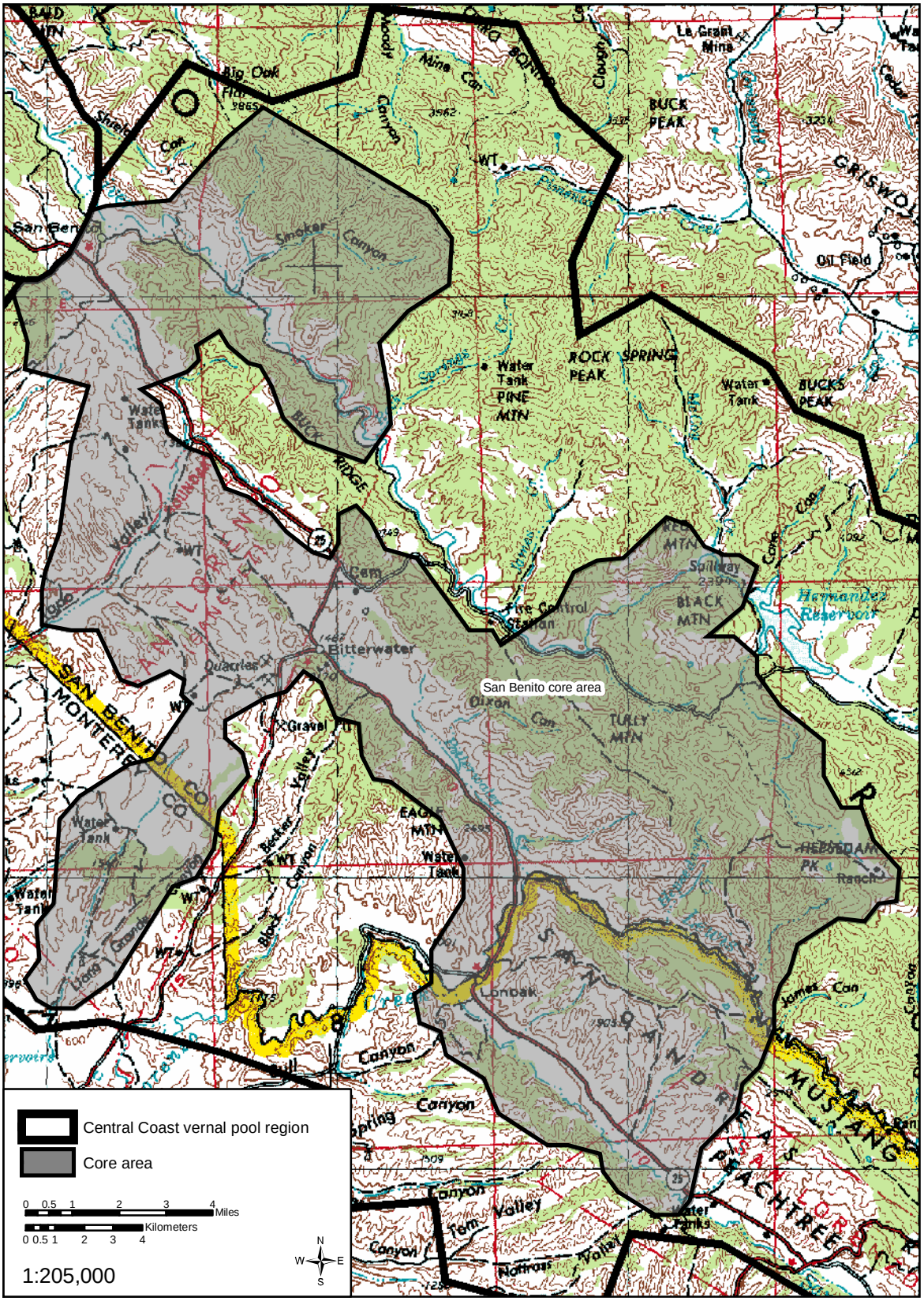

Figure III-3c. San Benito core area within the Central Coast vernal pool region.

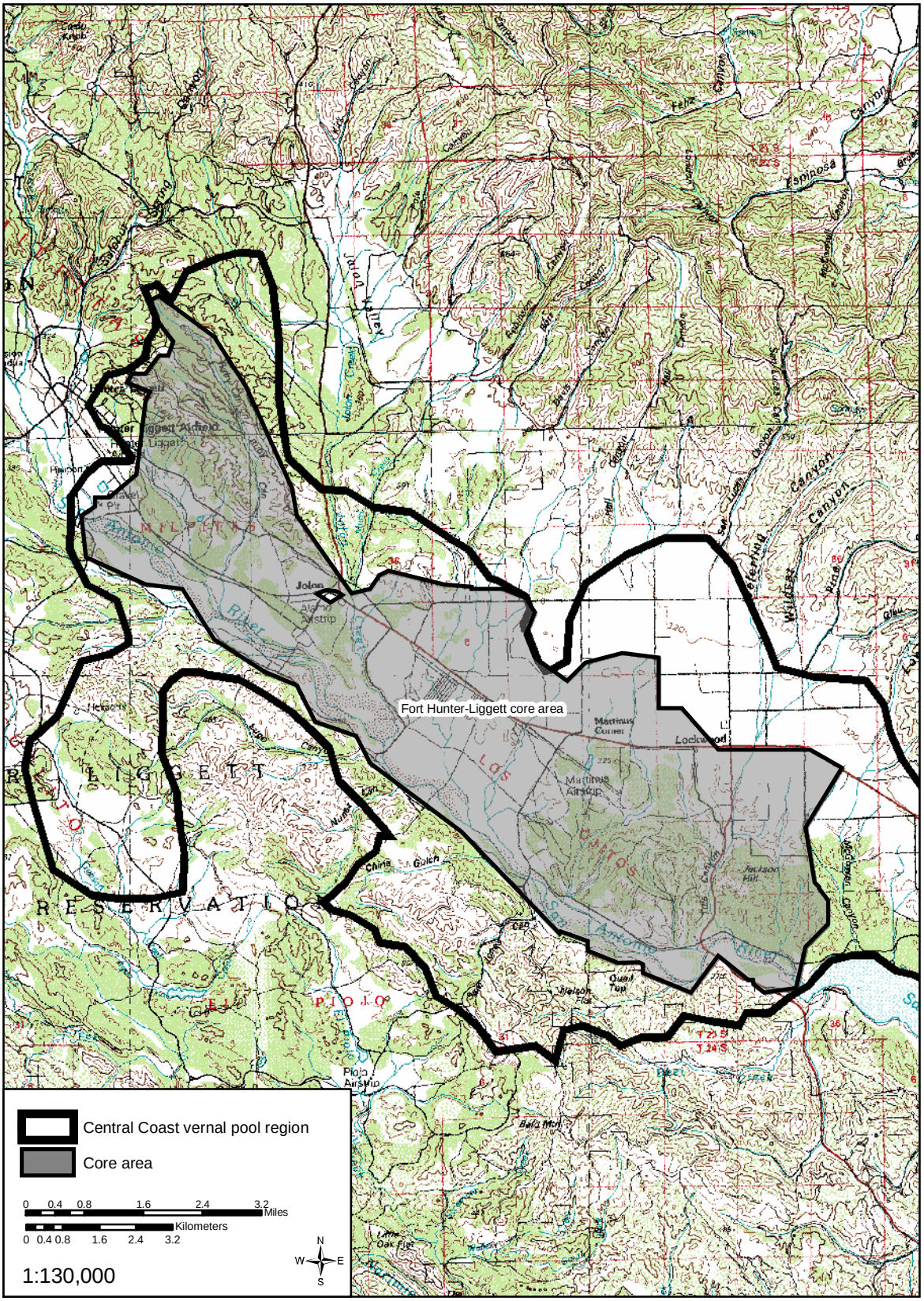

Figure III-3d. Fort Hunter-Liggett core area within the Central Coast vernal pool region.

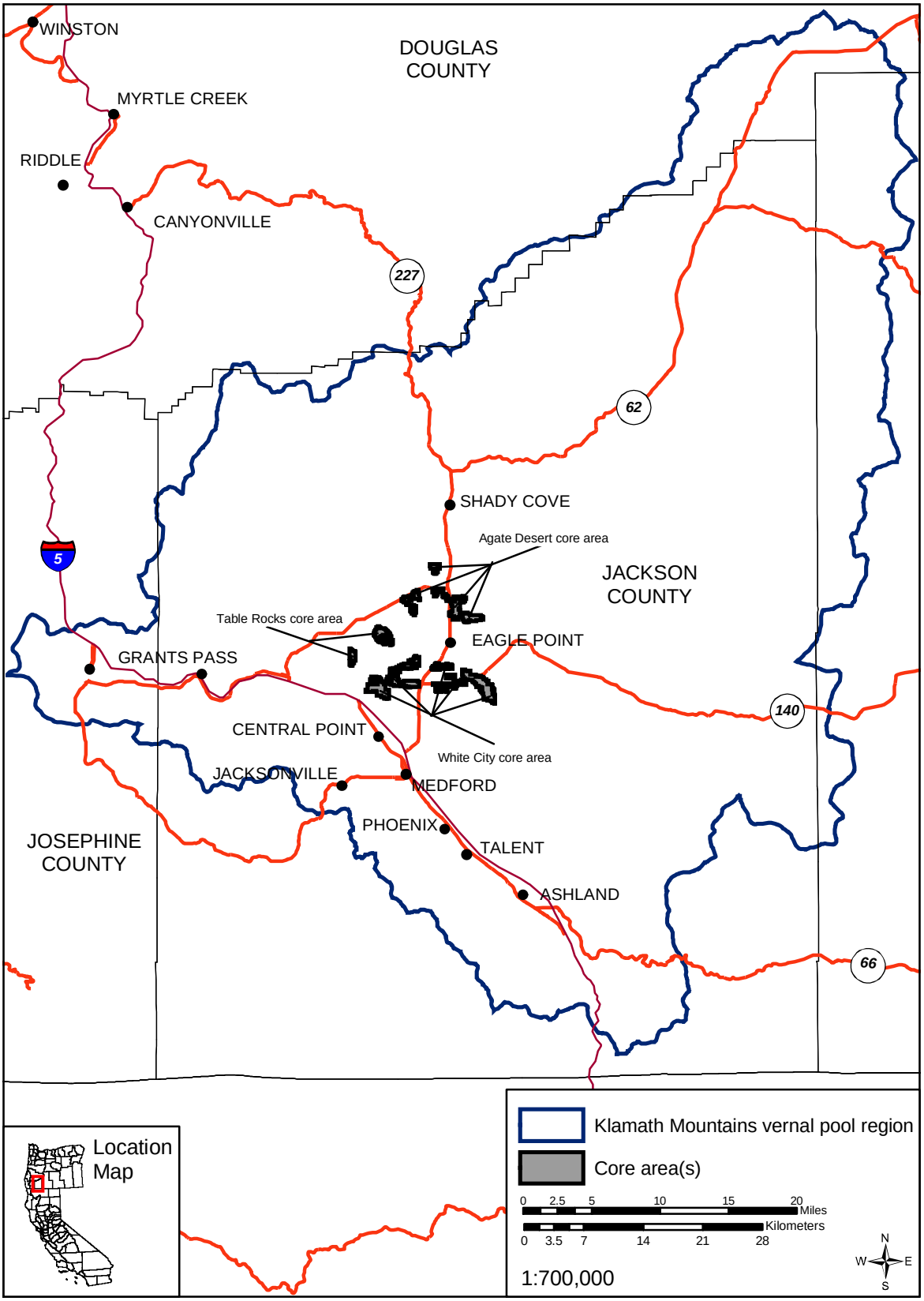

Figure III-4. Klamath Mountains vernal pool region.

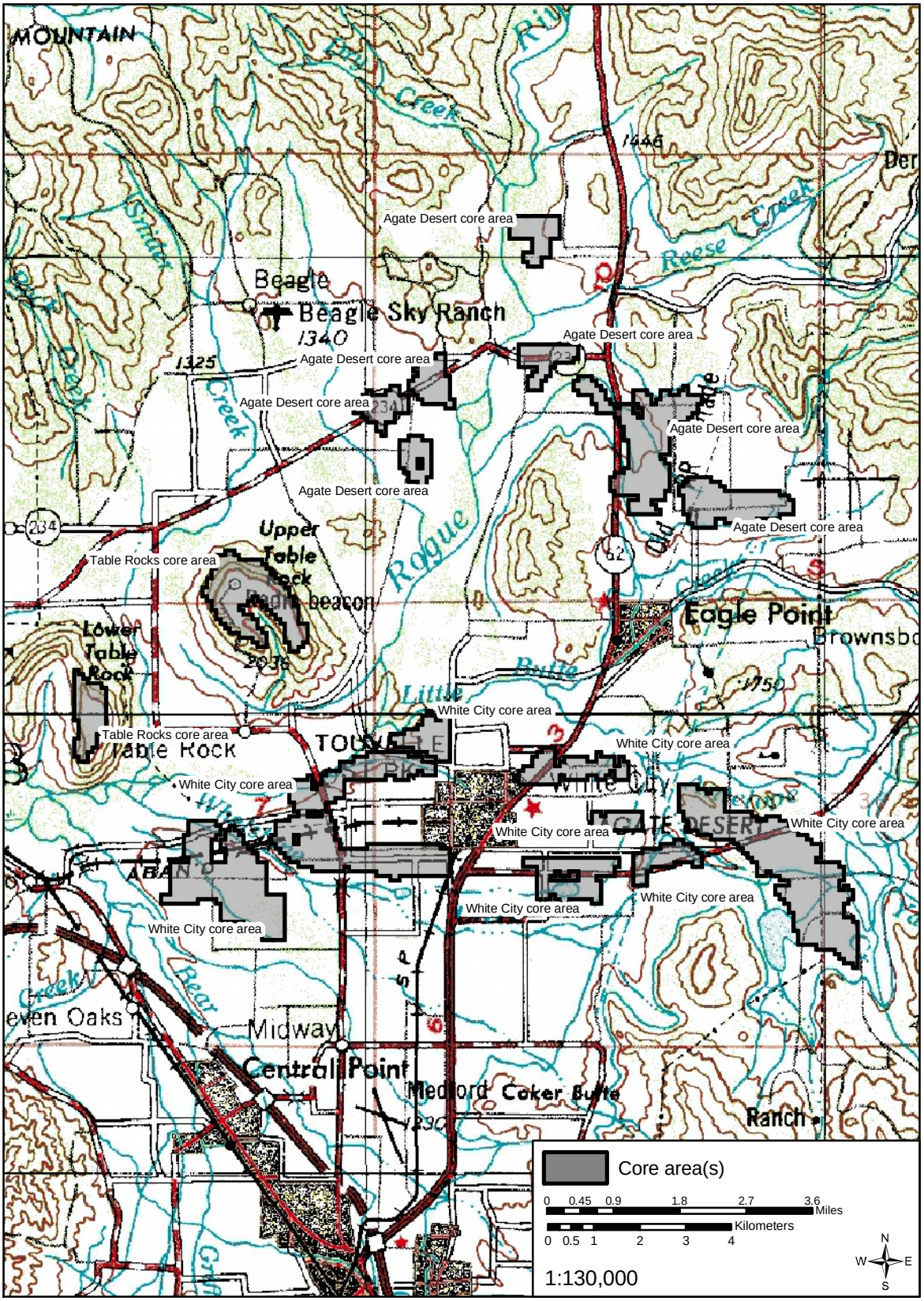

Figure III-4a. Agate Desert, Table Rocks, and White City core areas within the Klamath Mountains vernal pool region.

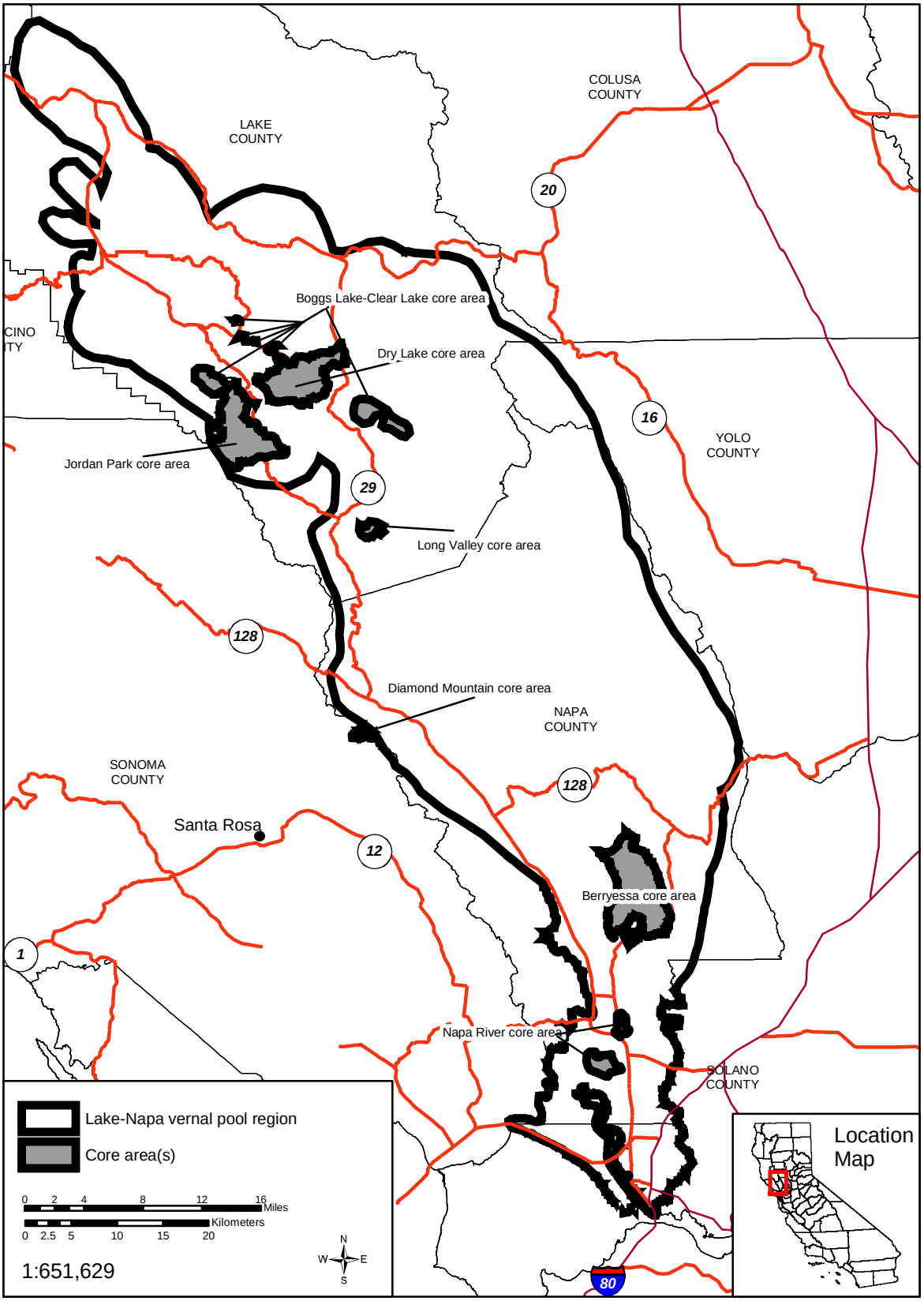

Figure III-5. Lake-Napa vernal pool region.

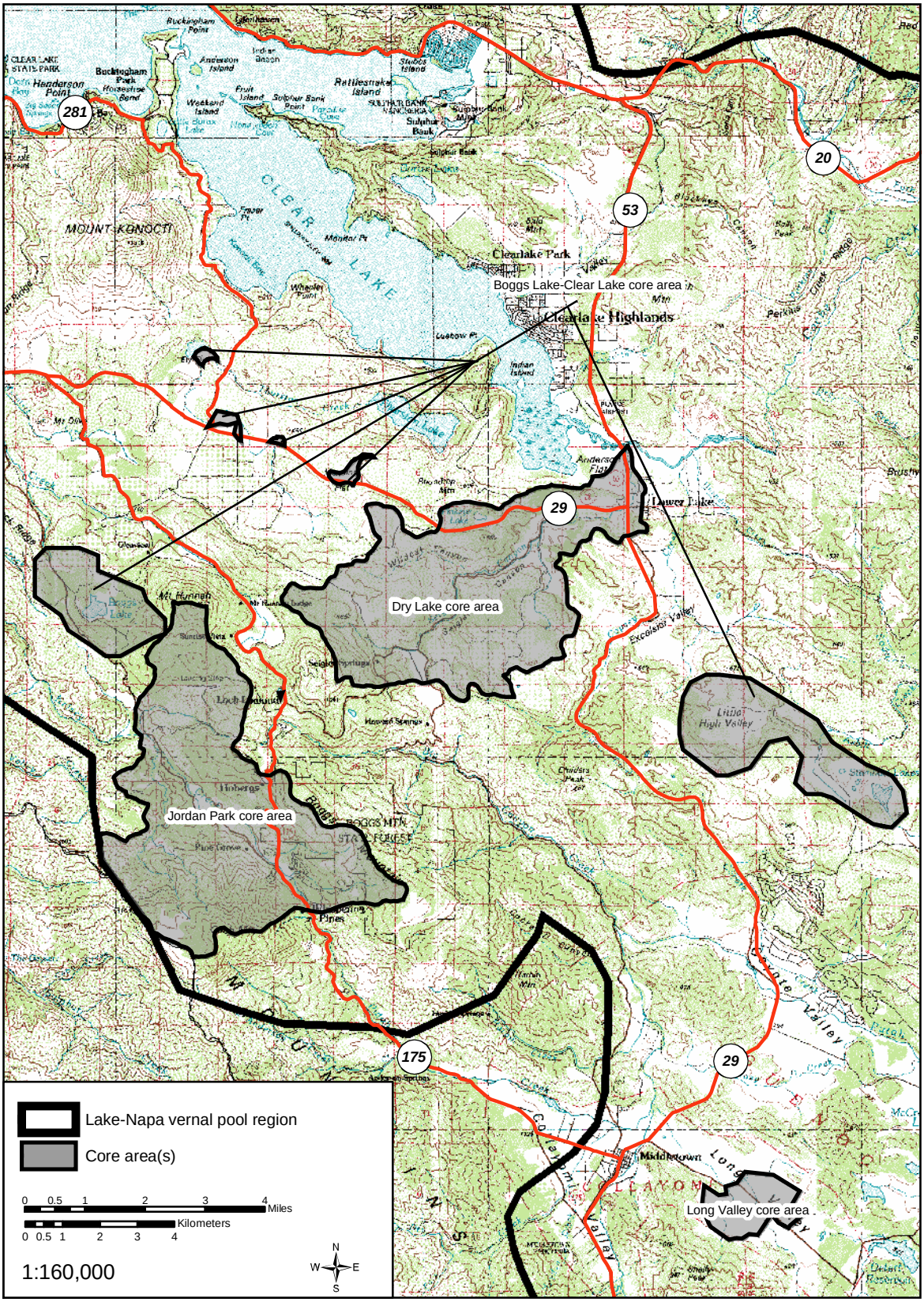

Figure III-5a. Boggs Lake-Clear Lake, Jordan Park, Dry Lake, and Long Valley core areas within the Lake-Napa vernal pool region.

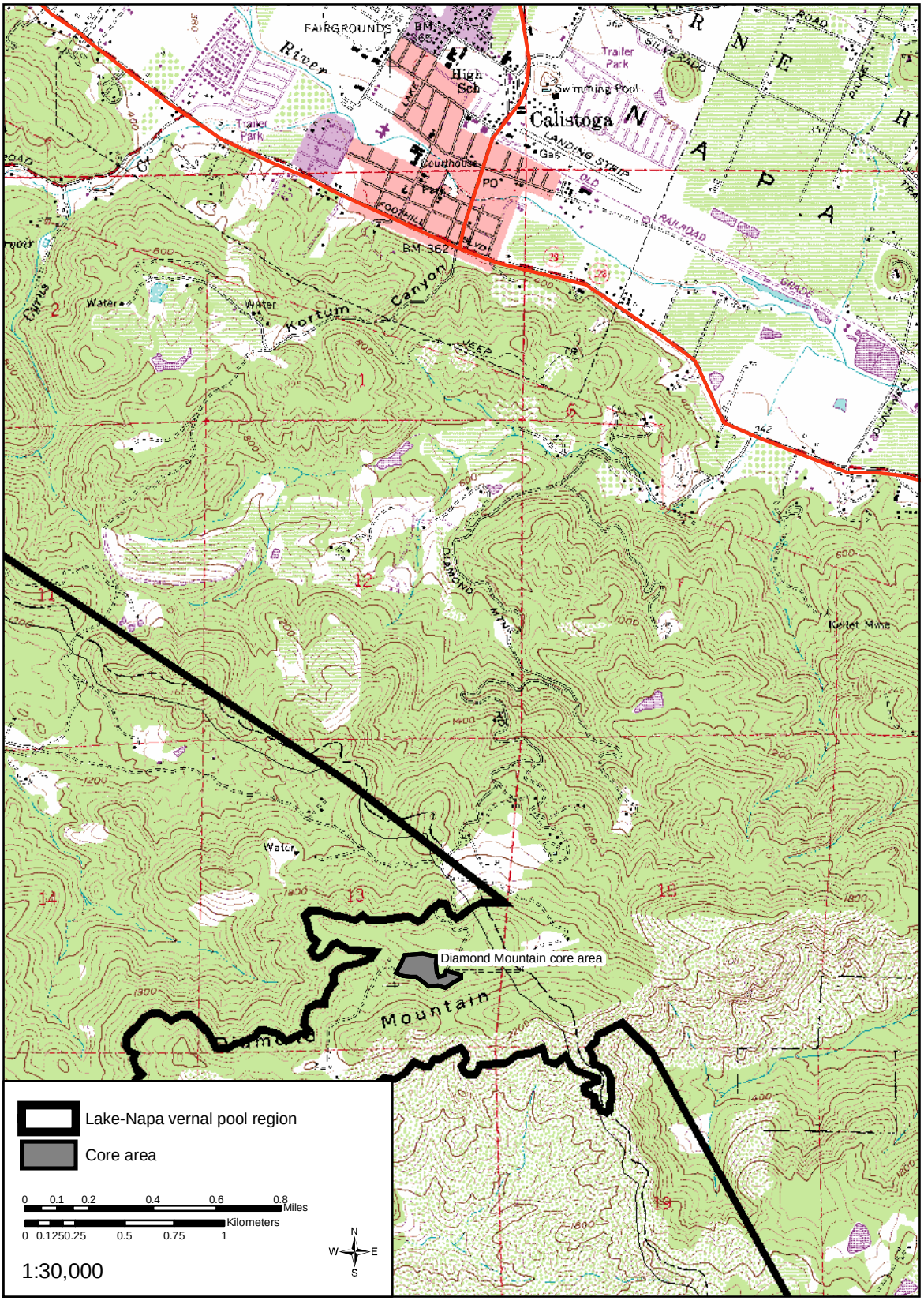

Figure III-5b. Diamond Mountain core area within the Lake-Napa vernal pool region.

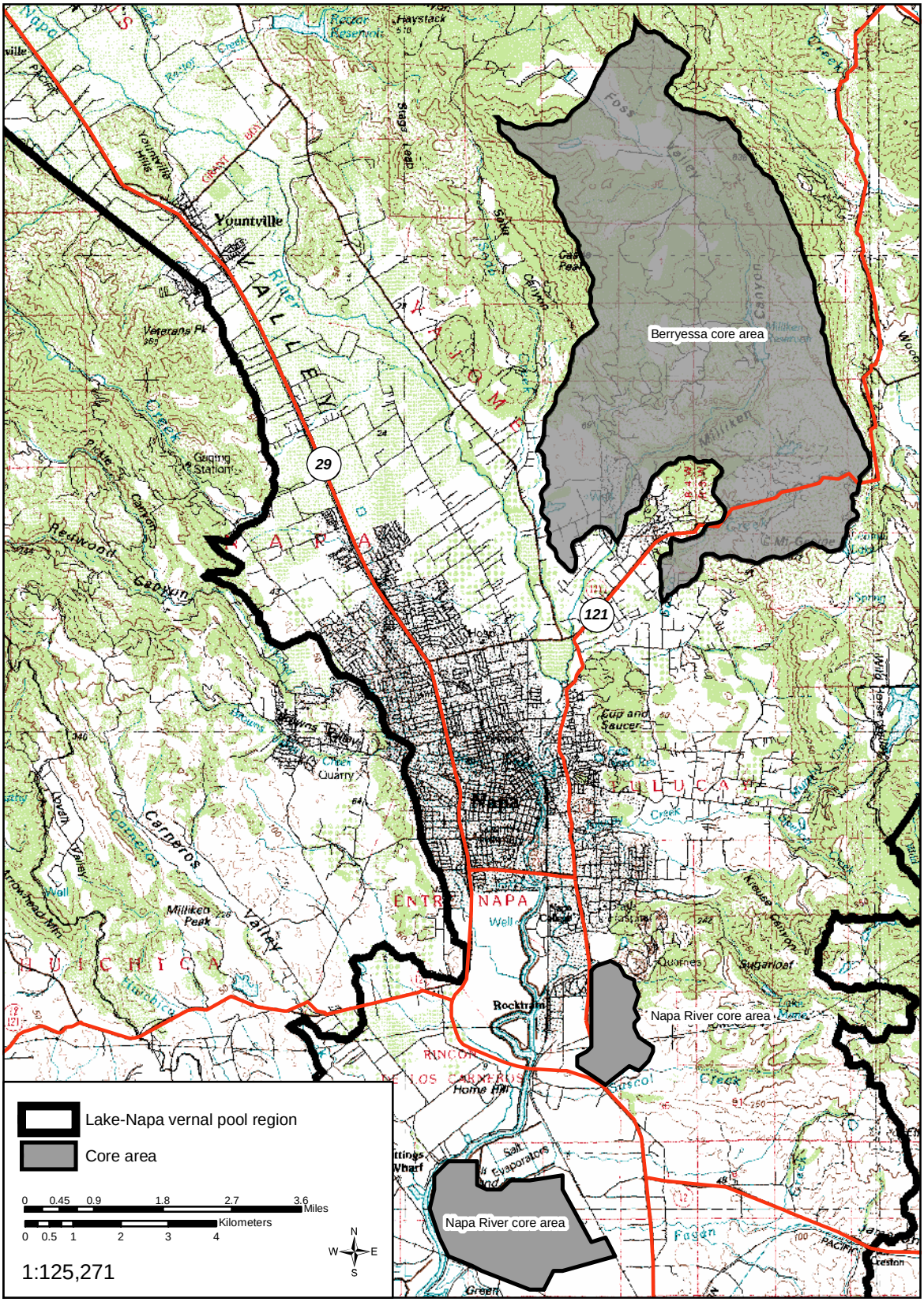

Figure III-5c. Berryessa and Napa River core areas within the Lake-Napa vernal pool region.

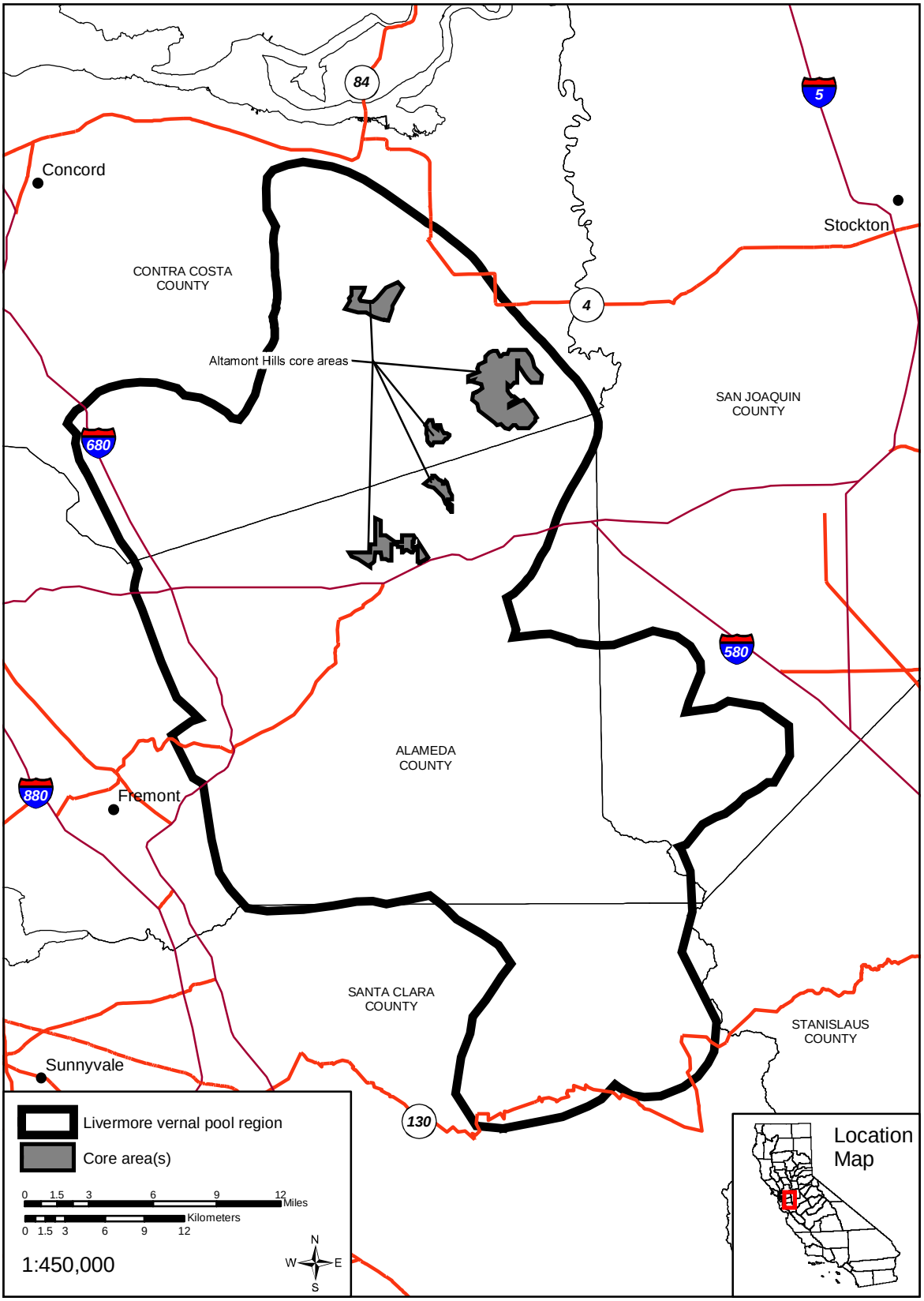

Figure III-6. Livermore vernal pool region.

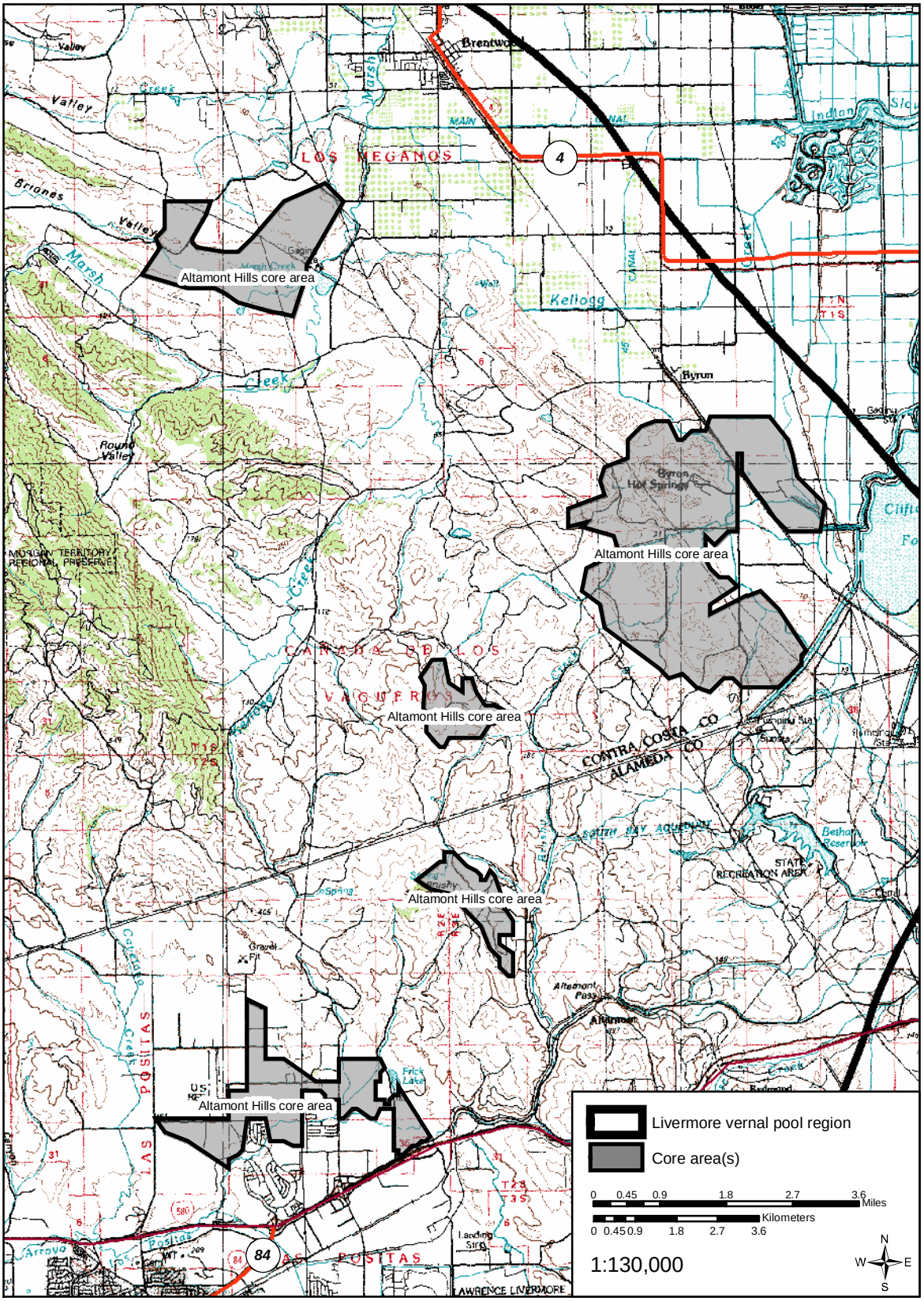

Figure III-6a. Altamont Hills core areas within the Livermore vernal pool region.

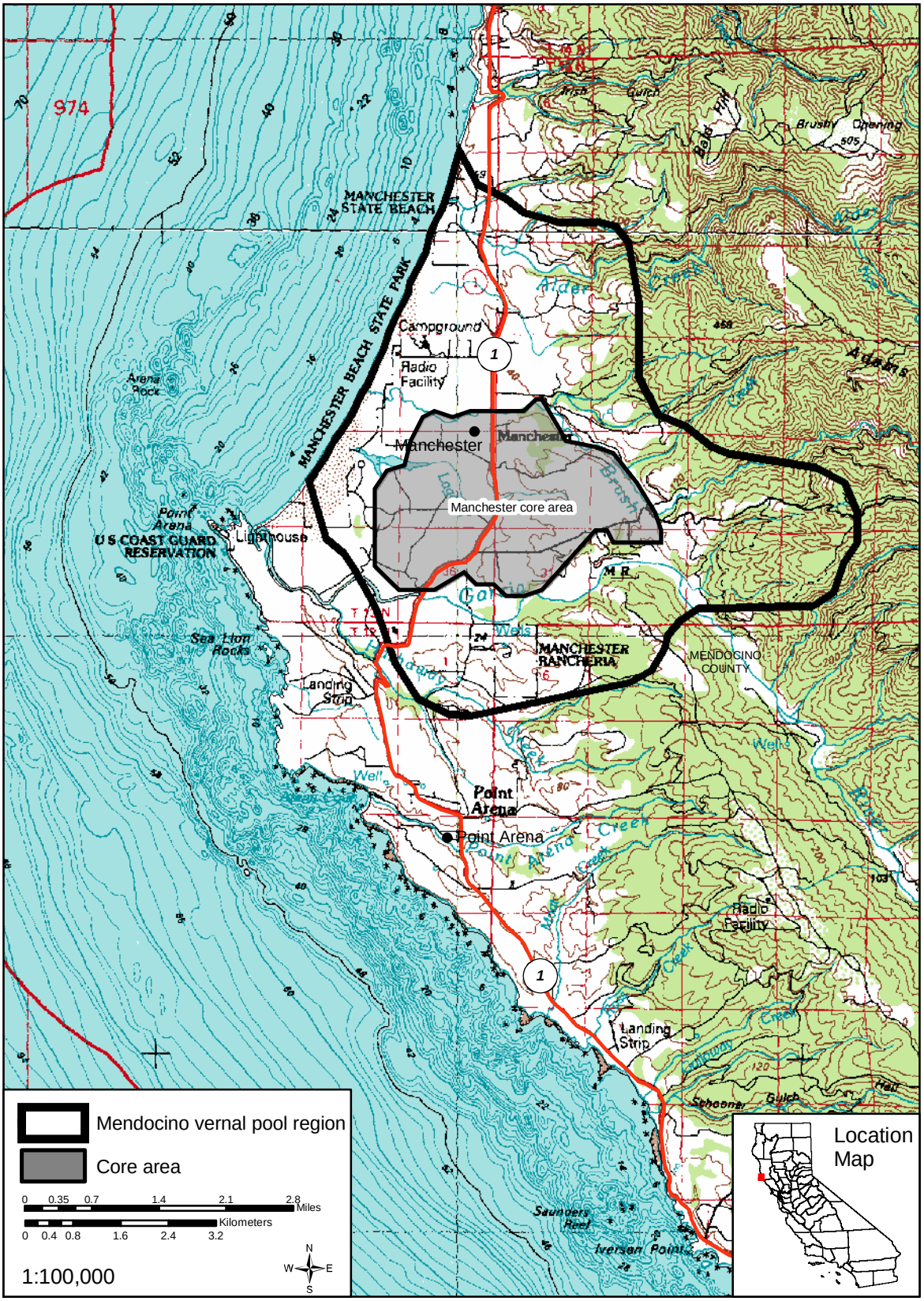

Figure III-7. Manchester core area within the Mendocino vernal pool region.

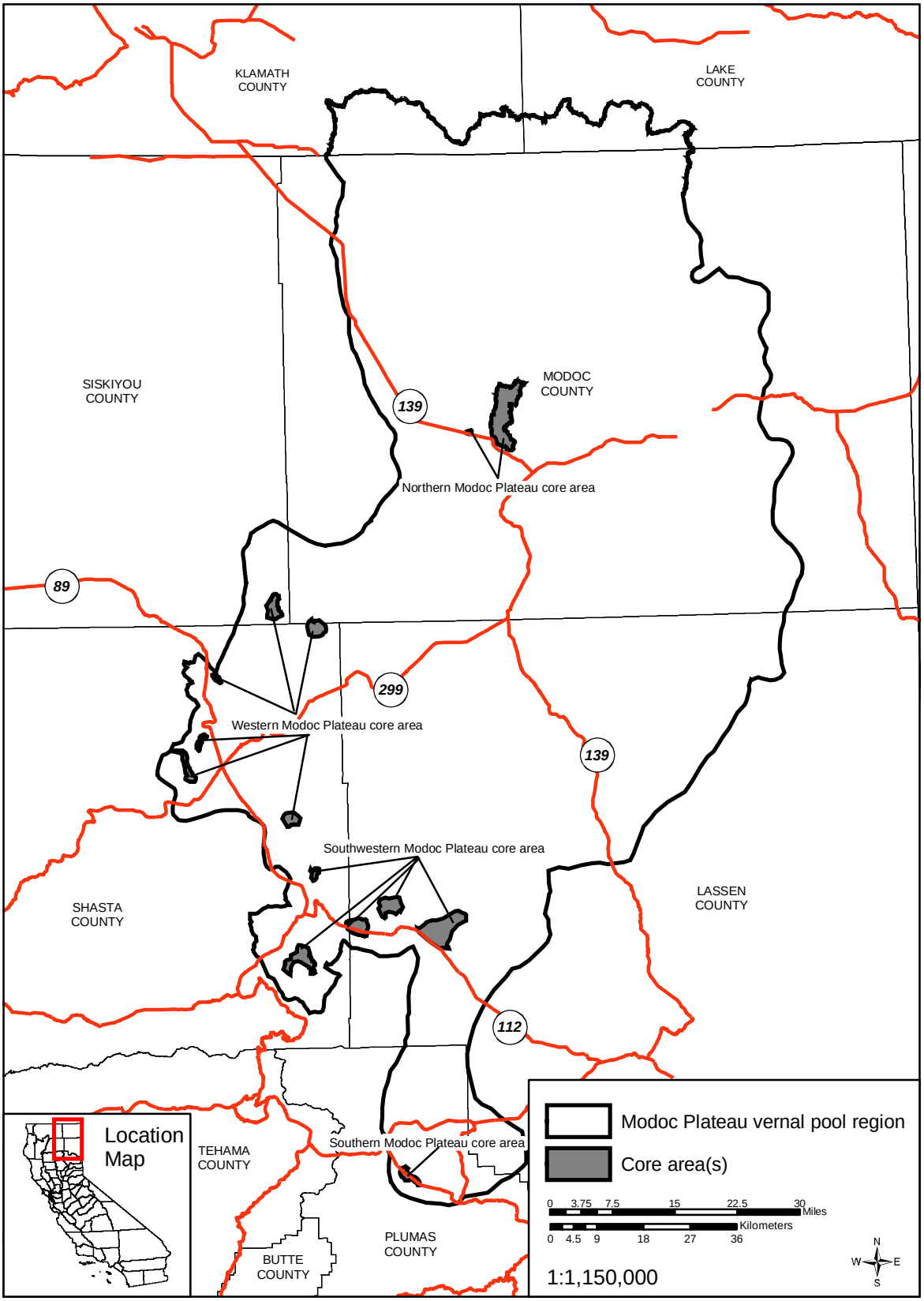

Figure III-8. Modoc Plateau vernal pool region.

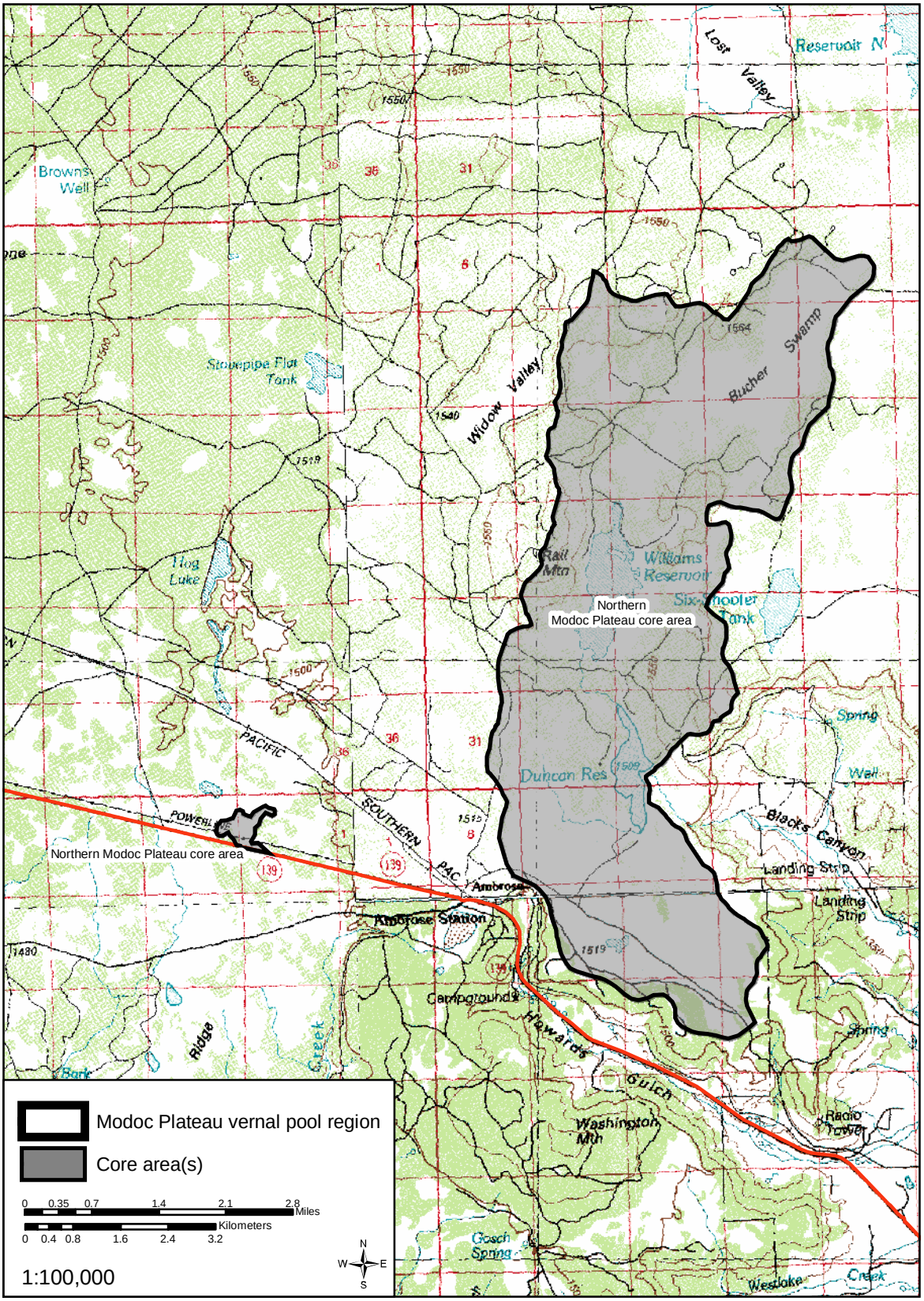

Figure III-8a. Northern Modoc Plateau core areas within the Modoc Plateau vernal pool region.

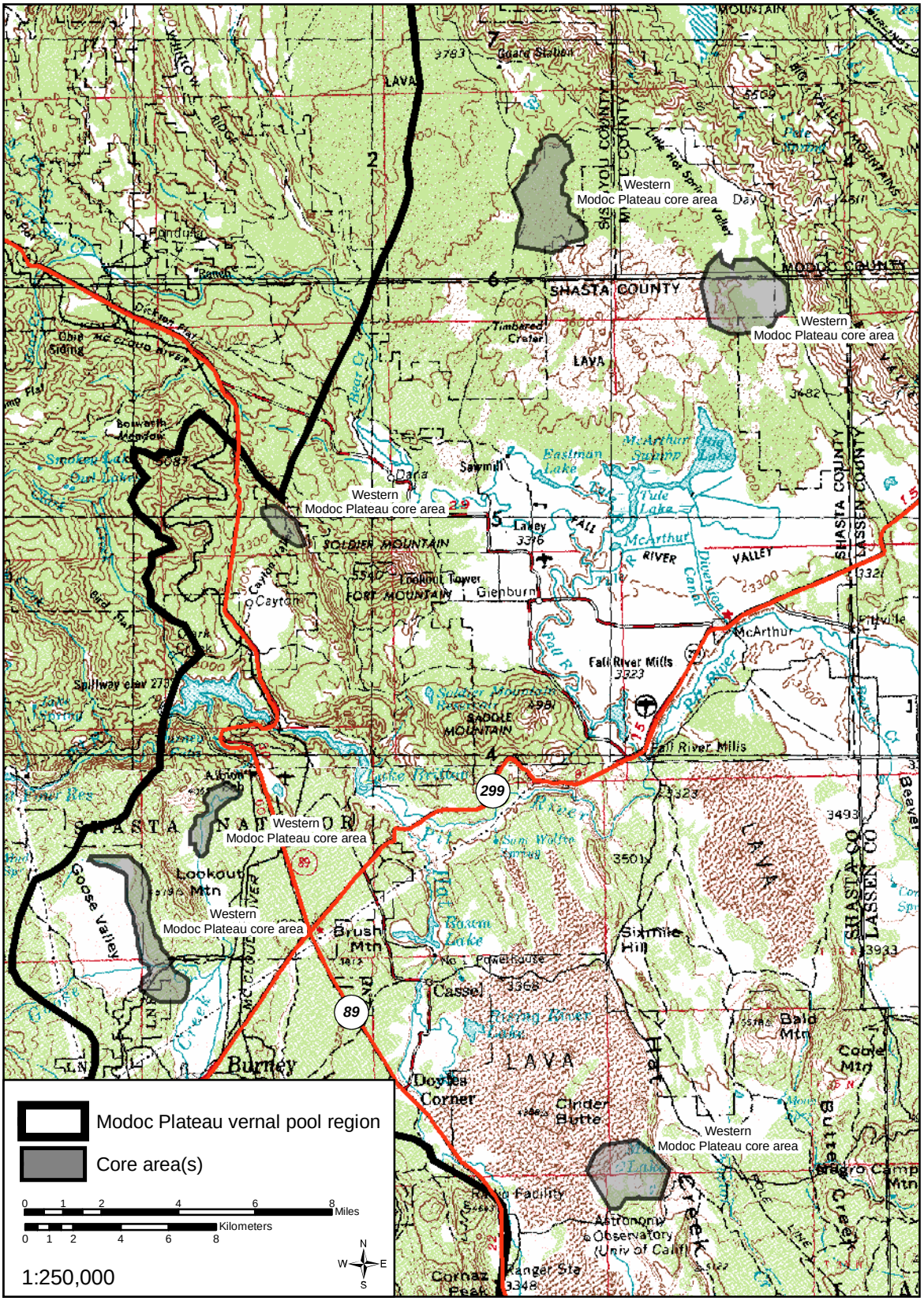

Figure III-8b. Western Modoc Plateau core areas within the Modoc Plateau vernal pool region.

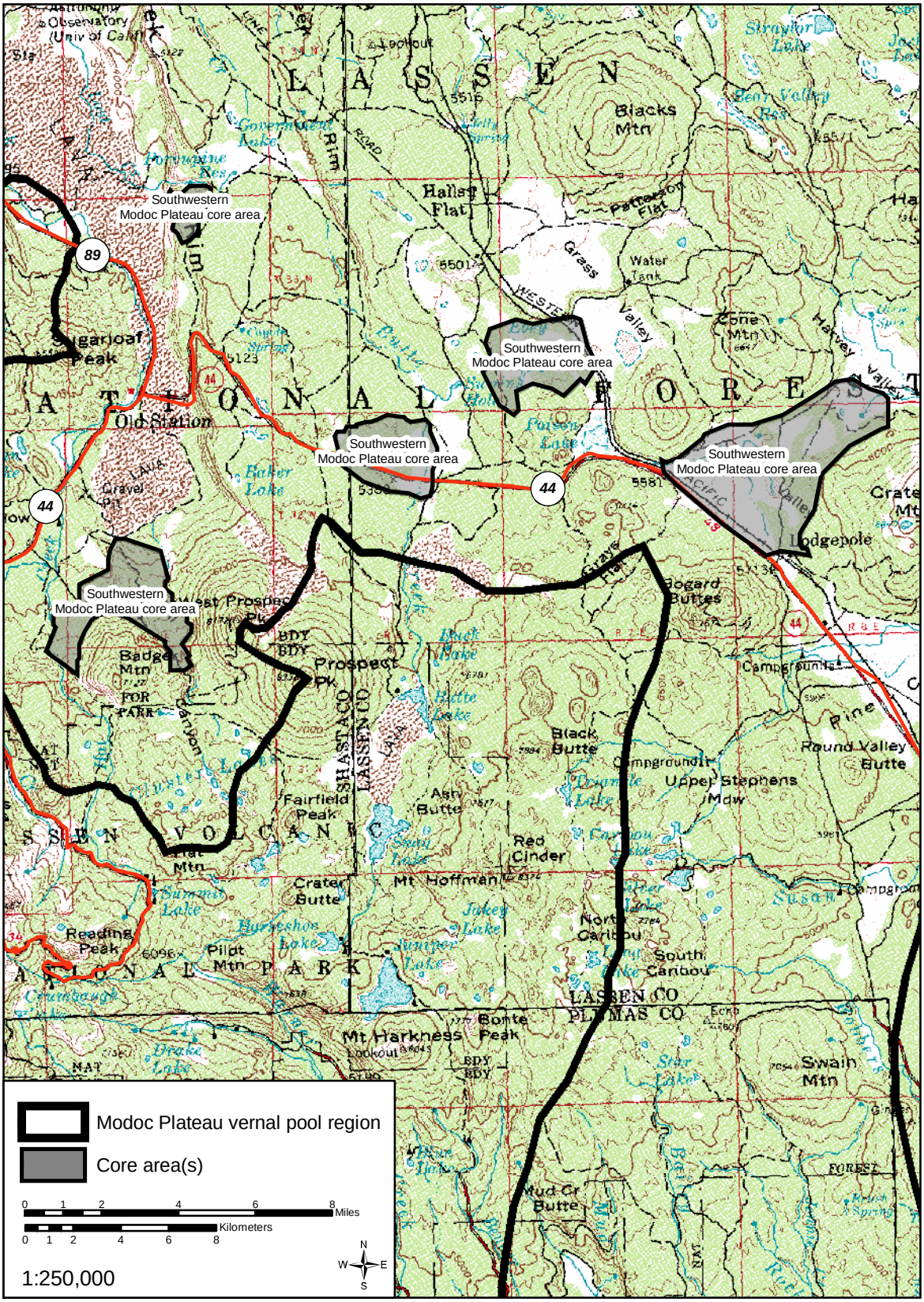

Figure III-8c. Southwestern Modoc Plateau core areas within the Modoc Plateau vernal pool region.

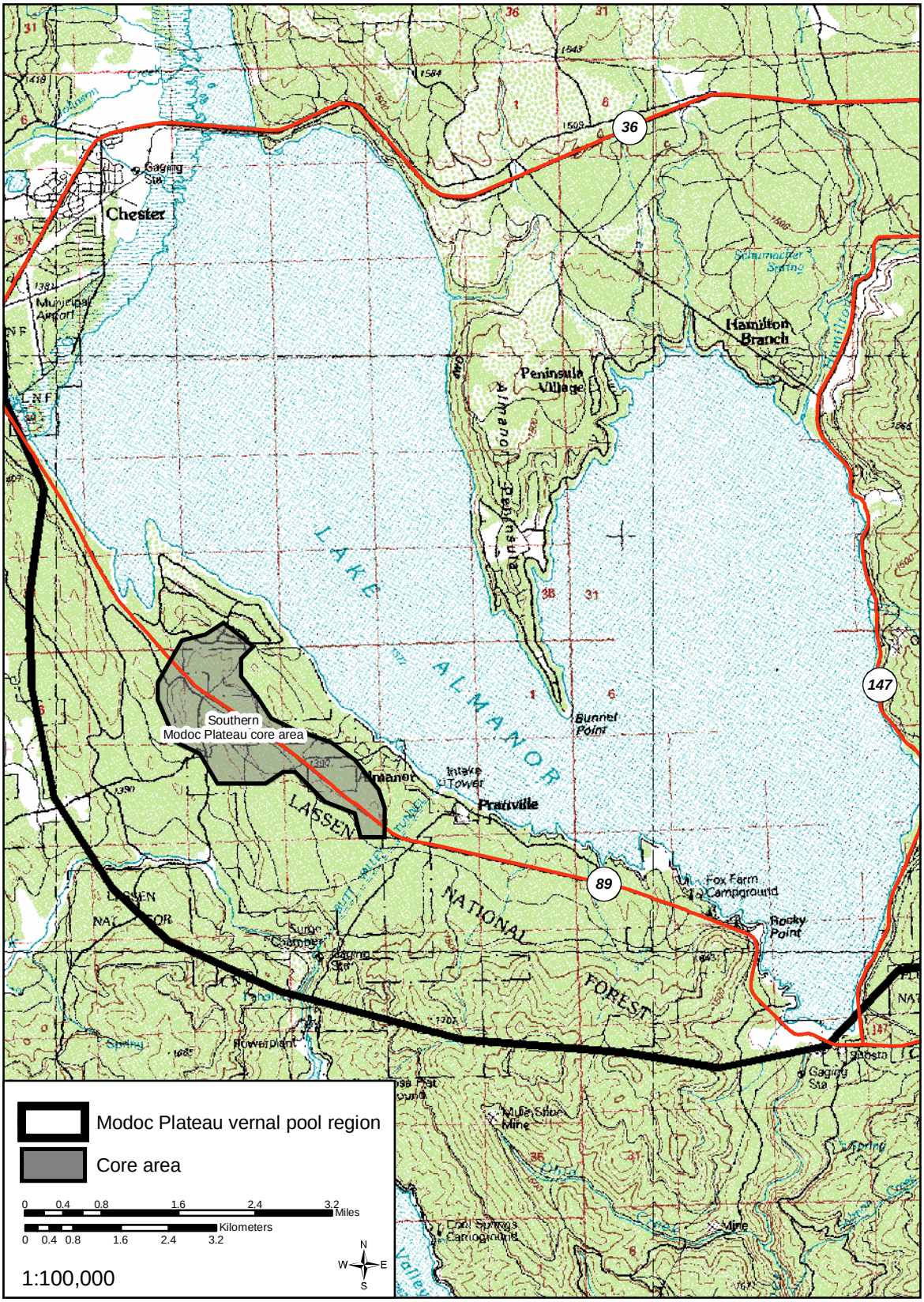

Figure III-8d. Southern Modoc Plateau core area within the Modoc Plateau vernal pool region.

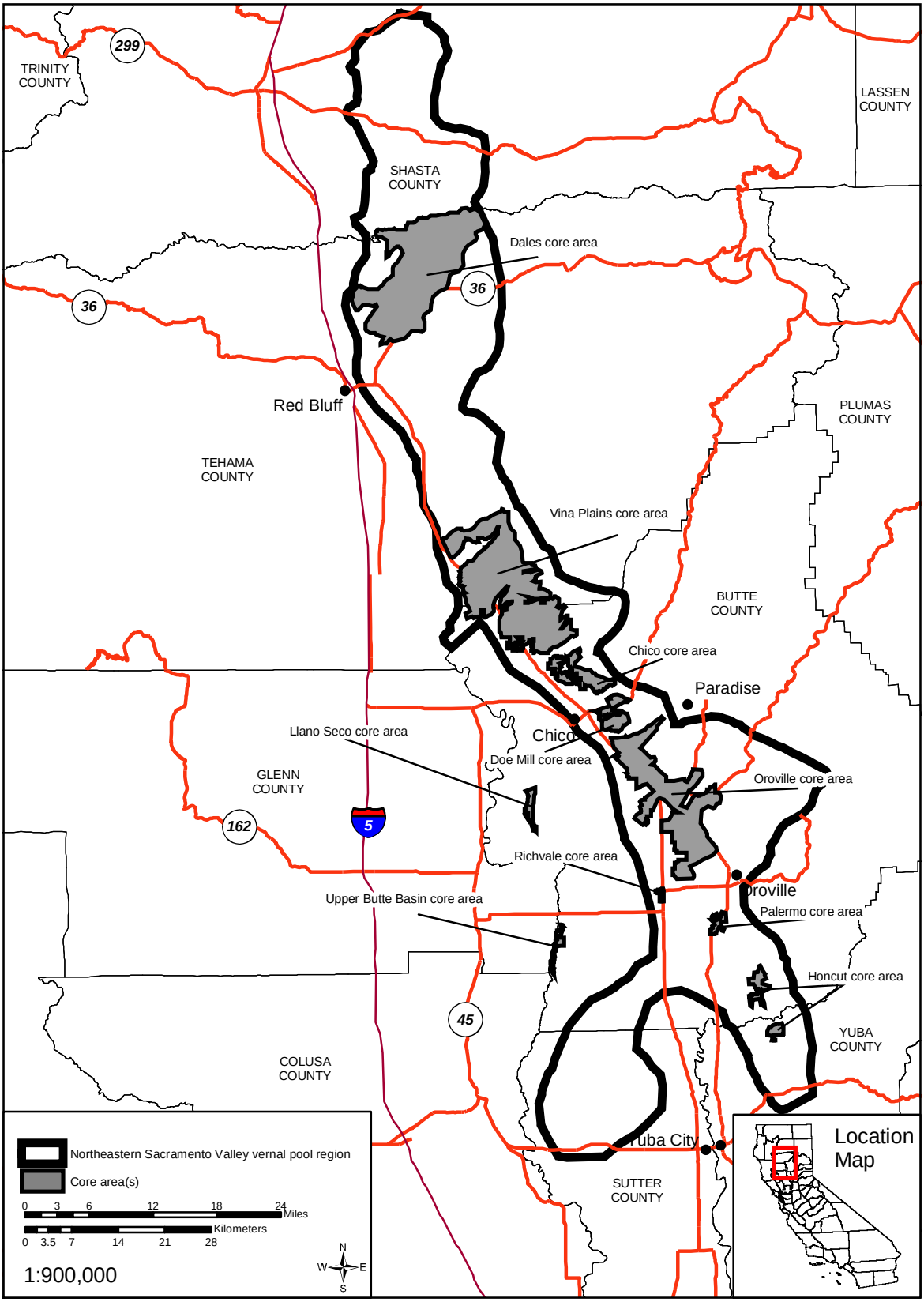

Figure III-9. Northeastern Sacramento Valley vernal pool region.

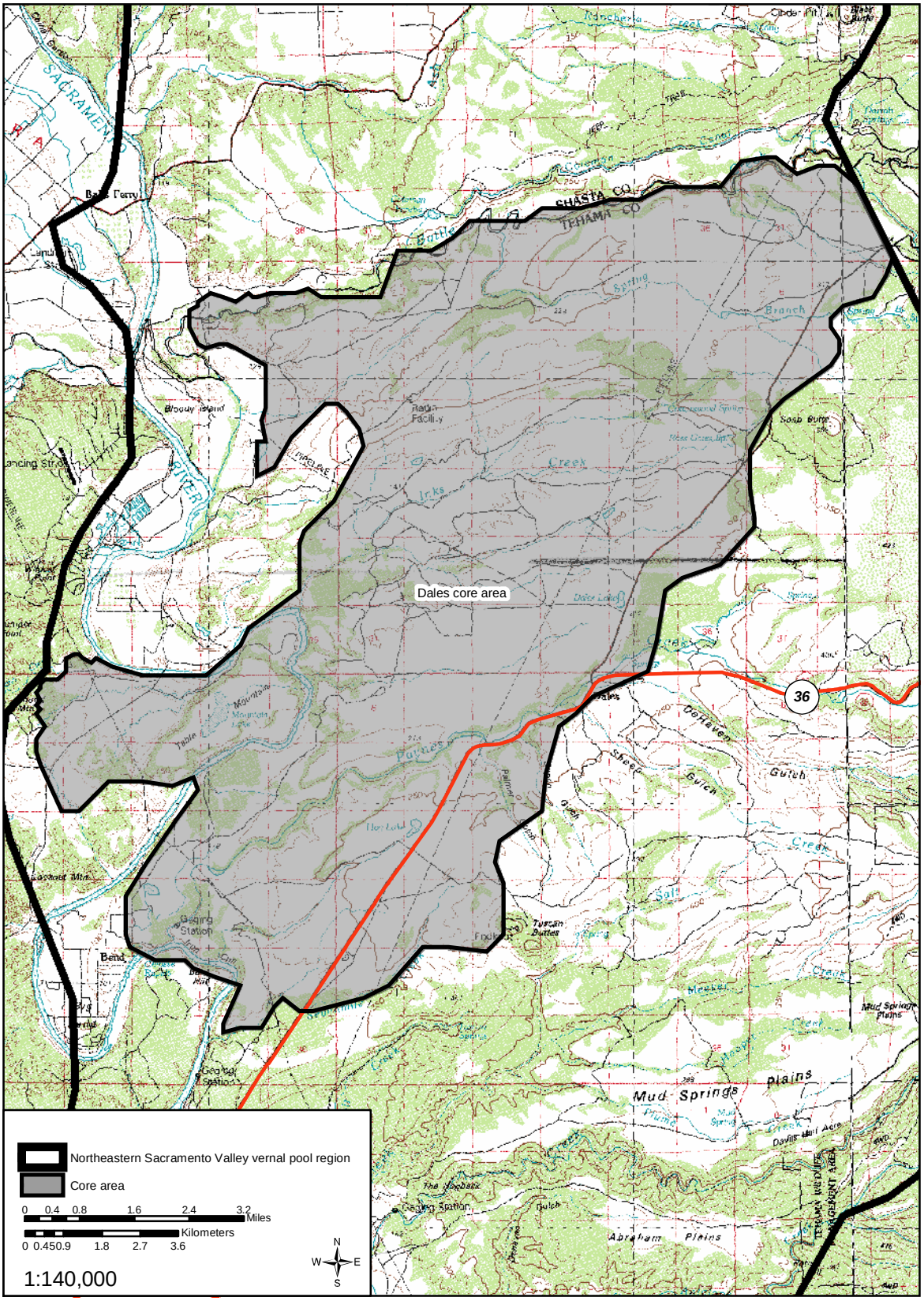

Figure III-9a. Dales core area within the Northeastern Sacramento Valley vernal pool region.

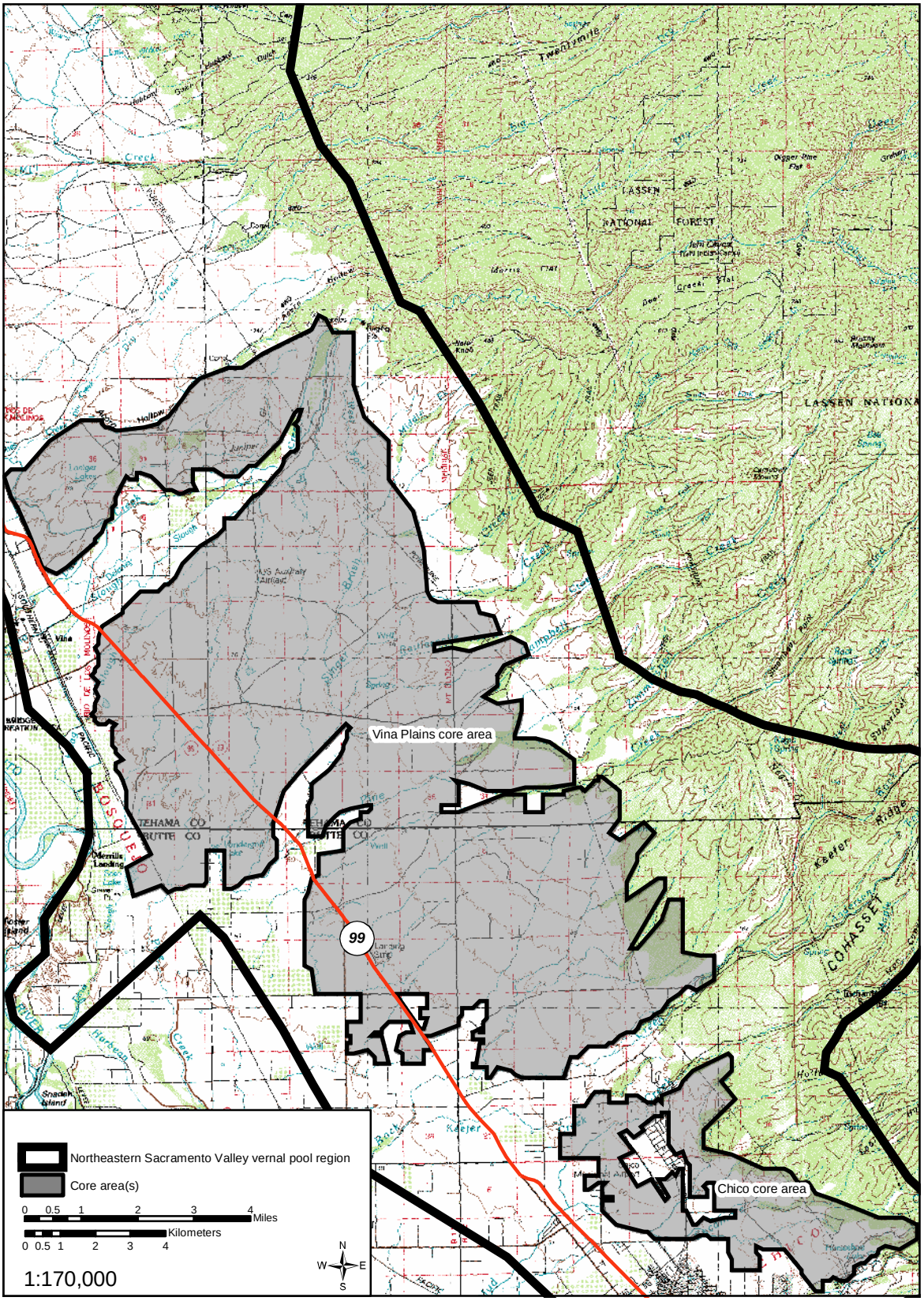

Figure III-9b. Vina Plains and Chico core areas within the Northeastern Sacramento Valley vernal pool region.

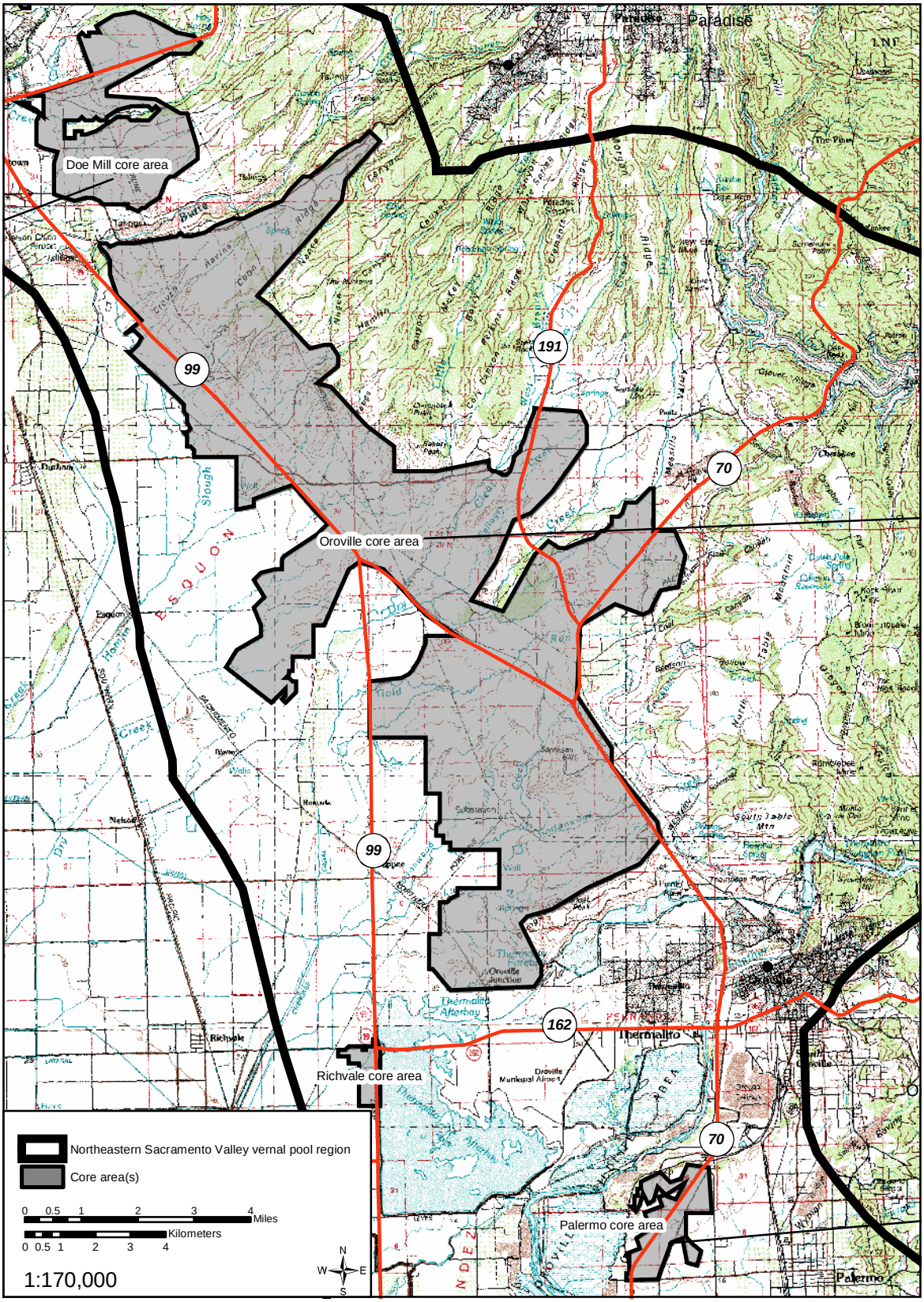

Figure III-9c. Doe Mill, Oroville, Richvale, and Palermo core areas within the Northeastern Sacramento Valley vernal pool region.

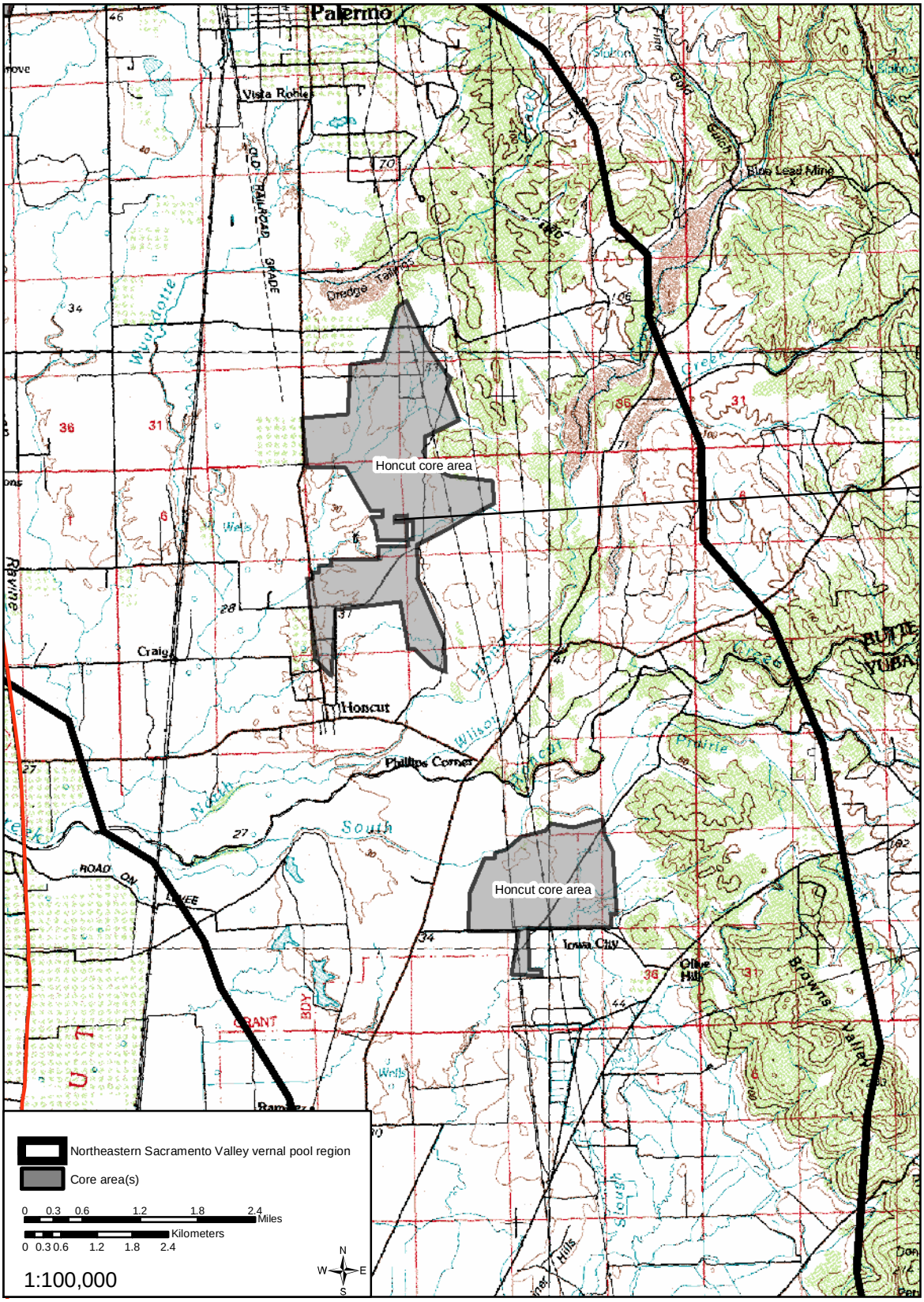

Figure III-9d. Honcut core areas within the Northeastern Sacramento Valley vernal pool region.

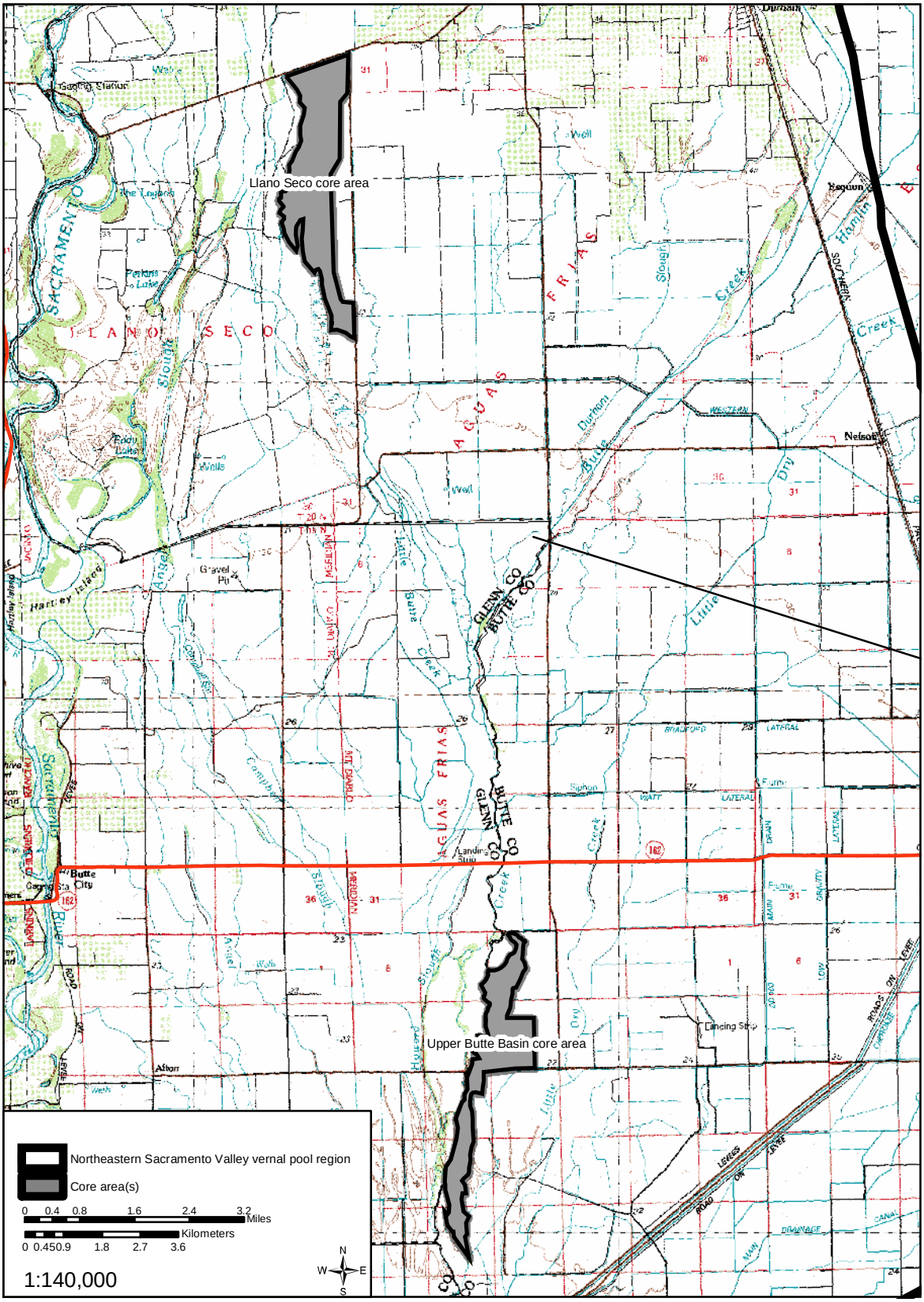

Figure III-9e. Sacramento National Wildlife Refuge Llano Seco and Upper Butte Basin core areas within the Northeastern Sacramento Valley vernal pool region.

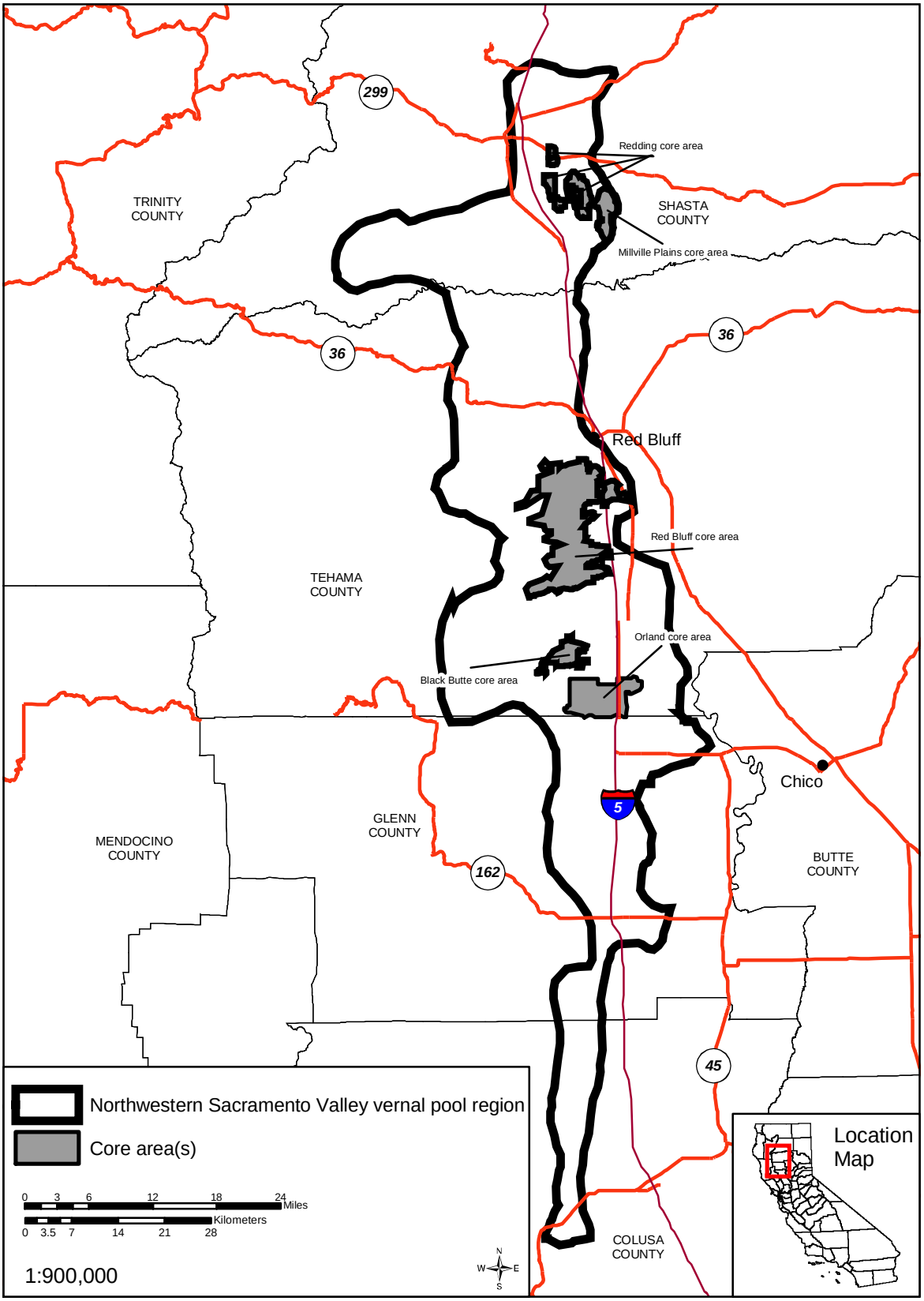

Figure III-10. Northwestern Sacramento Valley vernal pool region.

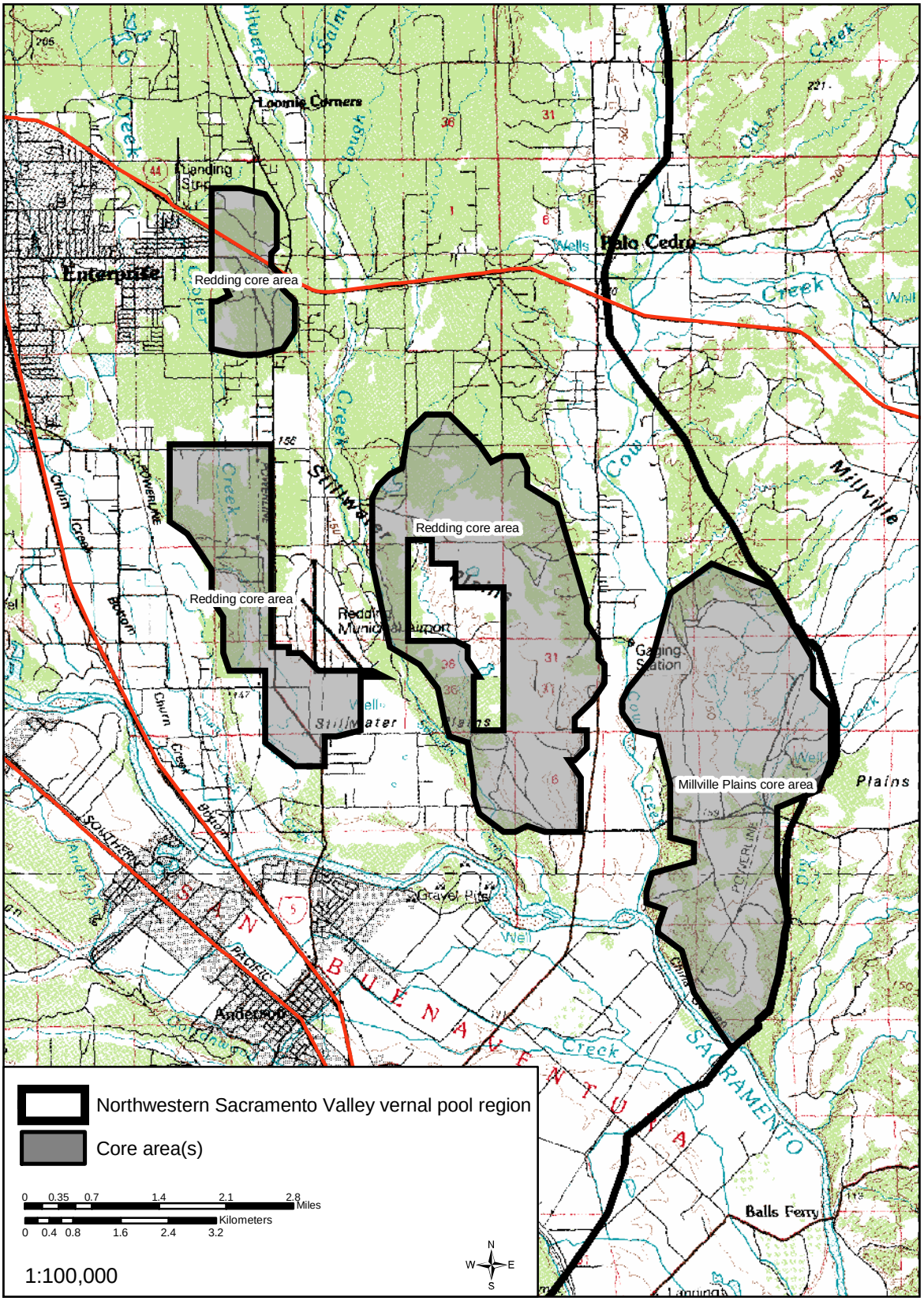

Figure III-10a. Redding and Millville Plains core areas within the Northwestern Sacramento Valley vernal pool region.

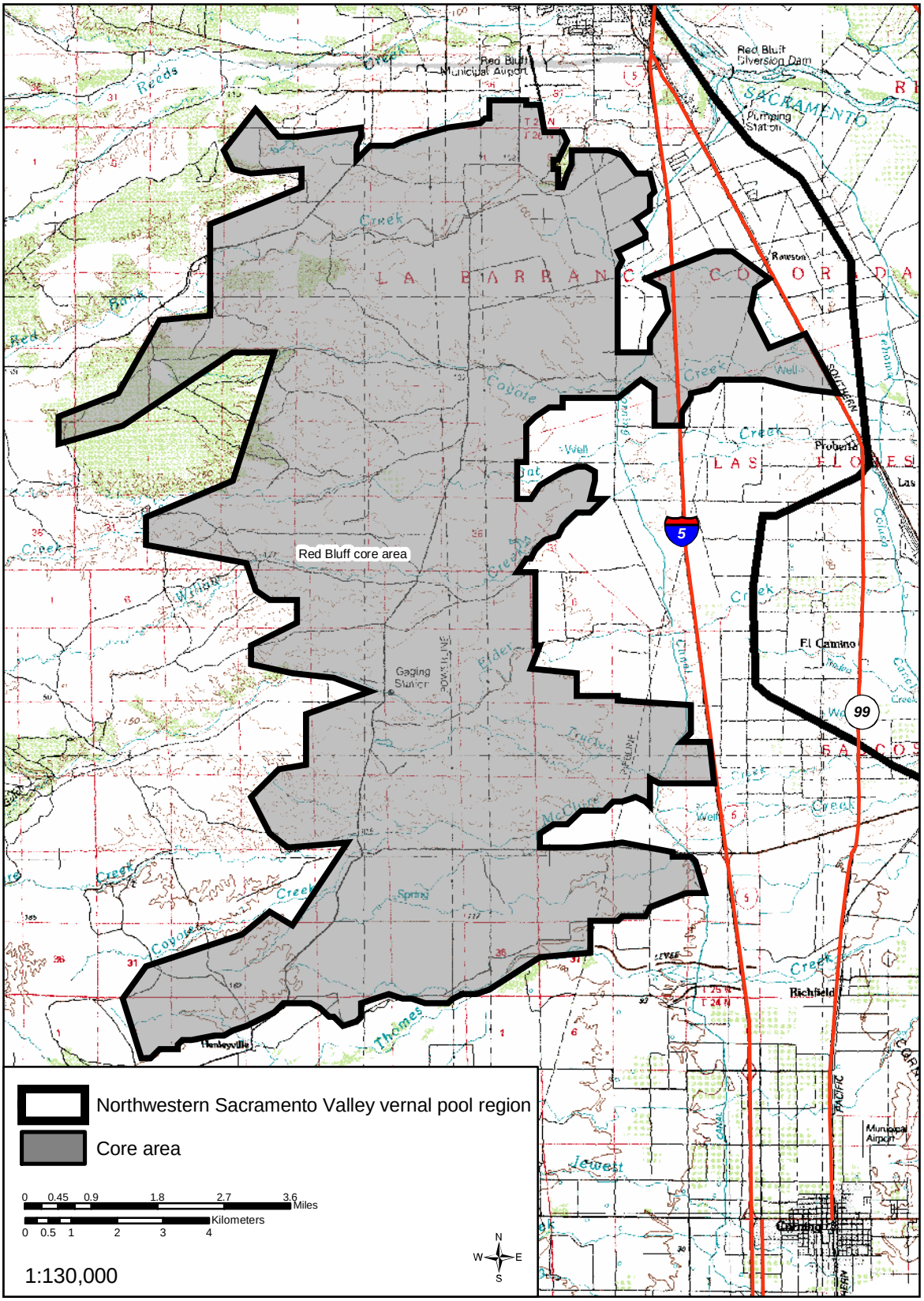

Figure III-10b. Red Bluff core area within the Northwestern Sacramento Valley vernal pool region.

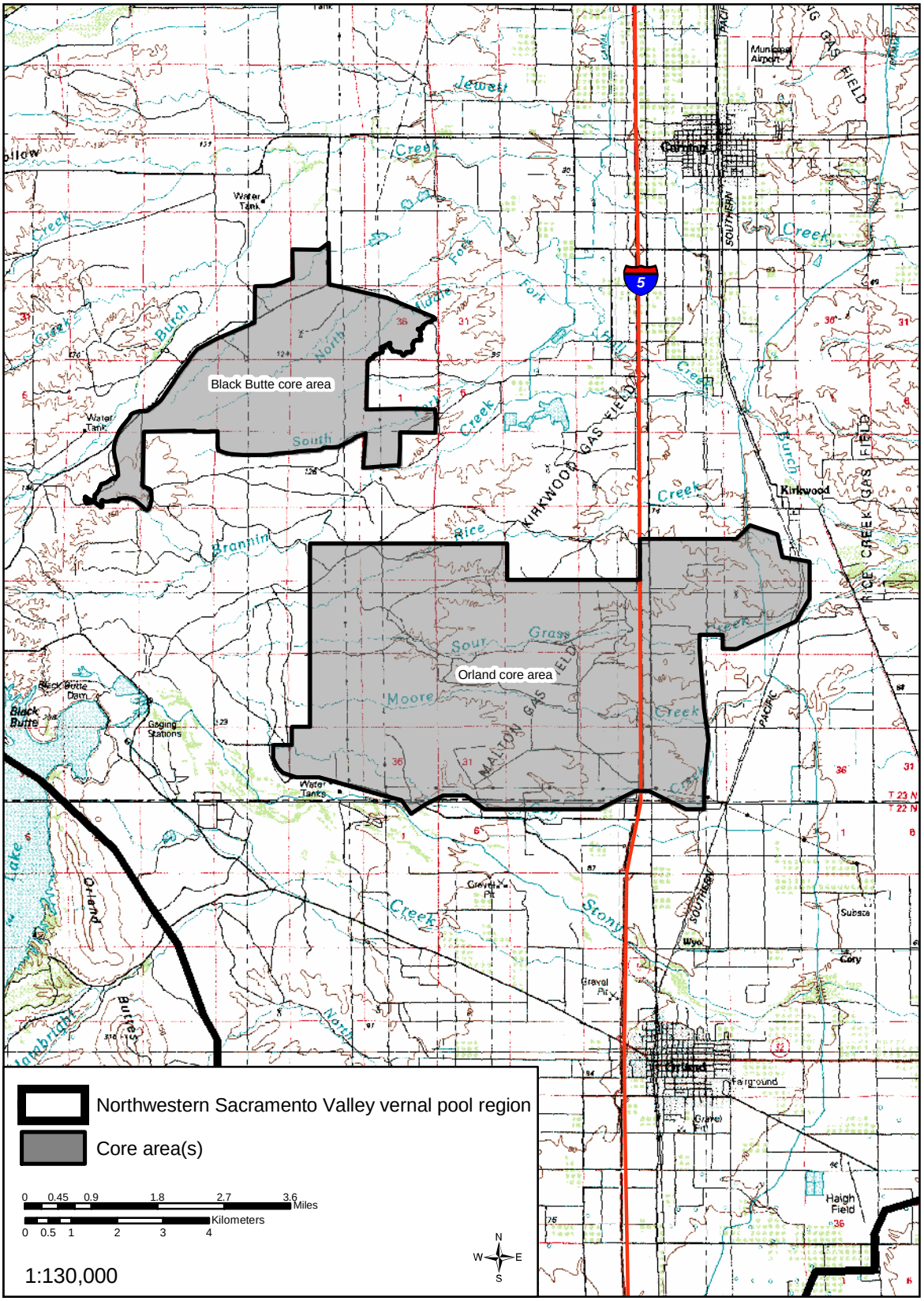

Figure III-10c. Black Butte and Orland core areas within the Northwestern Sacramento Valley vernal pool region.

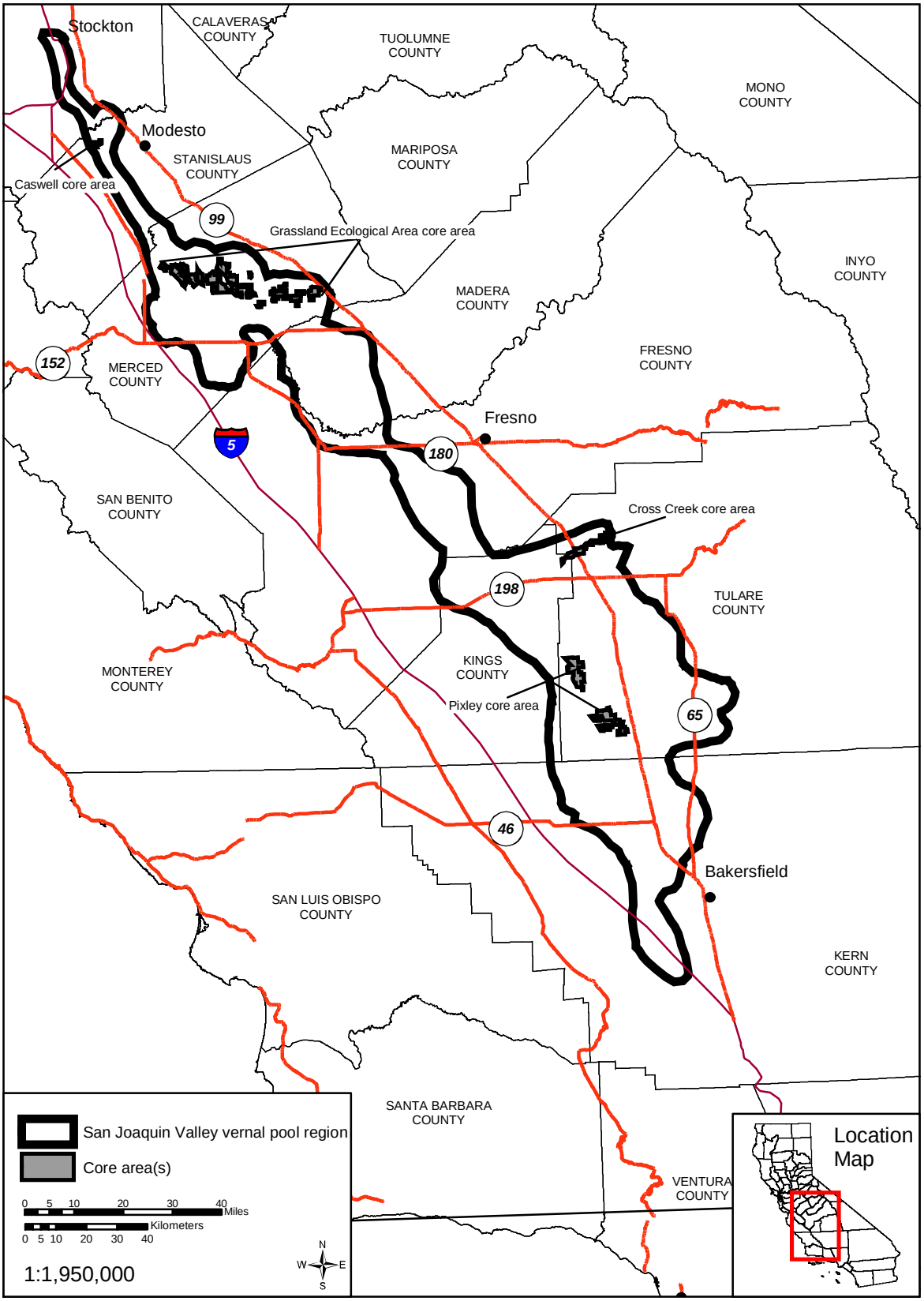

Figure III-11. San Joaquin Valley vernal pool region.

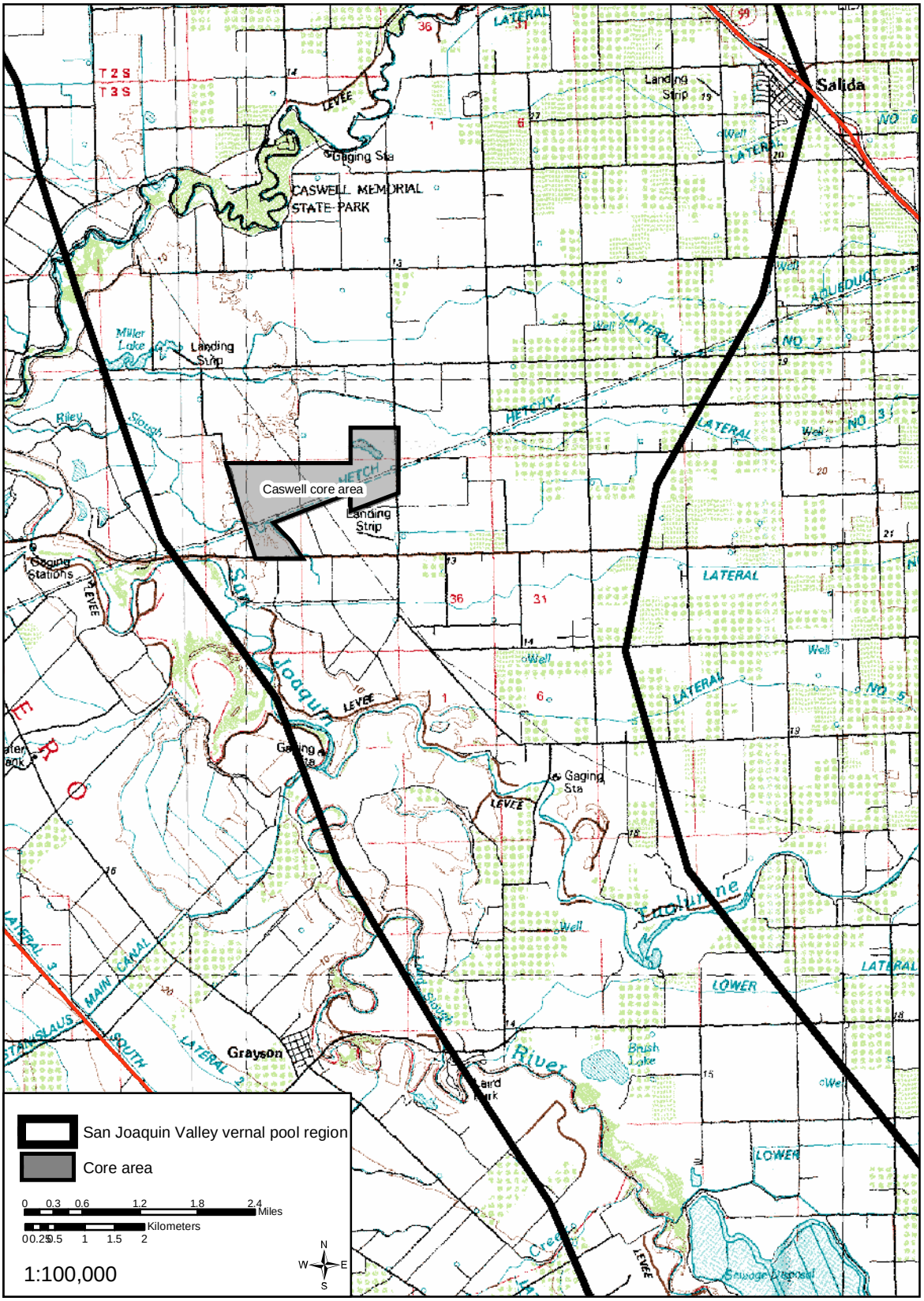

Figure III-11a. Caswell core area within the San Joaquin Valley vernal pool region.

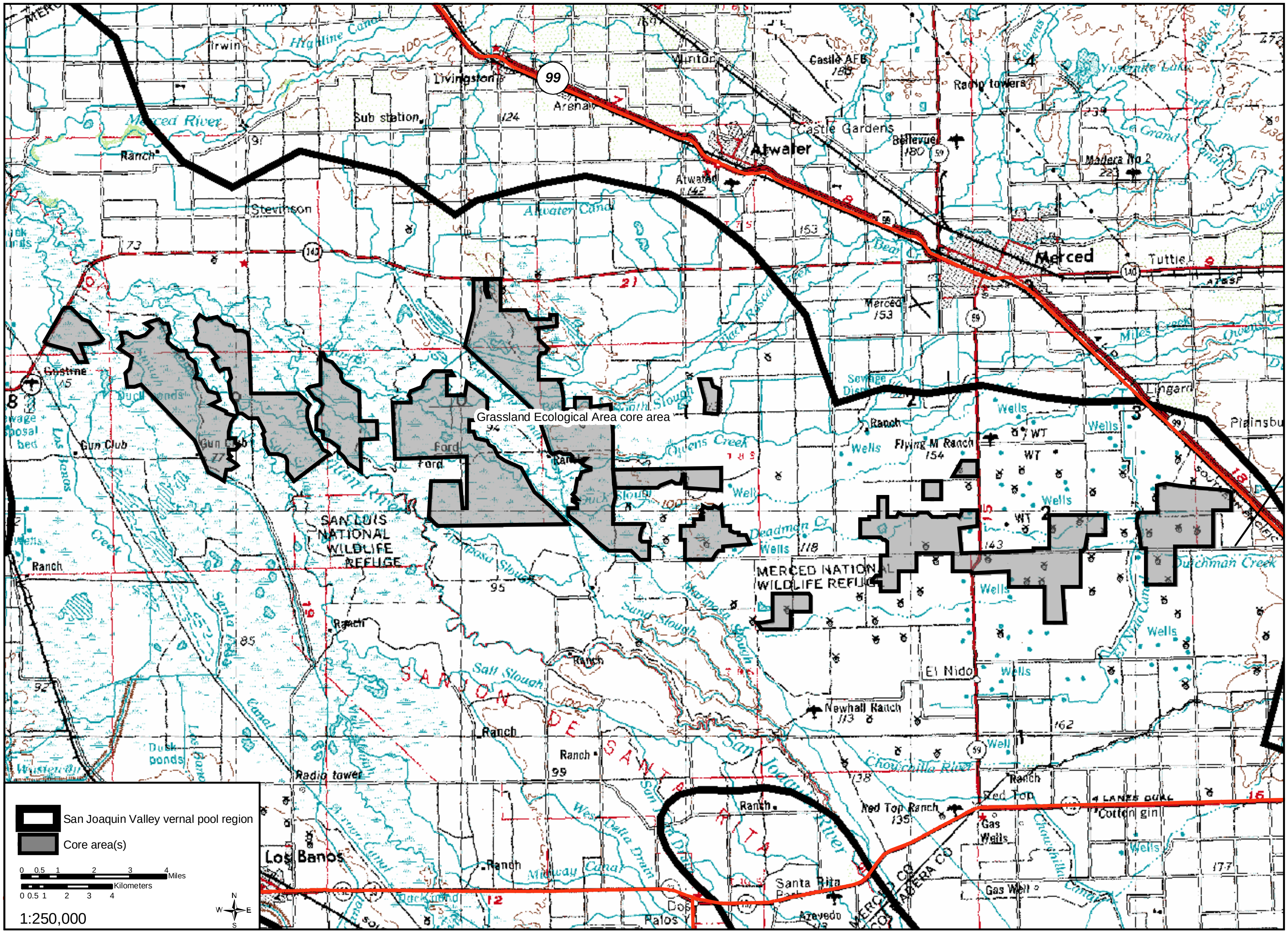

Figure III-11b. Grassland Ecological Area core areas within the San Joaquin Valley vernal pool region.

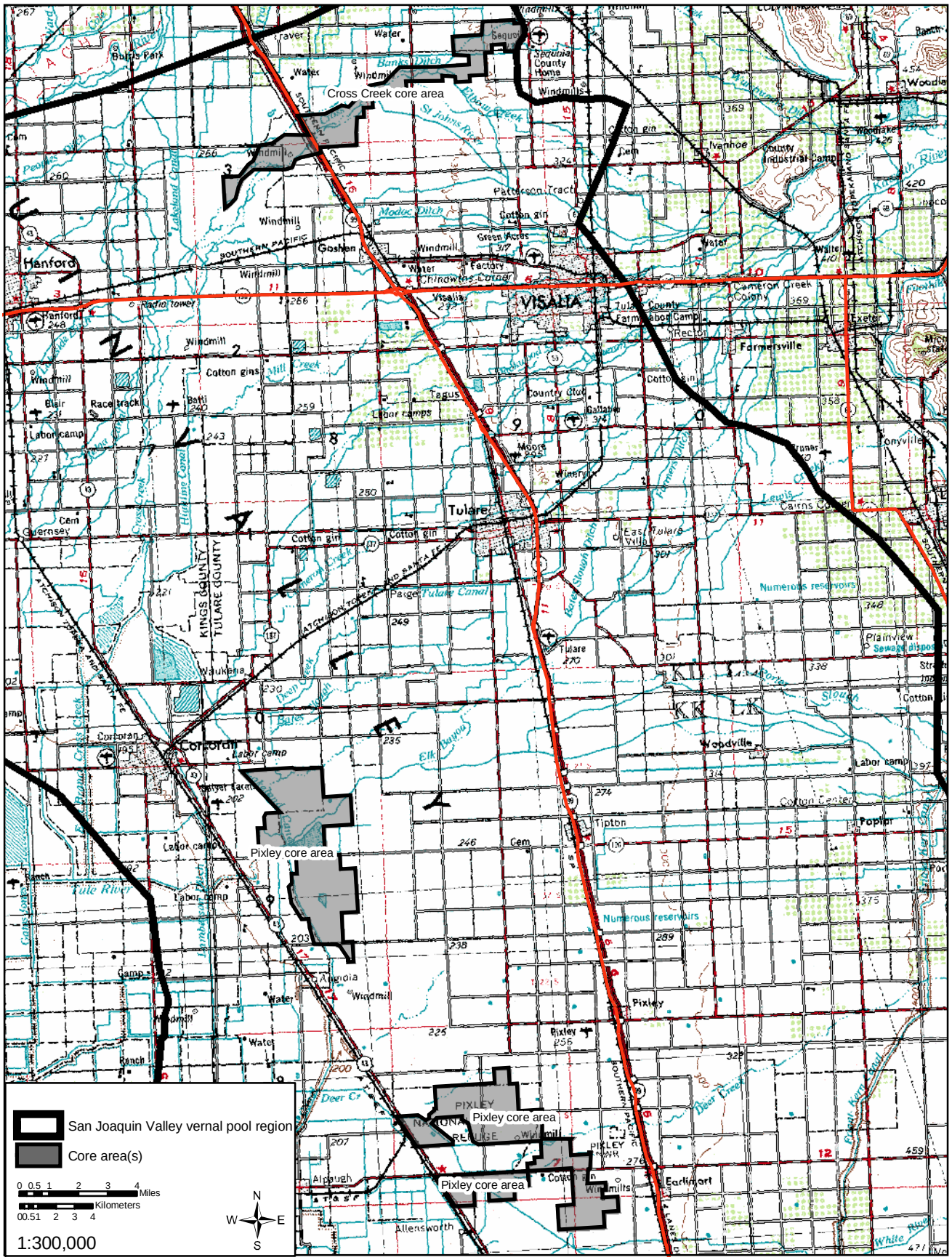

Figure III-11c. Cross Creek and Pixley core areas within the San Joaquin Valley vernal pool region.

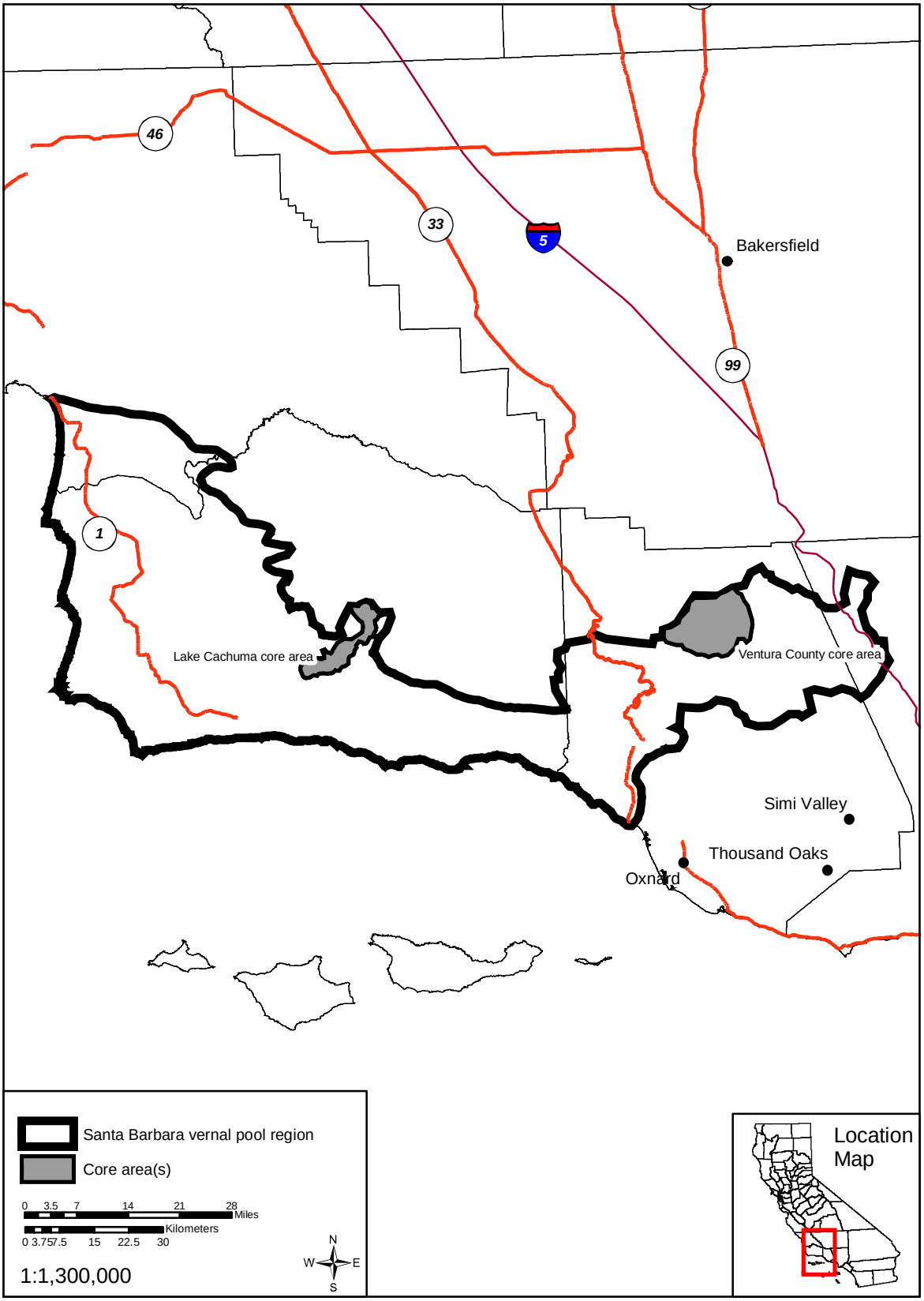

Figure III-12. Santa Barbara vernal pool region.

Figure III-12a. Lake Cachuma and Ventura County core areas within the Santa Barbara vernal pool region.

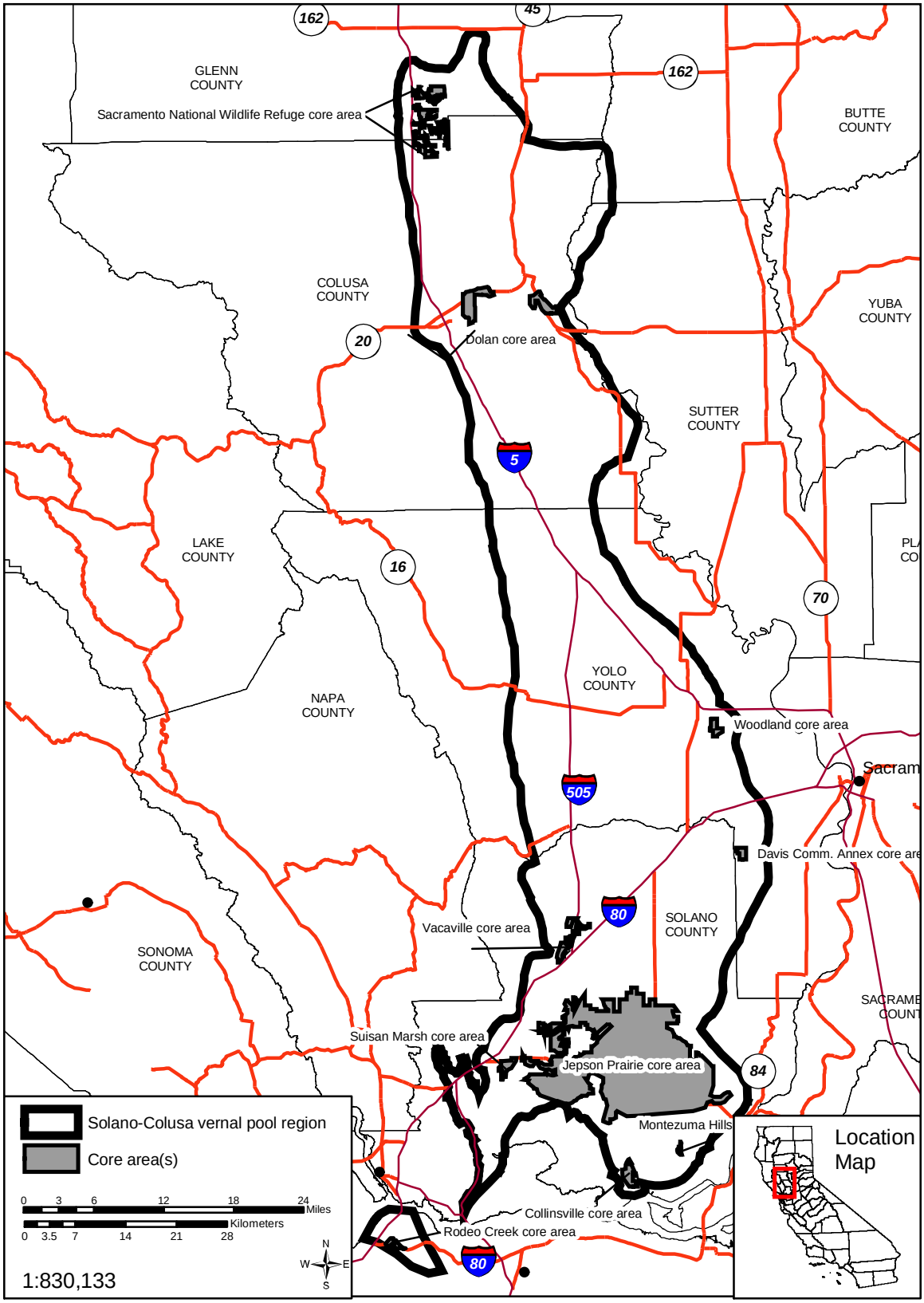

Figure III-13. Solano-Colusa vernal pool region.

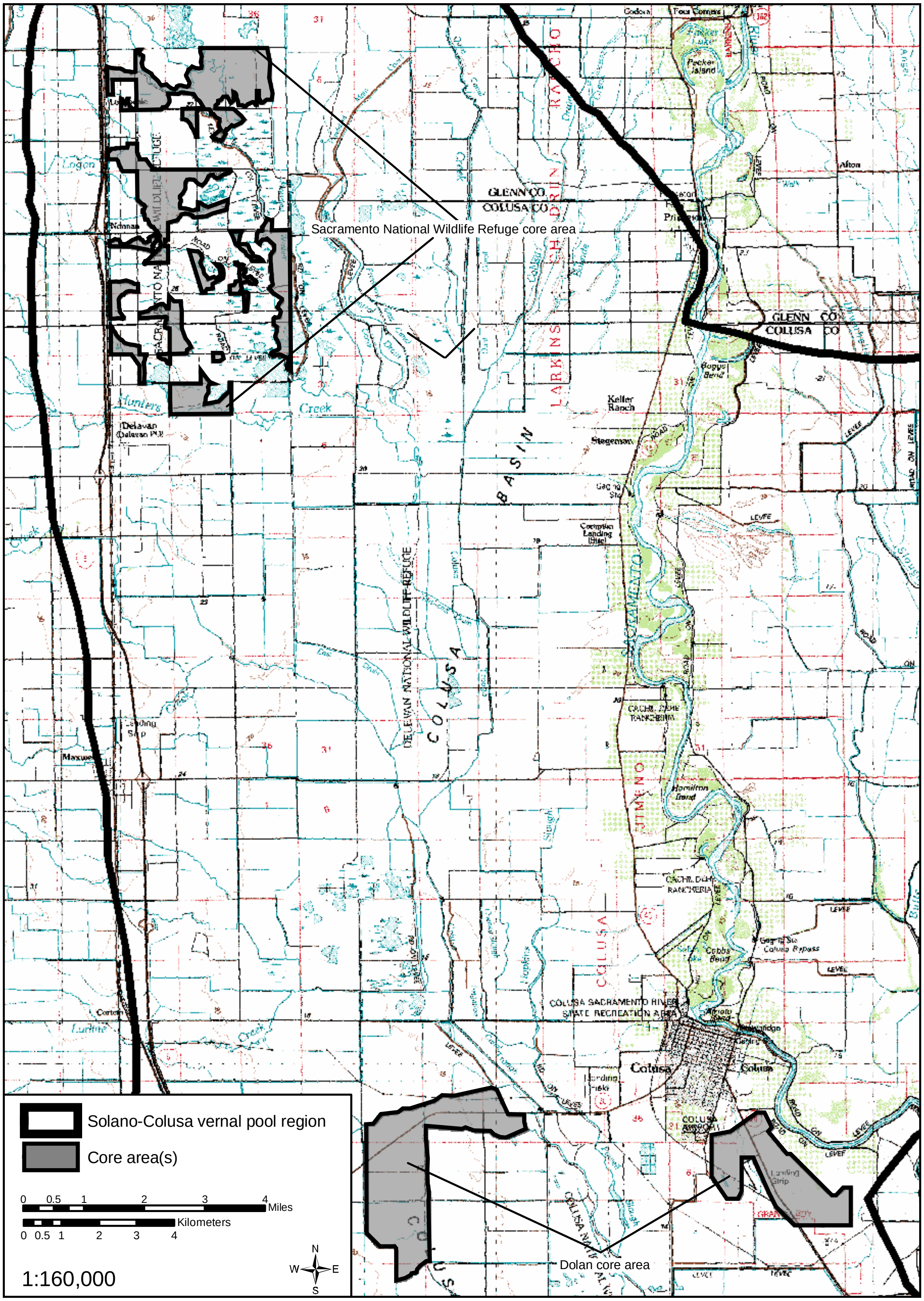

Figure III-13a. Sacramento National Wildlife Refuge and Dolan core areas within the Solano-Colusa vernal pool region.

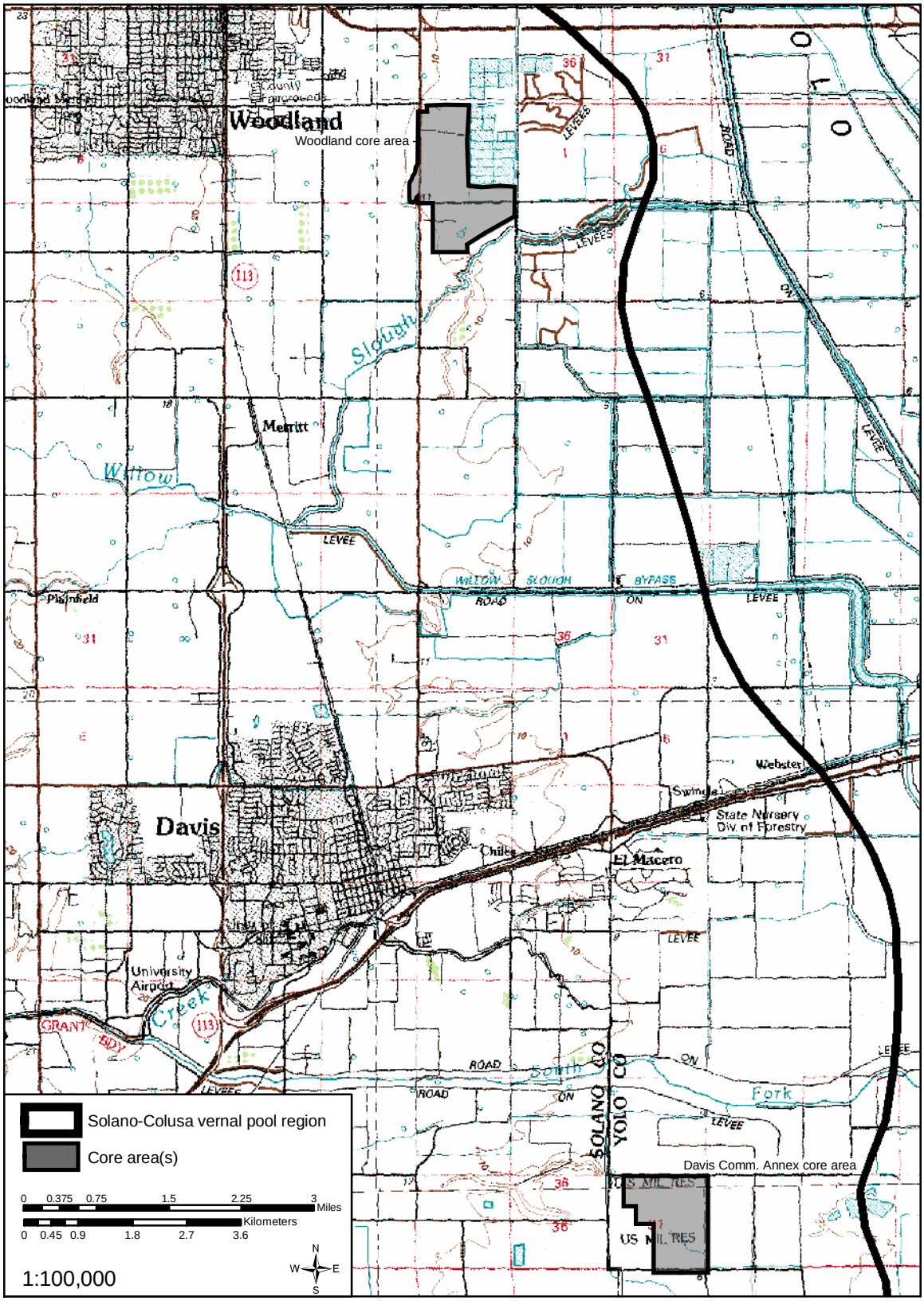

Figure III-13b. Woodland and Davis Comm. Annex core areas within the Solano-Colusa vernal pool region.

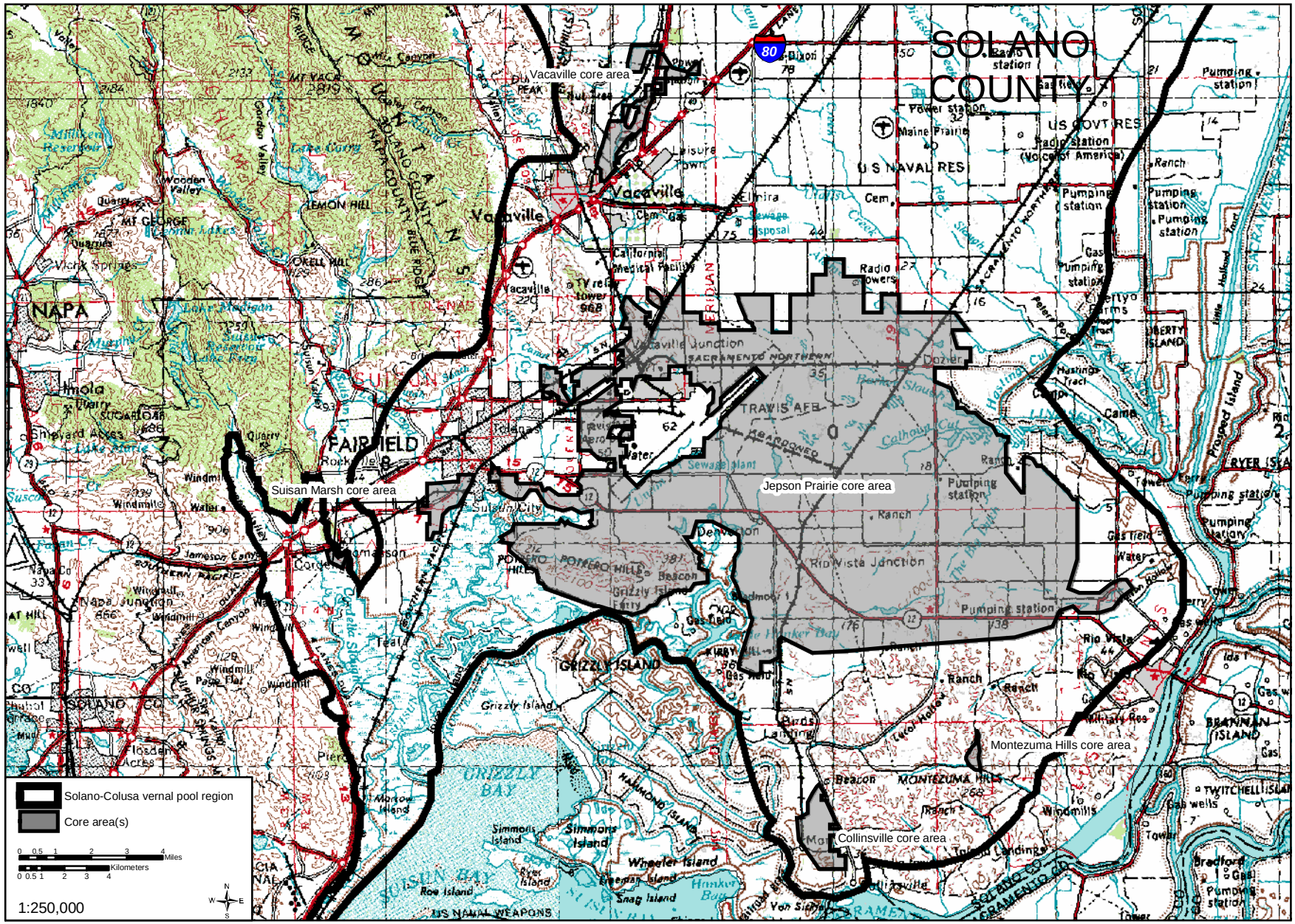

Figure III-13c. Vacaville, Jepson Prairie, Suisan Marsh, Collinsville, and Montezuma Hills core areas within the Solano-Colusa vernal pool region.

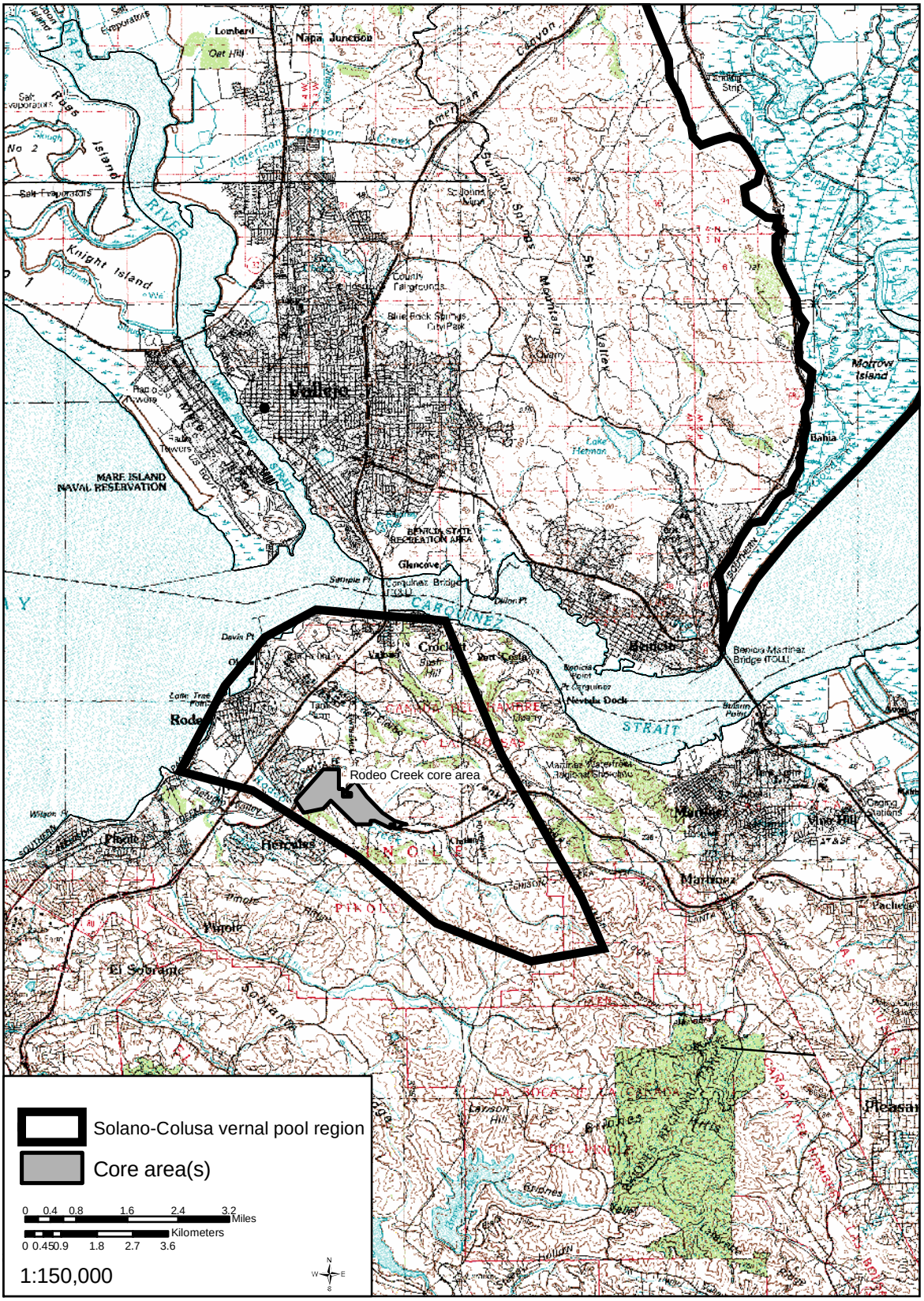

Figure III-13d. Rodeo Creek core area within the Solano-Colusa vernal pool region.

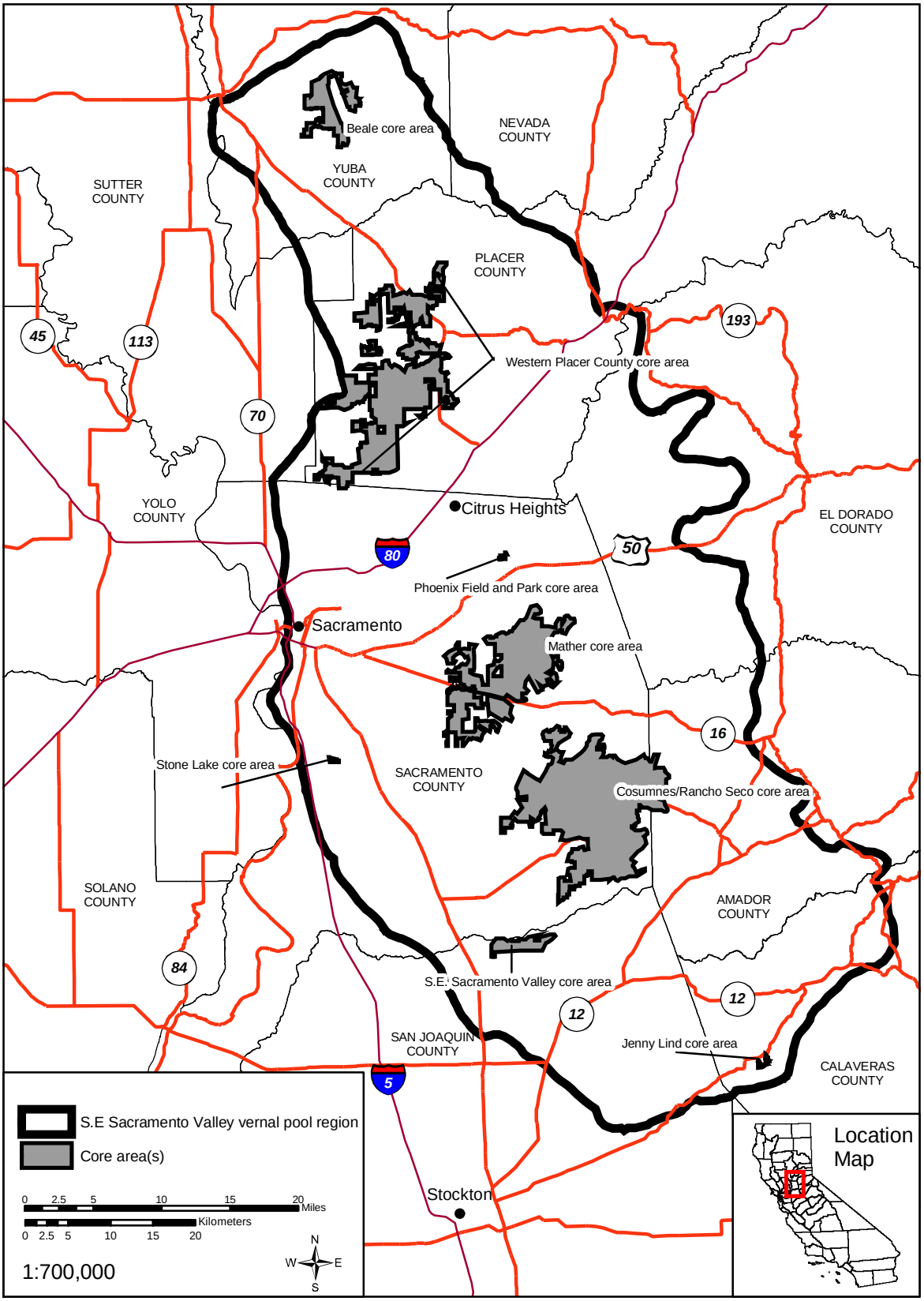

Figure III-14. Southeastern Sacramento Valley vernal pool region.

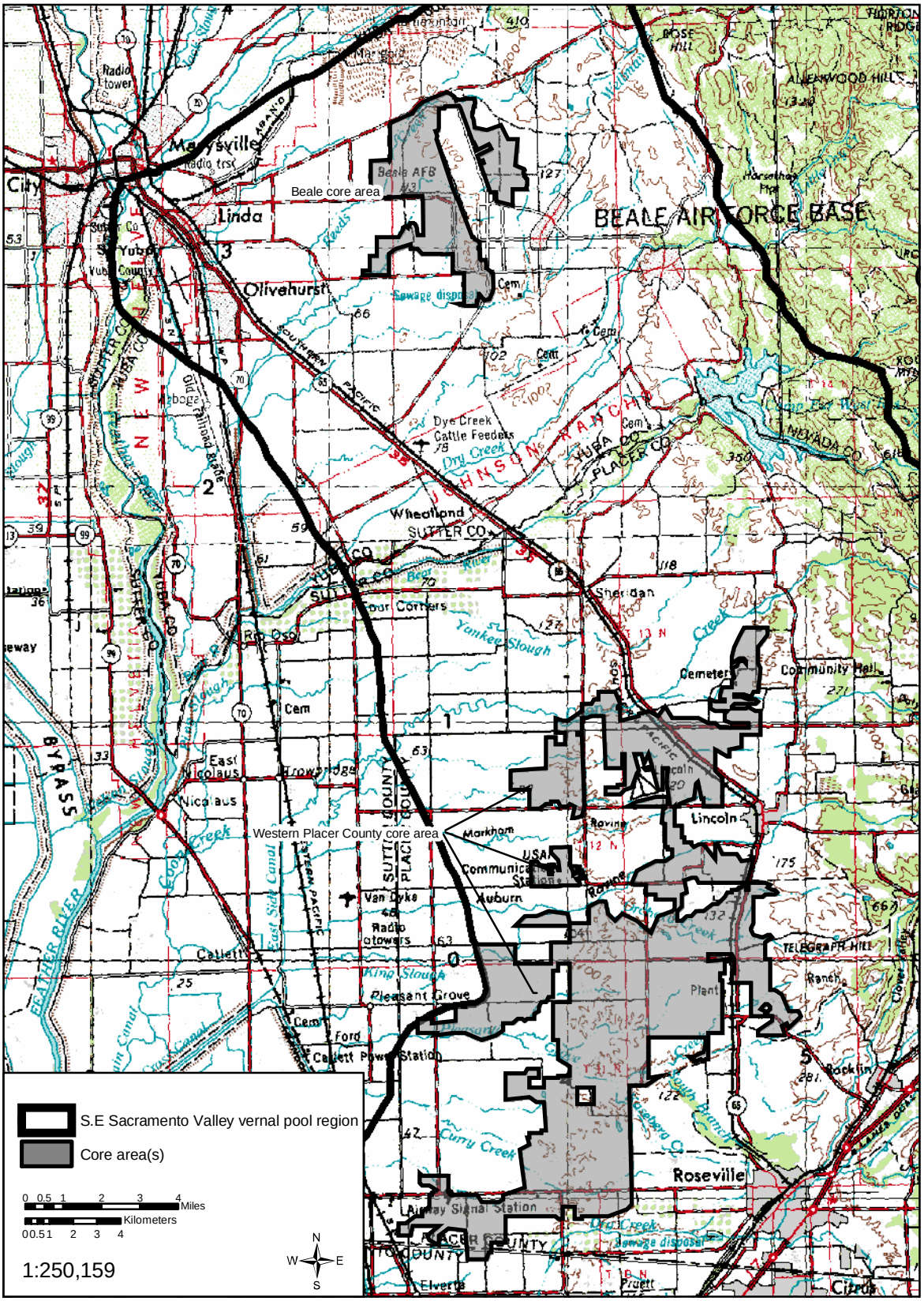

Figure III-14a. Beale and Western Placer County core areas within the Southeastern Sacramento Valley vernal pool region.

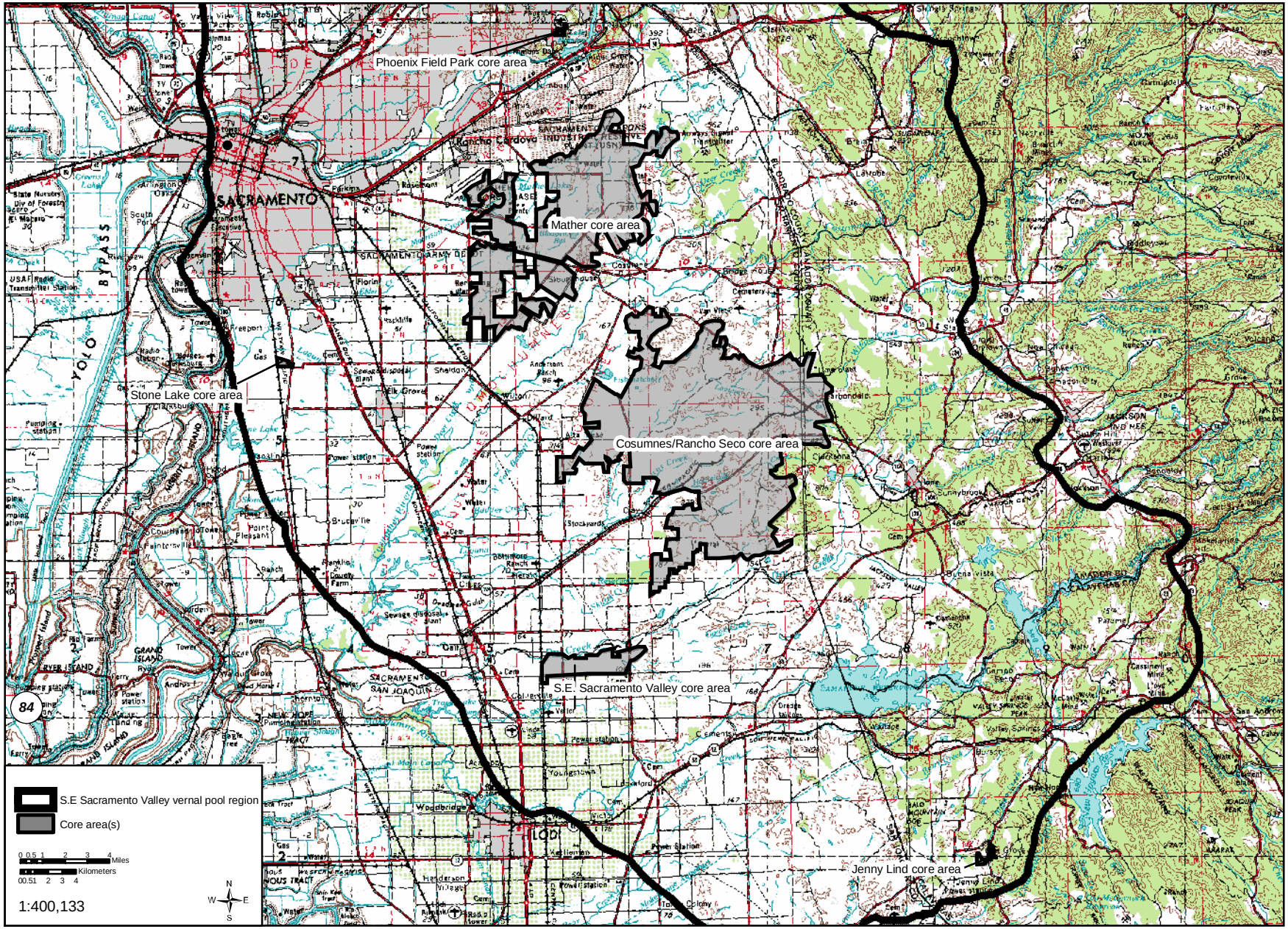

Figure III-14b. Phoenix Field Park, Mather, Stone Lake, Cosumnes/Rancho Seco, S.E. Sacramento Valley, and Jenny Lind core areas within the Southeastern Sacramento Valley vernal pool region.

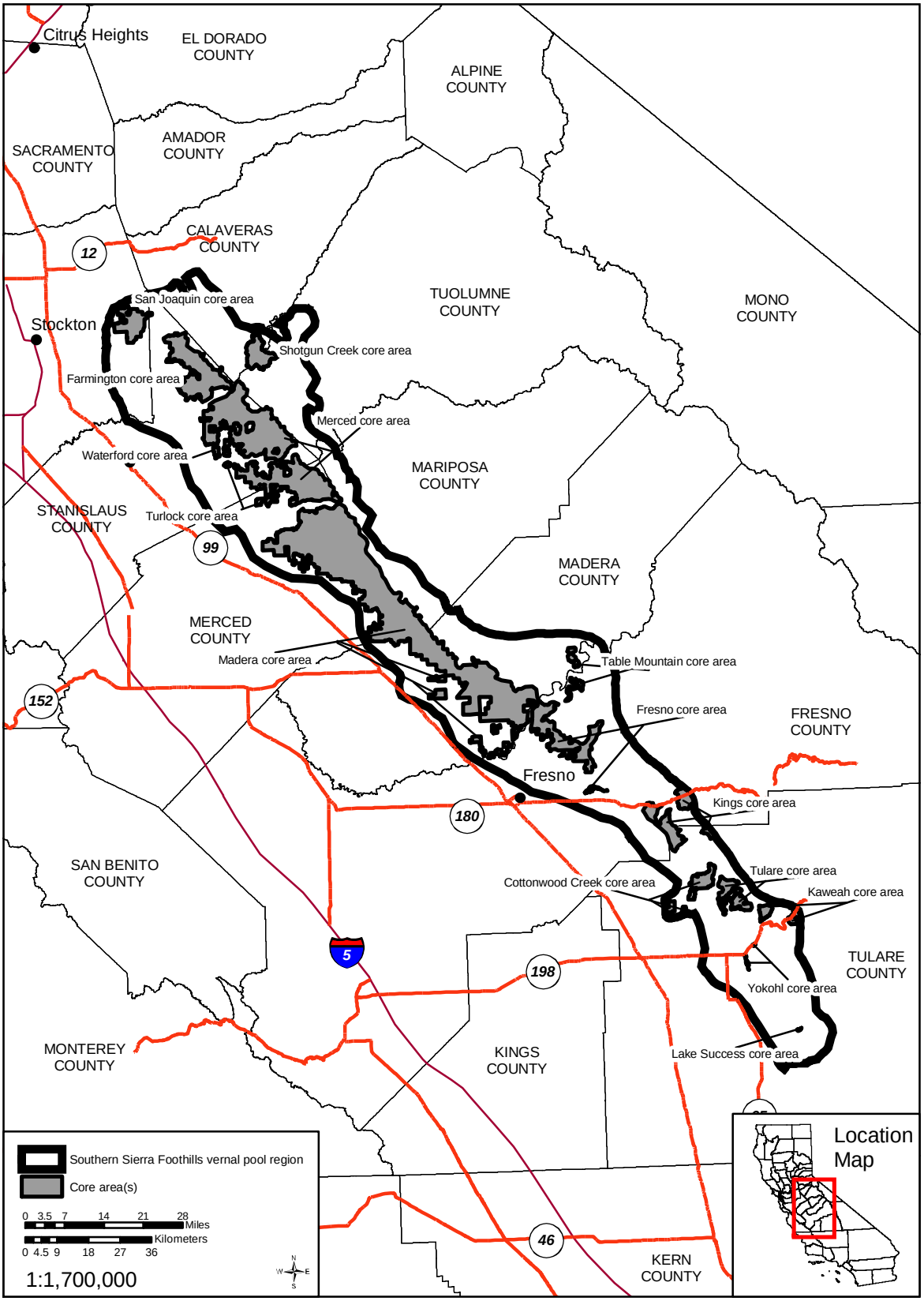

Figure III-15. Southern Sierra Foothills vernal pool region.

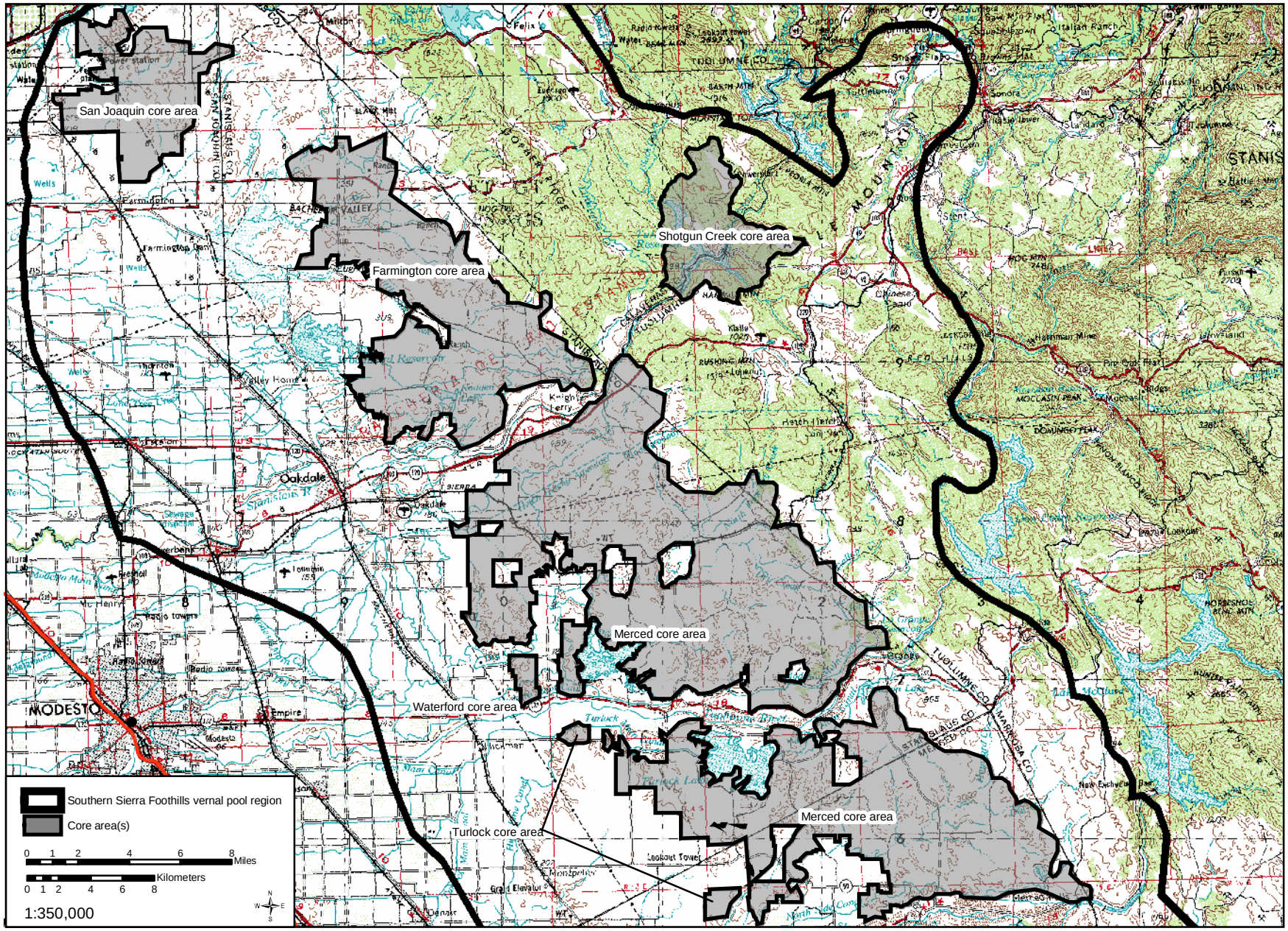

Figure III-15a. San Joaquin, Shotgun Creek, Farmington, Waterford, Turlock and Merced core areas within the Southern Sierra Foothills vernal pool region.

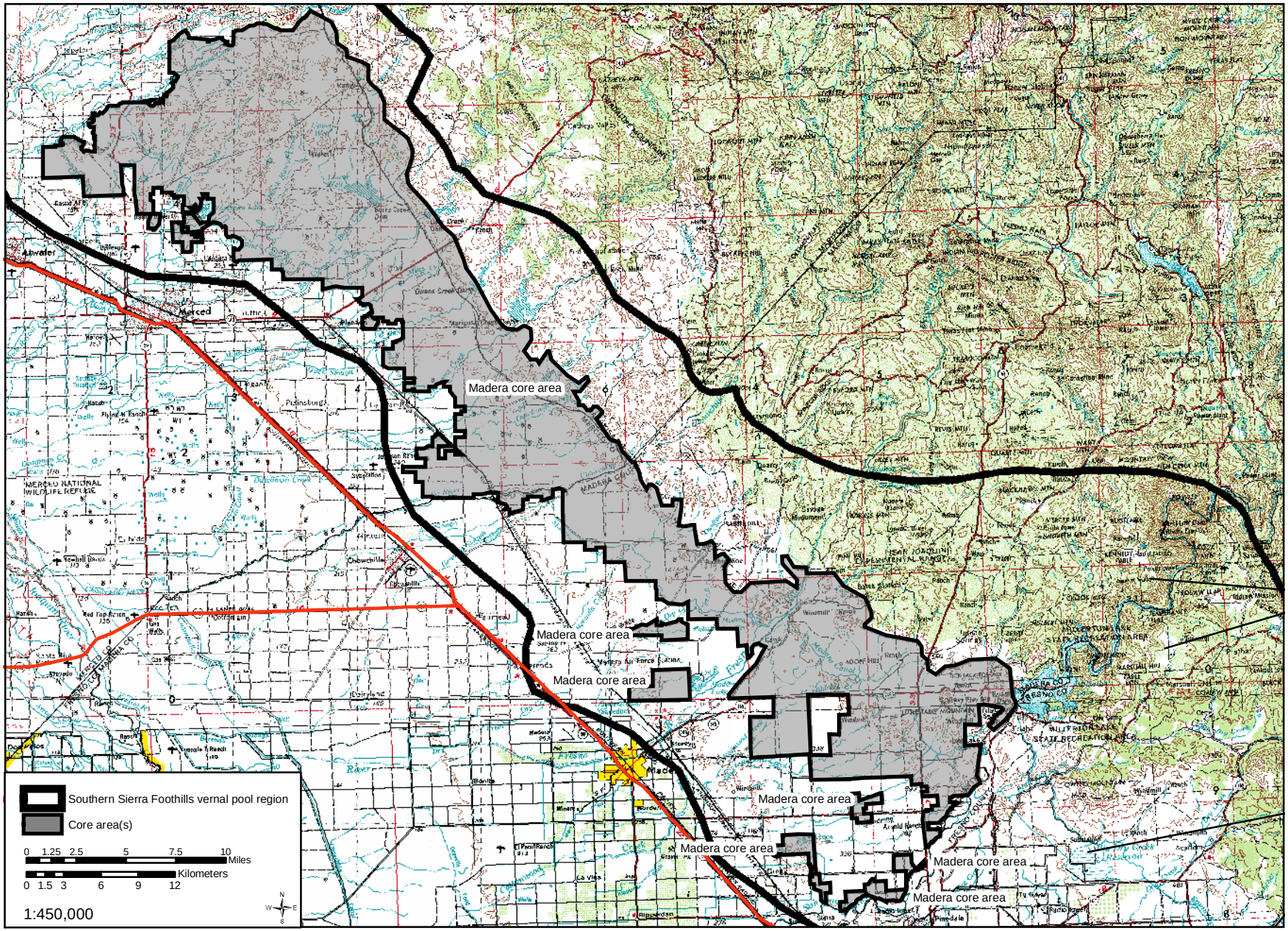

Figure III-15b. Madera core areas within the Southern Sierra Foothills vernal pool region.

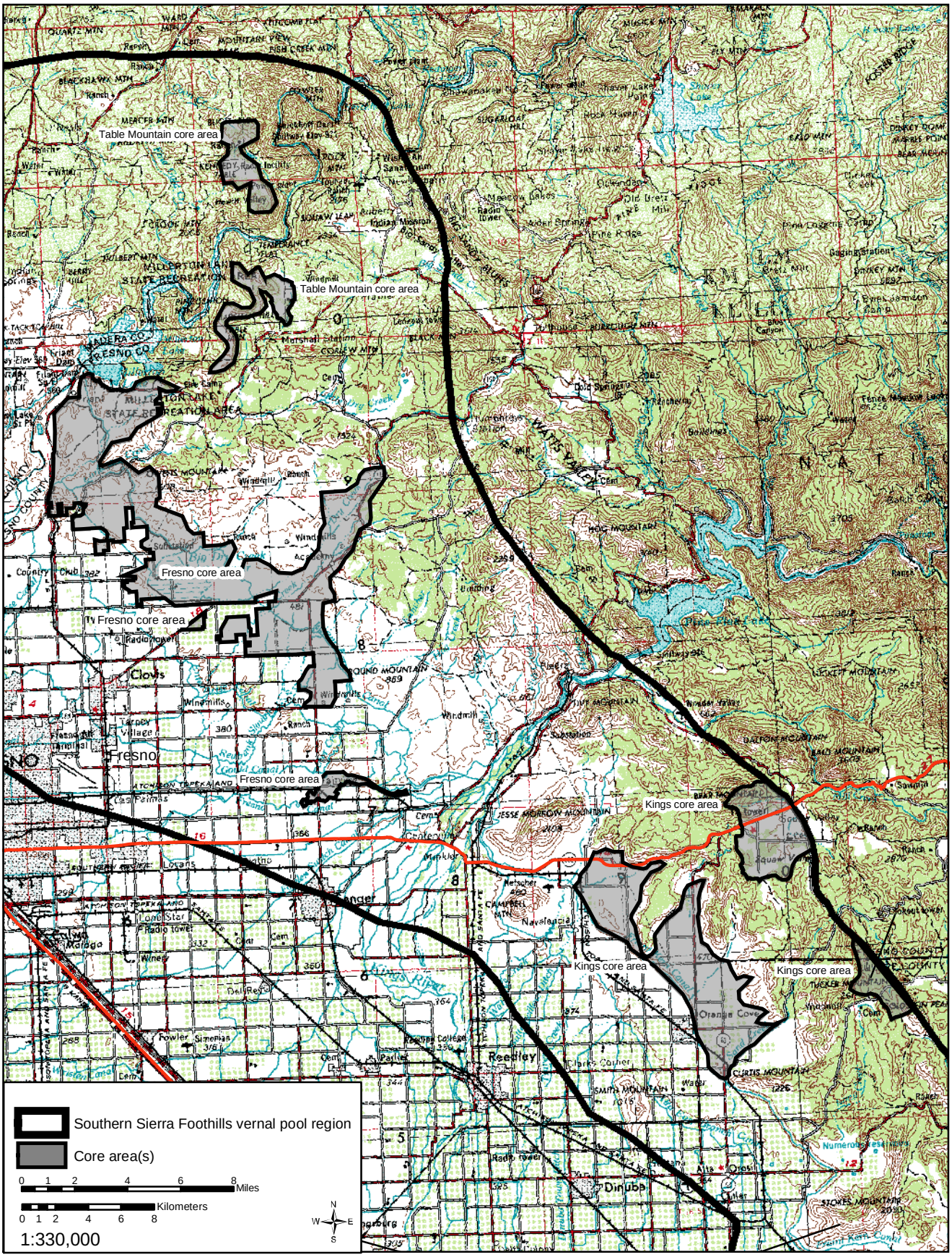

Figure III-15c. Table Mountain, Fresno, and Kings core areas within the Southern Sierra Foothills vernal pool region.

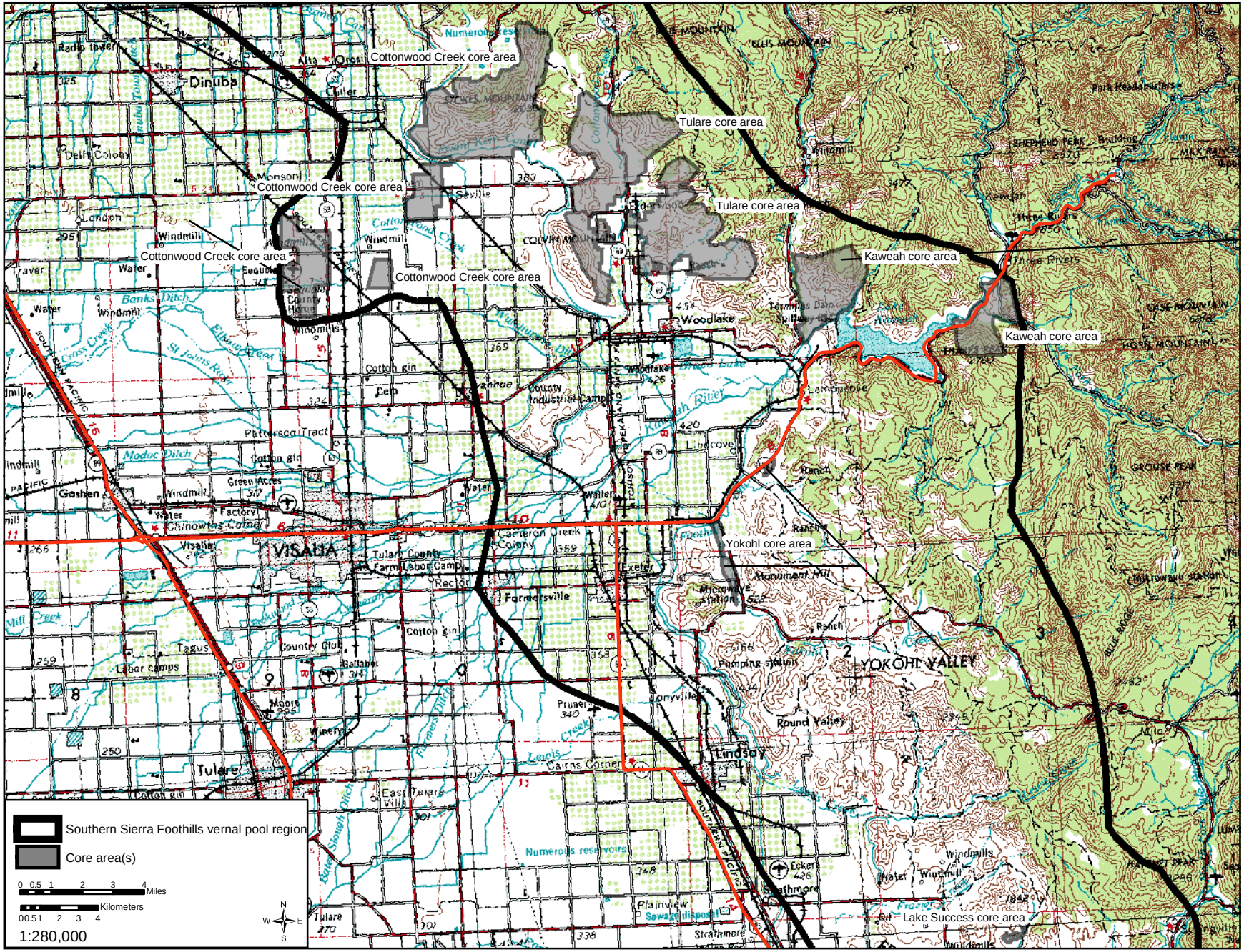

Figure III-15d. Cottonwood Creek, Tulare, Kaweah, Yokohl and Lake Success core areas within the Southern Sierra Foothills vernal pool region.

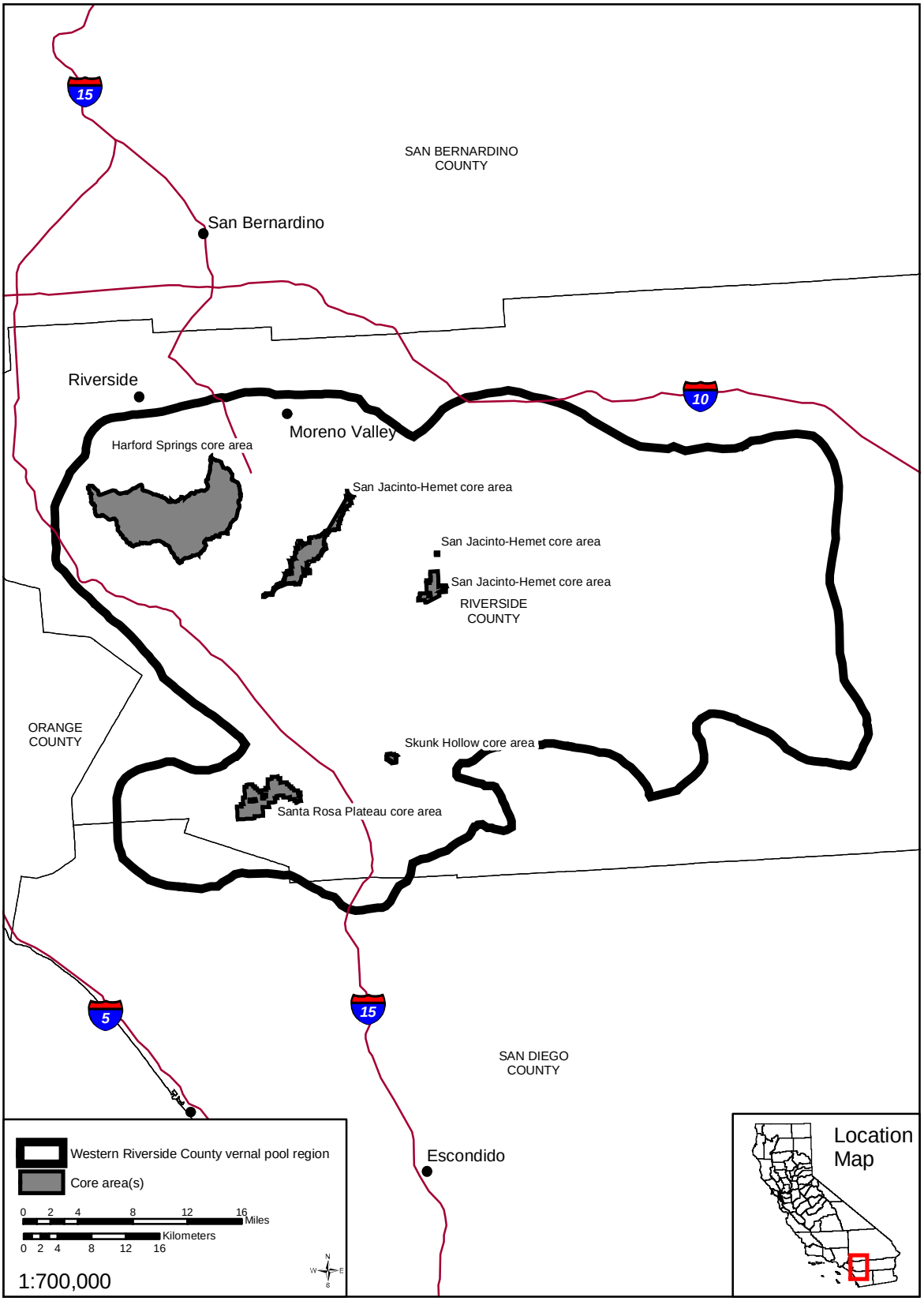

Figure III-16. Western Riverside County vernal pool region.

Figure III-16a. Harford Spring, Santa Rosa Plateau, Skunk Hollow, and San Jacinto-Hemet core areas within the Western Riverside County vernal pool region.

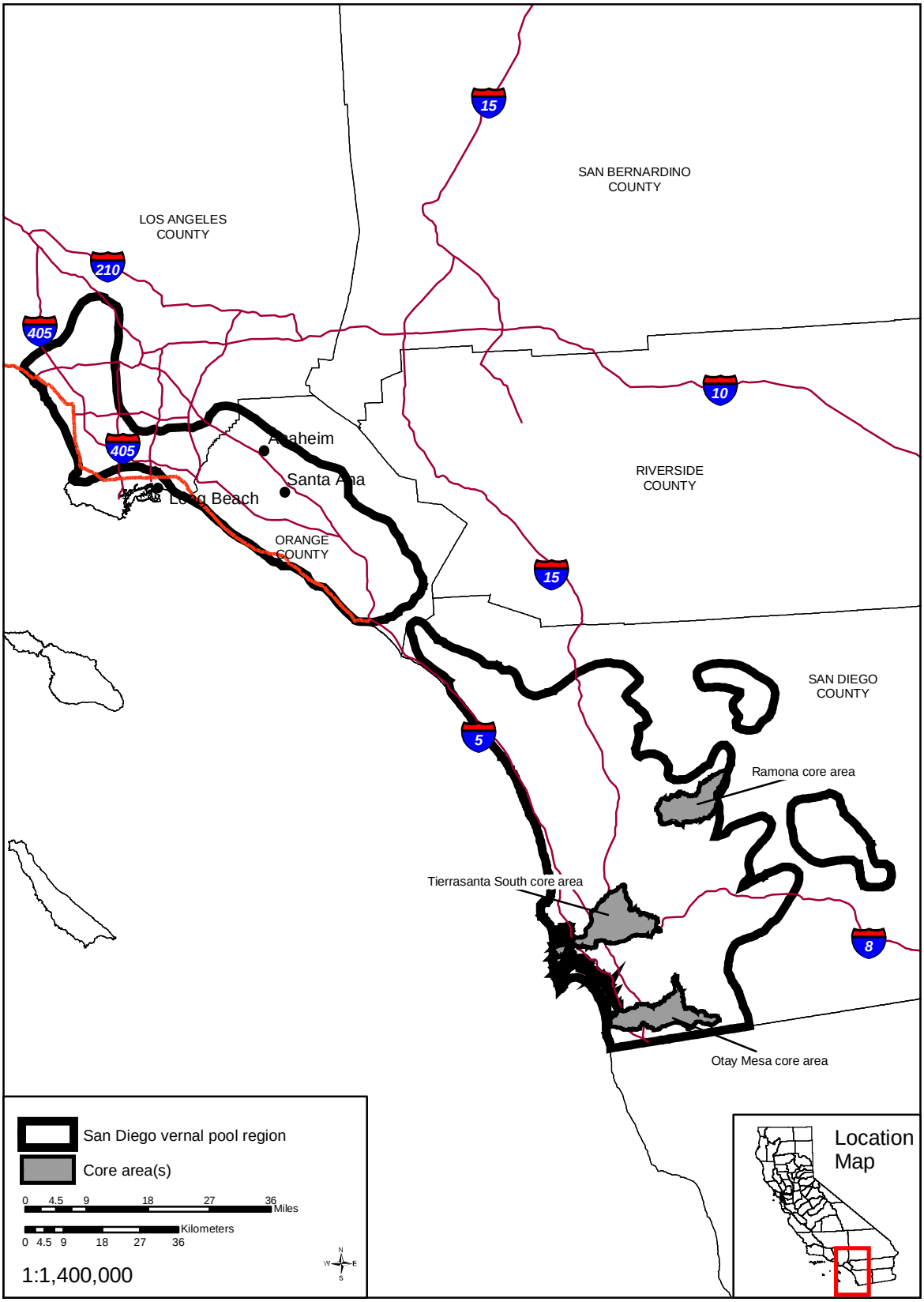

Figure III-17. San Diego vernal pool region.

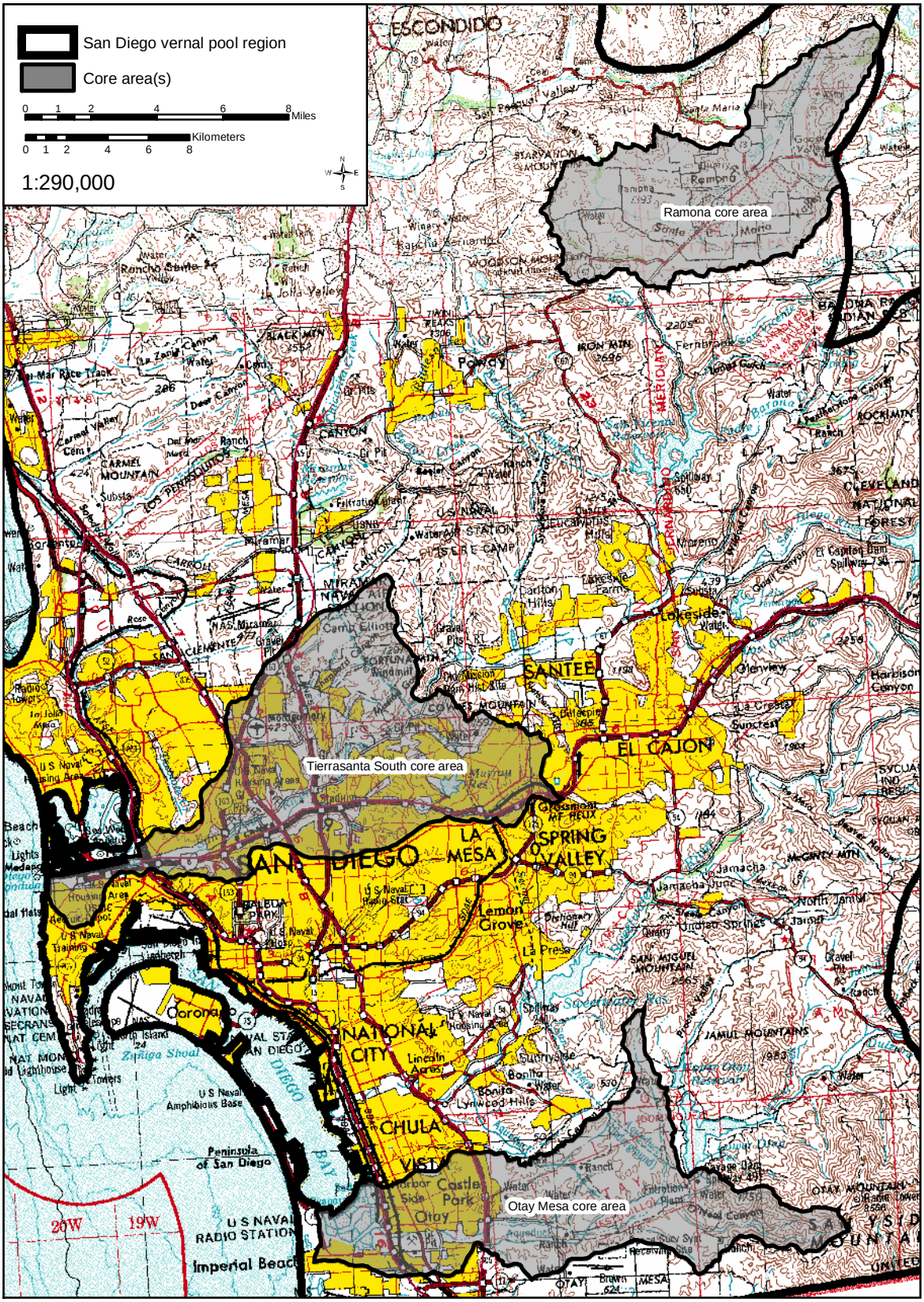

Figure III-17a. Otay Mesa, Ramona, and Tierrasanta core areas within the San Diego vernal pool region.

1. Carrizo Vernal Pool Region

The geographic location of the Carrizo Vernal Pool Region and associated core areas is depicted in **Figures III-2 and III-2a-c**. This vernal pool region is almost entirely in San Luis Obispo County but does incorporate small areas of adjacent Kern and Monterey Counties. It includes two separate polygons: the Carrizo Plain/San Andreas Fault zone and the Paso Robles area (Keeler-Wolf *et al*. 1998). The Carrizo Vernal Pool Region is in the Central California Coast Ranges Section of the California Coastal Range Shrub-Forest-Meadow Province (Goudey and Smith 1994). The boundaries of this vernal pool region differ from the region boundaries identified by Keeler-Wolf *et al.* (1998) in areas surrounding the Central Coast Ranges core area and Fort Hunter-Liggett core area by encompassing species occurrences within adjacent watersheds. Two types of vernal pools occur in the Carrizo Vernal Pool Region. Northern Claypan Vernal Pools form in shallow depressions near the ephemeral Soda Lake on the Carrizo Plain, where the topography is fairly level, and also over the San Andreas fault, where movement of the earth's plates creates small basins (sag ponds). Pools in the Paso Robles area have not been classified and are thus assigned to the undefined "Northern Vernal Pool" category (Keeler-Wolf *et al*. 1998). Soils in the region are still being mapped. Landowners in the vernal pool region are the U.S. Bureau of Land Management, The Nature Conservancy, the California Department of Fish and Game, and private individuals.

2. Central Coast Vernal Pool Region

The geographic location of the Central Coast Vernal Pool Region and associated core areas is depicted in **Figures III-3 and III-3a-d**. The Central Coast Vernal Pool Region includes several separate polygons distributed over portions of nine counties (Alameda, Fresno, Merced, Monterey, San Benito, San Mateo, Santa Clara, Santa Cruz, and Stanislaus). Within the polygons, vernal pools are scattered among valleys of the inner and outer coast ranges and the coastal plain near Monterey Bay; many are associated with fault lines (Keeler-Wolf *et al*. 1998). The boundaries of this vernal pool region differ from the region boundaries identified by Keeler-Wolf *et al*. (1998) in areas surrounding the San Benito core area, Fort Ord core area, and Central Coast Ranges core area and encompasses species occurrences within adjacent watersheds. The Central Coast Vernal Pool Region is in the same ecological section as the Carrizo Vernal Pool Region, *i.e.*, the Central California Coast Ranges Section of the California Coastal Range Shrub-Forest-Meadow Province (Goudey and Smith 1994). The vernal pools in the Central Coast Vernal Pool Region are unclassified "Northern Vernal Pools" (Keeler-Wolf *et al*. 1998). No particular soils are characteristic of the region. Landowners in the vernal pool region include the U.S. Fish and Wildlife

Service, U.S. Department of Defense, U.S. Bureau of Land Management, and private individuals.

3. Klamath Mountains Vernal Pool Region

The geographic location of the Klamath Mountains Vernal Pool Region and associated core areas is depicted in **Figures III-4 and III-4a**. This vernal pool region is in the Klamath Mountains Ecoregion (Thorson *et al.* 2003) of the Sierran Steppe-Mixed Forest-Coniferous Forest-Alpine Meadow Province of the Mediterranean Regime Mountains Division. The Klamath Mountains Vernal Pool Region includes hardpan vernal pools in "mounded prairie," which is similar to mima mound topography, and basalt flow vernal pools on two flat-topped "Table Rocks" near the Rogue River. Landowners in the region include The Nature Conservancy, the U.S. Bureau of Land Management, Bureau of Reclamation, Oregon Department of Fish and Wildlife, City of Medford, and private individuals (C. Tuss, pers. comm. 2004).

In addition to the vernal pool fairy shrimp, which is addressed in this recovery plan, two listed plant species are endemic to vernal pool habitats in the Klamath Mountains Vernal Pool Region: *Limnanthes floccosa* ssp. *grandiflora* (large-flowered woolly meadowfoam) and *Lomatium cookii* (Cook's lomatium). Recovery of these plant species will be separately addressed in a recovery plan for species of the upper Rogue River Valley, currently in preparation by our Roseburg Field Office. Site-specific recovery actions and strategies for vernal pool fairy shrimp populations in the Klamath Mountains Vernal Pool Region will also be addressed in the Rogue River Valley recovery plan within the context of integrated conservation and ecosystem-level management for all three species, consistent with the recovery criteria and generalized recovery strategy identified for vernal pool fairy shrimp in this Vernal Pool Ecosystem Draft Recovery Plan.

4. Lake-Napa Vernal Pool Region

The geographic location of the Lake-Napa Vernal Pool Region and associated core areas is depicted in **Figures III-5 and III-5a-c**. This vernal pool region occurs primarily in Lake and Napa Counties but incorporates a small portion of northwestern Yolo County and just barely crosses into Sonoma County (Keeler-Wolf *et al*. 1998). The boundaries of this vernal pool region differs from the vernal pool region boundaries identified by Keeler-Wolf *et.al*. (1998) in the area surrounding the Diamond Mountain Core Area and encompasses species occurrences above 610 meters (2,000 feet) elevation. Additionally, the boundaries differ in the southern end of the region to capture several occurrences of rare plants. Ecological units in the Lake-Napa Vernal Pool Region are the

Northern California Coast Ranges Section of the Sierran Forest-Alpine Meadows Province and the Northern California Coast Section of the California Coastal Steppe-Mixed Forest-Redwood Forest Province (Goudey and Smith 1994). Vernal pools in the region are of three types: Northern Volcanic Ashflow, Northern Basalt Flow, and unclassified "Northern Vernal Pools." Northern Volcanic Ashflow Vernal Pools often are large lakes that may remain wet in the center year-round; however, their margins function as vernal pools. The other pool types are smaller and may occur in complexes. Soil types vary throughout the region. Northern Volcanic Ashflow Vernal Pools are often on Oxalis variant soils, whereas Northern Basalt Flow Vernal Pools occur on Konocti variant soils and the Northern Vernal Pools in the region are soils of the Aiken, Bressa-Dibble complex, Contra Costa, or other series (Keeler-Wolf *et al*. 1998). Landowners in the Lake-Napa Vernal Pool Region include the California Department of Fish and Game, the Trust for Wildland Communities, and private individuals.

5. Livermore Vernal Pool Region

The geographic location of the Livermore Vernal Pool Region and associated core areas is depicted in **Figures III-6 and III-6a**. The Livermore Vernal Pool Region straddles Alameda, Contra Costa, and Santa Clara Counties, extending into southwestern San Joaquin County (Keeler-Wolf *et al*. 1998). The entire region is in the Central California Coast Ranges Section of the California Coastal Range Shrub-Forest-Meadow Province (Goudey and Smith 1994). Landforms vary from floodplains to basin rims and terraces in fairly level topography. Northern Claypan Vernal Pools are characteristic of the region, although swales and some Northern Hardpan Vernal Pools are present. Another type of ephemeral pools in the region (*tinajas*) are not technically vernal pools because they form in rock outcrops and do not support characteristic plants, but these pools may have longhorn fairy shrimp. Soils underlying Northern Claypan Vernal Pools in the region are typically Solano fine sandy loam. The vernal pool biota in the Livermore Vernal Pool Region is similar to that of the San Joaquin Valley Vernal Pool Region, but the two regions do not merge (Keeler-Wolf *et al*. 1998).

6. Mendocino Vernal Pool Region

The geographic location of the Mendocino Vernal Pool Region and associated core area is depicted in **Figure III-7**. This vernal pool region occupies several disjunct polygons in valleys of the North Coast Ranges and on the coastal terrace near Manchester. This region is not far from, and is somewhat similar to, the Lake-Napa Vernal Pool Region (Keeler-Wolf *et al*. 1998). Like the Lake-Napa region, it spans two ecological units, the Northern California Coast Ranges Section of the Sierran Forest-Alpine Meadows Province and the Northern

California Coast Section of the California Coastal Steppe-Mixed Forest-Redwood Forest Province (Goudey and Smith 1994). Unlike the Lake-Napa region, the vernal pools in the Mendocino Vernal Pool Region are all of the unclassified "Northern Vernal Pool" type. They occur singly in depressions or blocked drainages. No particular soils are characteristic of the region (Keeler-Wolf *et al.* 1998).

7. Modoc Plateau Vernal Pool Region

The geographic location of the Modoc Plateau Vernal Pool Region and associated core areas is depicted in **Figures III-8 and III-8a-d**. Most of the region is in Modoc and Lassen Counties, but it does include small areas of northeastern Shasta County, southeastern Siskiyou County, and northern Plumas County. The boundaries of this vernal pool region differ from the region boundaries identified by Keeler-Wolf *et al.* (1998) in areas surrounding the Modoc Plateau core area to encompass watersheds that may support additional populations of species covered by this draft recovery plan. The Lake County, Oregon population of *Gratiola heterosepala* occupies similar ecological conditions (Kaye *et al*. 1990), but is disjunct from the Modoc Plateau Vernal Pool Region. This species is well represented in other core areas throughout its range, and has not been included in this vernal pool region. Further ground truthing should be conducted to determine if additional populations should be included in this vernal pool region. The Modoc Plateau Vernal Pool Region spans the Modoc Plateau and Southern Cascades Sections of the Sierran Forest-Alpine Meadows Province (Goudey and Smith 1994). The vernal pools in the region are of the Northern Basalt Flow and Northern Volcanic Mudflow types because the substrate was formed by volcanic activity. These pools range from tiny wetlands to vernal lakes; smaller pools may occur in complexes, whereas lakes are isolated. Typical soils in the region are of the Deven and Supan series (Keeler-Wolf et al. 1998). Landowners in the Modoc Plateau Vernal Pool Region include the U.S. National Park Service, U.S. Forest Service, U.S. Bureau of Land Management, California State Parks, and private individuals.

8. Northeastern Sacramento Valley Vernal Pool Region

The geographic location of the Northeastern Sacramento Valley Vernal Pool Region and associated core areas is depicted in **Figures III-9 and III-9a-e**. The vernal pool region extends from the Millville Plains to Sutter Buttes, including parts of Butte, Shasta, Sutter, Tehama, and Yuba Counties. It is adjacent to the Northwestern Sacramento Valley Vernal Pool Region, but the two regions differ in soil type. The boundaries of this vernal pool region differ from the region boundaries identified by Keeler-Wolf *et al.* (1998) in areas surrounding the Vina

Plains core area and Sacramento Refuge Llano Seco core areas in order to encompass species occurrences. Anita, Inks, Toomes, and Tuscan series soils are most prevalent in the Northeastern Sacramento Valley Vernal Pool Region. Another differentiating feature is that *Limnanthes floccosa* ssp. *californica* is restricted to the Northeastern Sacramento Valley Vernal Pool Region (Keeler-Wolf *et al*. 1998). The Northeastern Sacramento Valley Vernal Pool Region incorporates parts of both the Mediterranean Division and the Mediterranean Regime Mountains Division. The former is represented in the vernal pool region by the Great Valley Section of the California Dry Steppe Province, whereas the latter is represented by the Northern California Interior Coast Ranges Section of the Sierran Forest-Alpine Meadows Province (Goudey and Smith 1994). Three types of vernal pools occur in the Northeastern Sacramento Valley Vernal Pool Region. Northern Volcanic Mudflow pools are widespread throughout the region but occur as small, isolated, scattered pools. Northern Hardpan Vernal Pools are found on terraces of the Vina Plains and in the Chico area, where they occur in complexes of numerous pools of varying sizes. A few Northern Basalt Flow Vernal Pools are found in the region on Table Mt. near Oroville; they are typically small and in close proximity to each other (Keeler-Wolf *et al*. 1998). Land owners for these core areas include The Nature Conservancy, the California Department of Fish and Game, the U.S. Bureau of Land Management, the U.S. Fish and Wildlife Service, the City of Chico, and private individuals.

9. Northwestern Sacramento Valley Vernal Pool Region

The geographic location of the Northwestern Sacramento Valley Vernal Pool Region and associated core areas is depicted in **Figures III-10 and III-10a-c**. The Northwestern Sacramento Valley Vernal Pool Region extends from the Redding area of Shasta County south to the Williams area of Colusa County, also including parts of Glenn and Tehama Counties. It abuts the Northeastern Sacramento Valley Vernal Pool Region in Shasta and Tehama Counties and likewise includes portions of both the Great Valley Section of the California Dry Steppe Province and the Northern California Interior Coast Ranges Section of the Sierran Forest-Alpine Meadows Province (Goudey and Smith 1994). Unlike the Northeastern Sacramento Valley Vernal Pool Region, the Northwestern Sacramento Valley Vernal Pool Region is characterized by soils of the Corning and Redding series. Most of the vernal pools in this vernal pool region are small, Northern Hardpan Vernal Pools, which occur in complexes in mima-mound topography, but those on the Stillwater Plains are larger. A few Northern Volcanic Mudflow Vernal Pools are found near Black Butte Reservoir (Keeler-Wolf *et al.* 1998). Most of the lands in Northwestern Sacramento Valley Vernal Pool Region are privately owned, but some lands are publicly owned by the

California Department of Fish and Game, the City of Redding, and the U.S. Bureau of Land Management.

10. San Joaquin Valley Vernal Pool Region

The geographic location of the San Joaquin Valley Vernal Pool Region and associated core areas is depicted in **Figures III-11 and III-11a-c**. The San Joaquin Valley Vernal Pool Region occupies the trough that runs southward from San Joaquin County to Kern County, including parts of Fresno, Kings, Madera, Merced, Stanislaus, and Tulare Counties. Soils in the region are alkaline and are typically of the Lewis, Rossi, Waukena, Fresno, and Traver series. The Aeolian Hilmar and Delhi series still exists at Arena Plains Unit of Merced National Wildllife Refuge (NWR). The latter are among the rarest vernal pool soil types in the Great Valley (Silveira, pers. comm. 2004). Vernal pools in the San Joaquin Valley Vernal Pool Region are primarily the Northern Claypan type; they can exist as shallow, playa-like pools or more typical vernal pools in mima mound topography (Keeler-Wolf *et al*. 1998). The San Joaquin Valley Vernal Pool Region is entirely within the Great Valley Section of the California Dry Steppe Province (Goudey and Smith 1994). Landowners in the core areas include the California Department of Fish and Game, the Center for Natural Lands Management, the U.S. Fish and Wildlife Service, and private individuals.

The California Department of Transportation has proposed the creation of a new north-south freeway east of Highway 99, from east Sacramento County to Tulare County. Although several years away in planning, if successful, this new freeway could have significant direct and indirect (growth-inducing) effects to vernal pool species in this vernal pool region.

11. Santa Barbara Vernal Pool Region

The geographic location of the Santa Barbara Vernal Pool Region and associated core areas is depicted in **Figures III-12 and III-12a**. This vernal pool region includes the coastal plains of San Luis Obispo, Santa Barbara, and Ventura Counties, as well as isolated polygons in Los Angeles and Ventura Counties. Ecological units included in this vernal pool region are the Central and Southern California Coast Sections of the California Coastal Chaparral Forest and Shrub Province as well as the Southern California Mountains and Valleys Section of the California Coastal Range Shrub-Forest-Meadow Province (Goudey and Smith 1994). The boundaries of this vernal pool region differ from the region boundaries identified by Keeler-Wolf *et al.* (1998) in areas surrounding the Lake Cachuma core area and Ventura County core area in order to encompass species occurrences and vernal pool habitats in adjacent local watersheds. Vernal pools in

the region are of the unclassified "Southern Vernal Pool" type, and may occur in complexes or singly. Many soil series are known from the region, including Arnold, Betteravia, Botella, Chamise, Narlon, Salinas, Santa Ynez, Shedd, and Tangair (Keeler-Wolf *et al.* 1998). Landowners in the Santa Barbara Vernal Pool Region include the U.S. Forest Service, U.S. Bureau of Land Management, and private individuals.

12. Solano-Colusa Vernal Pool Region

The geographic location of the Solano-Colusa Vernal Pool Region and associated core areas is depicted in **Figures III-13 and III-13a-d**. In addition to Solano and Colusa Counties, this vernal pool region includes a substantial area of Yolo County and small parts of Glenn, Butte, Sutter, and Contra Costa Counties. The boundaries of this vernal pool region differ from the region boundaries identified by Keeler-Wolf *et al.* (1998) in areas surrounding the Jepson Prairie and Rodeo Creek core areas to encompass species occurrences and vernal pool habitats in adjacent local watersheds. The Solano-Colusa Vernal Pool Region is analogous to the San Joaquin Valley Vernal Pool Region in that it occupies alkaline basins in the Sacramento Valley (Keeler-Wolf *et al*. 1998); likewise, it is in the Great Valley Section of the California Dry Steppe Province (Goudey and Smith 1994). Northern Claypan Vernal Pools are typical of the Solano-Colusa Vernal Pool Region. They may occur as small pools in mima-mound topography or as somewhat larger playas. Some Northern Hardpan Vernal Pools are present in the region; these pools are small and occur in complexes among mima mounds. Featured vernal pool species also occur in the saline-alkaline transition zone between vernal pools and tidal marshes in this region. The Pescadero, Riz, Sycamore, and Willows soil series are prevalent in the vernal pool region (Keeler-Wolf *et al*. 1998). Landowners in the Solano-Colusa Vernal Pool Region include the California Department of Fish and Game, the U.S. Department of Defense, the U.S. Fish and Wildlife Service, and private individuals.

13. Southeastern Sacramento Valley Vernal Pool Region

The geographic location of the Southeastern Sacramento Valley Vernal Pool Region and associated core areas is depicted in **Figures III-14 and III-14a-b**. This vernal pool region extends from southern Yolo County south to San Joaquin and Calaveras Counties, incorporating most of Sacramento County and smaller areas of Amador, El Dorado, Nevada, Placer, and Sutter Counties. It occurs on terraces in both the Great Valley Section of the California Dry Steppe Province and the Sierra Nevada Foothills Section of the Sierran Forest-Alpine Meadows Province (Goudey and Smith 1994). Northern Hardpan Vernal Pools are most common in the Southeastern Sacramento Valley Vernal Pool Region, where they

occur in complexes of many small pools and swales among mima mounds on soils of the Pentz-Pardee-Red Bluff, Redding-Corning, and San Joaquin series. A few Northern Volcanic Mudflow Vernal Pools occur in Placer County on Exchequer soils. In terms of landforms and soils, the Southeastern Sacramento Valley Vernal Pool Region is similar to the Southern Sierra Foothills Vernal Pool Region, but *Orcuttia viscida* is restricted to the former (Keeler-Wolf *et al*. 1998). Among the landowners in the vernal pool region are the California Department of Fish and Game, the County of Sacramento, The Nature Conservancy, the U.S. Department of Defense, the U.S. Bureau of Land Management, private individuals, and mitigation banking organizations.

The California Department of Transportation has proposed the creation of a new north-south freeway east of Highway 99, from east Sacramento County to Tulare County. Although several years away in planning, if successful, this new freeway could have significant direct and indirect (growth-inducing) effects to vernal pool species in this vernal pool region.

14. Southern Sierra Foothills Vernal Pool Region

The geographic location of the Southern Sierra Foothills Vernal Pool Region and associated core areas is depicted in **Figures III-15 and III-15a-d**. The Southern Sierra Foothills Vernal Pool Region occupies high and low terrace landforms ranging from the junction of San Joaquin, Stanislaus, and Calaveras Counties south to Tulare County. Portions of Fresno, Madera, Mariposa, Merced, and Tuolumne Counties also are included in the region. The Southern Sierra Foothills Vernal Pool Region is contiguous with the Southeastern Sacramento Valley Vernal Pool Region and occurs in the same two ecological units, the Great Valley Section of the California Dry Steppe Province and the Sierra Nevada Foothills Section of the Sierran Forest-Alpine Meadows Province (Goudey and Smith 1994). However, the Southern Sierra Foothills Vernal Pool Region differs in the presence of the endemic species *Orcuttia inaequalis* (Keeler-Wolf *et al*. 1998). The Southern Sierra Foothills Vernal Pool Region includes three types of vernal pools: Northern Hardpan, Northern Claypan, and Northern Basalt Flow. Due to the mima mound topography prevalent in this region, the vernal pools tend to be small; vernal pool species also occupy swales. Soil series underlying Northern Hardpan Vernal Pools in the region include Amador, Corning, Hornitos, Keyes, Pentz, Peters, Redding, San Joaquin, and Yokohl. Cometa, Lewis, Madera, and Meikle are among the soil series associated with Northern Claypan Vernal Pools in the region, and the Hideaway series is associated with Northern Basalt Flow Vernal Pools (Keeler-Wolf *et al.* 1998). Much of the vernal pool region is in private ownership, but some of the core areas are owned by the California Department of Fish and Game, California Department of Parks and Recreation,

the U.S. Bureau of Land Management, the U.S. Bureau of Reclamation, or various land trusts. The Nature Conservancy also has easements on some of the most important habitats.

The California Department of Transportation has proposed the creation of a new north-south freeway east of Highway 99, from east Sacramento County to Tulare County. Although several years away in planning, if successful, this new freeway could have significant direct and indirect (growth-inducing) effects to vernal pool species in this vernal pool region.

15. Western Riverside County Vernal Pool Region

The geographic location of the Western Riverside Vernal Pool Region and associated core areas is depicted in **Figures III-16 and III-16a**. The *Recovery Plan for Vernal Pools of Southern California* was published prior to release of the vernal pool regions by Keeler-Wolf *et al.* (1998), thus the boundaries of the vernal pool regions and management areas identified in the recovery plan do not correlate in entirety. This vernal pool region as identified herein corresponds to the vernal pool regions of Keeler-Wolf *et al.* (1998). Western spadefoot toad and *Myosurus minimus* var. *apus* are taxa of concern featured in this recovery plan that also occur in the Western Riverside County Vernal Pool Region. This vernal pool region is mostly in Riverside County but includes a small portion of adjacent San Diego County. Topography is diverse within the vernal pool region, including low-lying basins, the high Santa Rosa Plateau, and at least one pool in the San Jacinto Mountains. All are included in the Southern California Mountains and Valleys Section of the California Coastal Range Shrub-Forest-Meadow Province (Goudey and Smith 1994). Southern Basalt Flow Vernal Pools occur on the Santa Rosa Plateau and range from small pools to a vernal lake; other pools in the region are unclassified "Southern Vernal Pools." Soils in the Western Riverside County Vernal Pool Region are alkaline and are typically of the Domino, Travers, and Willows series (Keeler-Wolf *et al*. 1998). Landowners in the region include the California Department of Fish and Game, the County of Riverside, The Nature Conservancy, and private individuals.

16. San Diego Vernal Pool Region

The geographic location of the San Diego Vernal Pool Region and associated core areas is depicted in **Figures III-17 and III-17a**. There are no federally listed taxa in the San Diego Vernal Pool Region that are addressed with respect to this draft recovery plan. The federally listed taxa that occur in the San Diego Vernal Pool Region were addressed in the earlier *Recovery Plan for Vernal Pools of Southern California* (U.S. Fish and Wildlife Service 1998b). The *Recovery Plan for Vernal*

Pools of Southern California was published prior to release of the vernal pool regions by Keeler-Wolf *et al.* (1998), thus the boundaries of the vernal pool regions and management areas identified in the recovery plan do not correlate entirely. This vernal pool region as identified herein corresponds to the vernal pool regions of Keeler-Wolf *et al.* (1998). This vernal pool region is necessary for the long-term conservation of western spadefoot and *Myosurus minimus* var. *apus*, which are featured taxa of concern. It includes one polygon that extends from Los Angeles County into Orange County, plus one large and two small polygons in San Diego County. This region includes the Southern California Coast Section of the California Coastal Chaparral Forest and Shrub Province and the Southern California Mountains and Valleys Section of the California Coastal Range Shrub-Forest-Meadow Province (Goudey and Smith 1994). Most of the vernal pools in this region are of San Diego Mesa Hardpan type, but San Diego Mesa Claypan Vernal Pools and unclassified vernal pools also are present. These pools are small and occur in complexes among mima mounds. Olivenhain soils underlie both pool types. Other soil series associated with San Diego Mesa Hardpan Vernal Pools include the Redding and Huerhuero series, whereas the Las Flores-Placentia series may be associated with San Diego Mesa Claypan Vernal Pools (Keeler-Wolf *et al*. 1998). These sites are owned by the U.S. Department of Defense and private individuals, respectively.

E. RECOVERY CRITERIA

Delisting and downlisting criteria in this draft recovery plan are necessarily preliminary and will need periodic reassessment because certain data upon which to base decisions about recovery of vernal pool species are lacking. Many research actions, monitoring programs, and status surveys are included as recovery actions in order to obtain this information. The completion of research, monitoring, and status surveys has been incorporated into recovery criteria because we recognize that many decisions on recovery implementation must be made in the future as new information is obtained. The recovery actions set up processes for evaluating and making decisions on the types, numbers, and priorities of recovery actions to be implemented. We expect that information resulting from these actions will be used to refine recovery implementation, and ultimately may be used to revise and refine the recovery criteria.

Many decisions on recovery implementation must be made in the future; the recovery actions set up processes for evaluating and making decisions on the types, numbers, and priorities of recovery actions to be implemented.

For the purposes of this draft recovery plan, local average rainfall is to be determined from the precipitation period of record for the local area. “Average”

annual local rainfall is defined as historic mean precipitation plus or minus 35 percent. A multi-year drought is defined as a period of 2 or more years of below average local rainfall that prevents reproduction and successful recruitment of vernal pool plants and animals. The monitoring period for measuring ecosystem function and population viability or stability consists of at least one multi-year period that includes above average, average, and below average rainfall (as defined above), a multi-year drought, and a minimum of 5 years of post-drought monitoring (*i.e.* if successful reproduction and recruitment are not demonstrated in 5 years, the monitoring will be longer). The post-drought monitoring period is timed to be as long as the longest recent multi-year drought in California, which lasted 5 years. In addition, because most plant species addressed are annual plants that have high year-to-year variability in population numbers, a minimum of 5 years post-drought monitoring likely will be necessary to determine population viability. Monitoring must be established based on precipitation conditions within each vernal pool region (local rainfall) and cannot be averaged across vernal pool regions.

Recovery actions required to achieve recovery criteria are described below in section IV. Appendix I delineates connections between recovery action and the threats and recovery criteria.

1. Strategies for Accommodating and Addressing Uncertainties in Preliminary Recovery Criteria

The following describes some of the major gaps in knowledge and understanding of vernal pool species and ecosystems and species that hinder development of definitive recovery criteria, how the preliminary recovery criteria in this draft recovery plan have been designed to address these uncertainties, and strategies for refining recovery criteria as recovery actions are implemented.

a. Habitat Protection

Amounts and locations of habitat: The amounts and locations of habitat to protect cannot be exactly defined because we lack information on appropriate reserve size, buffers sizes necessary to minimize threats of adjacent incompatible land uses, current and historic distributions of species, basic biological needs and life histories of species, upland habitat requirements for estivation of vernal pool amphibians, upland habitat requirements of pollinators of vernal pool plants, amount of upland habitat (*i.e.*, watersheds) contributing to, and necessary for the maintenance of, vernal pool hydrological function, and landscape distribution of vernal pools and vernal pool complexes needed to provide for dispersal and genetic exchange.

The recovery criteria, strategies, and actions address these data gaps by recommending the protection of the largest degree of diversity of vernal pool habitats possible (protection of the diversity of vernal pool types, soil types, geographic distribution, and species diversity) and protection of habitat in blocks as large as possible, including the associated uplands, buffers, and contributing local watersheds. Appropriate size for effective management units should also be considered. Designation of vernal pool regions and focus on core areas within those vernal pool regions is part of the strategy used to ensure protection of diverse vernal pools and vernal pool species across the draft planning area.

Vernal pool regions have been designated based primarily on the currently known distribution of vernal pools as classified by Keeler-Wolf *et al.* (1998), which encompasses the range and variation of vernal pool habitats. Core areas within vernal pool regions, which are the focus for habitat protection efforts, have been defined and prioritized based on the known distribution of vernal pool species and vernal pool habitats, and include representative sites across given species' range, or support high species diversity. Protection of the majority of suitable habitat within core areas is recommended to provide corridors and dispersal habitat, support metapopulation dynamics, provide for reintroduction or introduction sites, and to protect currently undiscovered populations until the actual habitat needs of vernal pool species can be better defined. Actions intended to address the gaps in information on amount and location of habitat to be protected include research on reserve design and ecological function of vernal pools, basic biology of the covered species to better determine habitat requirements, habitat mapping and analysis to better define distribution of vernal pool habitats, and status surveys to determine if populations are stable, declining or increasing, and/or determine the presence of additional populations or habitat areas that are needed to contribute to recovery.

Numbers of populations and population sizes: The number of populations and population sizes that must be protected and/or reestablished in order to maintain genetic variability sufficient to allow for adaptation to changing environmental conditions and protect against the threat of stochastic events cannot be adequately defined. We currently lack information on population genetic structure (within and among populations); current population sizes, status, and distribution; and historic population sizes and distribution of the species.

The recovery strategy, actions, and criteria recommend protection of populations over the entire geographic and ecological distribution of each species in order to ensure representation of genetic variation. Designation of vernal pool regions and identification of prioritized core areas for each species is intended to assist in protecting species across their full geographic and ecological distributions and

thus ensure preservation of the range of genetic variation. Reintroductions and/or introductions also are recommended for vernal pool regions and soil types from which a species has been extirpated. The recovery criteria generally recommend 100 percent protection of all populations for species with currently fewer than 20 occurrences and that occur in 3 or fewer vernal pool regions, unless new populations are discovered or established (*i.e.* replacements for current occurrences). The recovery criteria generally recommend less than 100 percent protection of all species with more than 20 known occurrences as long as the species is protected throughout its geographic and ecological range. Actions intended to address the gaps in information on adequate numbers and distribution of populations to protect include research on population genetic structure (genetic variation within and among populations), habitat mapping and status surveys to identify additional populations, and research on species biology (*i.e.* dispersal mechanisms and pollination biology that would contribute to genetic exchange among populations).

b. Adaptive Habitat Management, Restoration, and Monitoring

Specific management methods, restoration techniques, expected outcomes that indicate ecosystem function and species response to management, and monitoring techniques needed to ensure threats are ameliorated or eliminated within otherwise appropriate habitat cannot be adequately defined. Most methods, expected outcomes, and monitoring techniques are not yet fully researched or tested. In addition, specific management regimes likely will need to be tailored to site-specific conditions because threats and specific environmental conditions vary among geographic areas and species.

The recovery strategy, actions, and criteria recommend conducting standardized habitat site-assessments to identify site-specific threats, continuing current management regimes while conducting monitoring or conducting interim management and monitoring, reviewing and revising existing management plans to ensure their adequacy, and ultimately developing and implementing comprehensive long-term management plans for vernal pool habitats and species. The current strategy is to base management on existing information including knowledge of historic management regimes and observed outcomes of ongoing management, but also to incorporate new information resulting from research and monitoring. Although exact parameters cannot be defined at this time, the recovery criteria recommend that monitoring indicate ecosystem function has been maintained over 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 ensure reproduction and recruitment is achieved following the drought. Actions intended to address the gaps in

information on appropriate management of habitat include conducting monitoring and incorporating results into habitat management plans (*i.e.*, adaptive management), and research on habitat management, restoration, monitoring techniques, and basic species biology and ecology.

c. Status Surveys

Measures of population viability: The appropriate parameters and the values of those parameters that would indicate population viability cannot be adequately determined because we lack basic life history and population biology information for vernal pool species. This information includes current population sizes, status, and distribution, historic land use and management of the site, historic population sizes and distributions of species, demographic characteristics (such as survivorship, reproductive rates, recruitment, and dispersal capabilities), and metapopulation dynamics (extinction and colonization rates of populations). In addition, developing models of population viability for many species addressed in this draft plan may be hindered by the complicated life histories that involve long-lived seed and cyst stages. The demographic characteristics of these life stages may be very difficult to adequately measure and characterize. Additionally, the extreme year-to-year environmental variability and the ephemeral nature of habitats and populations may add to the difficulty of measuring population sizes, demographic characteristics, and metapopulation dynamics necessary to model population viability.

The recovery strategy, actions, and criteria recommend that populations must be stable or increasing over 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. Monitoring populations over this multi-year period should capture the range of variability in environmental conditions and variability in population numbers and demographic characteristics. Actions intended to address gaps in information necessary to develop parameters and values to determine population viability include development of standardized species monitoring protocols, conducting periodic status surveys and reviews to develop information on changes in species status over time, and research actions to measure demographic characteristics and/or metapopulation dynamics.

d. Research

Lack of information on basic biology and ecology of vernal pools and vernal pool species is the single greatest limiting factor in developing specific recovery criteria and prescriptive recovery actions in this draft recovery plan. While many threats to species are well known, ways to ameliorate or eliminate those threats

are not. Extensive research will be necessary to refine recovery criteria and actions. However, the wide variety and number of information gaps creates an enormous list of potential research topics on vernal pool species ecosystem recovery. Research needs must be refined in order to ensure that research carried out will contribute directly to recovery of the covered species. In addition, many of this draft recovery plan's covered species and vernal pool ecosystems themselves are difficult to study because of complicated life histories, extremes in year-to-year variation in habitat conditions and population characteristics, and the ephemeral nature of vernal pool habitats. These difficulties may make certain research actions impractical or very costly and will require that research results be evaluated and immediately incorporated into every aspect of the recovery strategy prior to proceeding to the next recovery step. The recovery strategy and actions for research recommend that the existing information be evaluated and research needs be determined and prioritized in order to ensure that research actions most needed to refine recovery criteria, management, and recovery actions are carried out.

e. Participation and Outreach

The draft recovery plan recommends that a recovery implementation team be established to oversee implementation of recovery actions. The recovery implementation team will in turn establish vernal pool region working groups. The working groups and implementation teams will bring agency, technical, outreach, and stakeholder expertise together with site-specific information to implement recovery. These groups are expected to compile and review existing and new information, and use their expertise in making informed decisions regarding recovery actions as the recovery plan is implemented.

2. General Recovery Criteria

The following general criteria apply to all species addressed in this draft recovery plan. Species specific values for habitat protection, occurrence protection, specific reintroductions, and numbers of populations from which seeds should be banked are found in **Table III-1**.

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

> Habitat protection includes protecting (from loss, fragmentation, and incompatible uses) diverse vernal pool habitats in large habitat blocks that include local watersheds, unoccupied pools within vernal pool complexes,

Table III-1. Species specific recovery criteria for species occurrence and habitat protection, reintroduction, and seed banking.

Common name(s) Scientific name (status) Recovery step	Percent occurrences to protect [1]	Percent suitable vernal pool habitat to be protected within each core area, listed by Vernal Pool Region (recovery priority of core area in parentheses) [2]	Reintroductions / Introductions recommended within vernal pool regions or core area.	Collection sources for seed / cyst banking [3]
Listed Plant Species				
fleshy owl's clover *Castilleja campestris* ssp. *succulenta* (T) Delist	90%	<u>SE Sac</u> Southeast Sacramento Valley (2) 85% <u>So. Sierra Foothills</u> Fresno (2) 85% Madera (1) 95% Merced (1) 95% Table Mountain (1) 95%	Reintroduce to vernal pool regions and soil types from which status surveys indicate the species has been extirpated.	Each vernal pool region
Hoover's spurge *Chamaesyce hooveri* (T) Delist	80%	<u>NE Sac</u> Oroville (1) 95% Vina Plains (1) 95% <u>San Joaquin Valley</u> Grasslands Ecological Area (1) 95% <u>Solano-Colusa</u> Sacramento NWR (1) 95% <u>So. Sierra Foothills</u> Merced (1) 95% Cottonwood Creek (2) 85% Tulare (2) 85% Turlock (2) 85%	Reintroduce to vernal pool regions and soil types from which status surveys indicate the species has been extirpated.	each vernal pool region
Loch Lomond button-celery *Eryngium constancei* (E) Downlist	100%	<u>Lake-Napa</u> Boggs Lake-Clear Lake (1) 95% Diamond Mountain (1) 95%		each population
Delist	100% of newly discovered/ reintroduced populations	<u>Lake-Napa</u> Protect new populations discovered through surveys.	Additional populations in Lake and Sonoma Counties must be discovered or established in order to delist.	

Common name(s) Scientific name (status) Recovery step	Percent occurrences to protect [1]	Percent suitable vernal pool habitat to be protected within each core area, listed by Vernal Pool Region (recovery priority of core area in parentheses) [2]	Reintroductions / Introductions recommended within vernal pool regions or core area.	Collection sources for seed / cyst banking [3]
Contra Costa goldfields *Lasthenia conjugens* (E) Downlist	80%	<u>Central Coast</u> Fort Ord (2) 85% SE San Francisco Bay (2) 85% <u>Lake-Napa</u> Berryessa (2) 85% Napa River (2) 85% <u>Solano-Colusa</u> Jepson Prairie (1) 95% Suisun Marsh (2) 85% Rodeo Creek (2) 85%		each vernal pool region
Delist	100% of reintroduced occurrences	<u>Lake-Napa</u> Berryessa (2) 85% <u>Livermore</u> Altamont Hills (1) 95% <u>Mendocino</u> Manchester (3) tbd <u>Santa Barbara</u> tbd Location within vernal pool region to be determined.	Milliken Canyon / introduction none / introduction none / introduction none / introduction 3 other introductions on appropriate soil types to replace extirpated occurrences plus other reintroductions to vernal pool regions and soil types from which status surveys indicate the species has been extirpated.	
Butte County meadowfoam *Limnanthes floccosa* ssp. *californica* (E) Downlist	100%	<u>NE Sacramento Valley</u> Chico (1) 95% Doe Mill (1) 95% Oroville (1) 95% Vina Plains (1) 95%		each population
Delist	100% of reintroduced occurrences	<u>NE Sacramento Valley</u> Protect new populations discovered through surveys.	Reintroduce appropriate races to soil types to replace extirpations.	

Common name(s) Scientific name (status) Recovery step	Percent occurrences to protect [1]	Percent suitable vernal pool habitat to be protected within each core area, listed by Vernal Pool Region (recovery priority of core area in parentheses) [2]	Reintroductions / Introductions recommended within vernal pool regions or core area.	Collection sources for seed / cyst banking [3]
few-flowered navarretia *Navarretia leucocephala* ssp. *pauciflora* (E) Downlist	100%	Lake-Napa Berryessa (2) 85% Boggs Lake-Clear Lake (1) 95% Dry Lake (1) 95%		each population
Delist	100% of newly discovered/ reintroduced populations	Lake-Napa Jordan Park (3) tbd Any other populations discovered	Determine presence at historic locality or reintroduce.	
many-flowered navarretia[4] *Navarretia leucocephala* ssp. *plieantha* (E) Downlist	100%	Lake-Napa Boggs Lake-Clear Lake (1) 95%		each population
Delist	100% of reintroduced occurrences	See footnote	Determine presence at historic locality or reintroduce. Reintroduce to vernal pool regions and soil types from which status surveys indicate the species has been extirpated.	

Common name(s) Scientific name (status) Recovery step	Percent occurrences to protect [1]	Percent suitable vernal pool habitat to be protected within each core area, listed by Vernal Pool Region (recovery priority of core area in parentheses) [2]	Reintroductions / Introductions recommended within vernal pool regions or core area.	Collection sources for seed / cyst banking [3]
Colusa grass *Neostapfia colusana* (T) Delist	90%	<u>San Joaquin Valley</u> Grasslands Ecological Area (1) 95% <u>Solano-Colusa</u> Davis Communications Annex (1) 95% Jepson Prairie (1) 95% <u>So. Sierra Foothills</u> Farmington (2) 85% Madera (1) 95% Merced (1) 95% Turlock (2) 85% Waterford (1) 95%	Arena Plains Unit of Merced NWR none / introduction in Colusa County none / introduction Reintroduce to vernal pool regions and soil types from which status surveys indicate the species has been extirpated.	each vernal pool region
San Joaquin Valley Orcutt grass *Orcuttia inaequalis* (T) Delist	90%	<u>So. Sierra Foothills</u> Fresno (2) 85% Madera (1) 95% Table Mountain (1) 95% Tulare (2) 85% Any rediscovered or newly discovered occurrences	none / introduction Reintroduce to soil types and parts of the vernal pool region from which status surveys indicate the species has been extirpated.	at least one population from each core area
hairy Orcutt grass *Orcuttia pilosa* (E) Downlist	90%	<u>NE Sac</u> Oroville (1) 95% Vina Plains (1) 95% <u>Solano-Colusa</u> Sacramento NWR (1) 95% <u>So. Sierra Foothills</u> Madera (1) 95% Merced (1) 95% Turlock (2) 85%		at least one population from each core area

Common name(s) Scientific name (status) Recovery step	Percent occurrences to protect [1]	Percent suitable vernal pool habitat to be protected within each core area, listed by Vernal Pool Region (recovery priority of core area in parentheses) [2]	Reintroductions / Introductions recommended within vernal pool regions or core area.	Collection sources for seed / cyst banking [3]
Delist	100% of reintroduced occurrences		Determine presence at historic localities or reintroduce within each vernal pool region. Reintroduce to vernal pool regions and soil types from which status surveys indicate the species has been extirpated.	
slender Orcutt grass *Orcuttia tenuis* (T) Delist	80%	<u>Lake-Napa</u> Boggs Lake-Clear Lake (1) 95% <u>Modoc Plateau</u> Northern Modoc Plateau (2) 85% Western Modoc Plateau (2) 85% Southwestern Modoc Plateau (2) 85% Southern Modoc Plateau (2) 85% <u>NE Sac</u> Dales (2) 85% Palermo (2) 85% Vina Plains (1) 95% <u>NW Sac</u> Redding (2) 85% Millville Plains (2) 85% <u>SE Sac</u> Mather (1) 95%	Reintroduce to vernal pool regions and soil types from which status surveys indicate the species has been extirpated.	each vernal pool region The following core areas contain small populations or few occurrences and should be first sources for seedbanking: Boggs Lake-Clear Lake, Millville Plains, Palermo, Mather, and Redding.
Sacramento Orcutt grass *Orcuttia viscida* (E) Downlist	100%	<u>SE Sac</u> Cosumnes/Rancho Seco (1) 95% Mather (1) 95% Phoenix Field and Park (1) 95%		each population
Delist	100% of newly discovered/ reintroduced populations	<u>SE Sac</u> Any newly discovered populations.	Reintroduce to appropriate soils in the Orangevale-Folsom area and Rancho Seco area to replace extirpated occurrences. Additional populations must be discovered or established in order to delist.	

Common name(s) Scientific name (status) Recovery step	Percent occurrences to protect [1]	Percent suitable vernal pool habitat to be protected within each core area, listed by Vernal Pool Region (recovery priority of core area in parentheses) [2]	Reintroductions / Introductions recommended within vernal pool regions or core area.	Collection sources for seed / cyst banking [3]
Lake County stonecrop *Parvisedum leiocarpum* (E) Downlist	100%	Lake-Napa Boggs Lake-Clear Lake (1) 95% Dry Lake (1) 95%		each population
Delist	100% of newly discovered/ reintroduced populations	Lake-Napa Any newly discovered populations.	Reintroduce to soil types from which status surveys indicate the species has been extirpated. Additional populations must be discovered or established in order to delist.	
Greene's tuctoria *Tuctoria greenei* (E) Downlist	80%	Modoc Plateau Western Modoc Plateau (2) 85% NE Sac Oroville (1) 95% Richvale (2) 85% Vina Plains (1) 95% Solano-Colusa Sacramento NWR (1) 95% So. Sierra Foothills Fresno (2) 85% Madera (1) 95% Merced (1) 95% Waterford (1) 95%		each vernal pool region
Delist	100% of all reintroduced populations	So. Sierra Foothills Madera (1) 95%	none /5 introduction (should include Farmington and Madera core areas) Reintroduce to vernal pool regions, counties, and soil types from which status surveys indicate the species has been extirpated. Includes Fresno, San Joaquin, Stanislaus, and Tulare Counties.	

Common name(s) Scientific name (status) Recovery step	Percent occurrences to protect [1]	Percent suitable vernal pool habitat to be protected within each core area, listed by Vernal Pool Region (recovery priority of core area in parentheses) [2]	Reintroductions / Introductions recommended within vernal pool regions or core area.	Collection sources for seed / cyst banking [3]
Solano grass *Tuctoria mucronata* (E) Downlist	100%	<u>Solano-Colusa</u> Davis Communications Annex (1) 95% Jepson Prairie (1) 95%		each population
Delist	100% of newly discovered/ reintroduced populations	<u>Solano-Colusa</u> Jepson Prairie (1) 95%	Olcott Lake Additional populations must be discovered or established in order to delist.	
Listed Animal Species				
Conservancy fairy shrimp *Branchinecta conservatio* (E) Downlist	100%	<u>NE Sac</u> Vina Plains (1) 95% <u>San Joaquin</u> Caswell (1) 95% Grasslands Ecological Area (1) 95% <u>Santa Barbara</u> Ventura County (2) 85% <u>Solano-Colusa</u> Jepson Prairie (1) 95% Sacramento NWR (1) 95% Collinsville(1) 95% <u>SE Sac</u> Beale (2) 85% <u>So. Sierra Foothills</u> Madera (1) 95%		
Delist	100% of newly discovered/ reintroduced populations	Any newly discovered populations.	Reintroduce to vernal pool regions and soil types from which status surveys indicate the species has been extirpated.	

Common name(s) Scientific name (status) Recovery step	Percent occurrences to protect [1]	Percent suitable vernal pool habitat to be protected within each core area, listed by Vernal Pool Region (recovery priority of core area in parentheses) [2]	Reintroductions / Introductions recommended within vernal pool regions or core area.	Collection sources for seed / cyst banking [3]
longhorn fairy shrimp *Branchinecta longiantenna* (E) Downlist	100%	Carrizo Carrizo Plain (2) 85% Livermore Altamont Hills (1) 95% San Joaquin Grasslands Ecological Area (1) 95%		
Delist	100% of newly discovered/ reintroduced populations		Reintroduce to vernal pool regions and soil types from which status surveys indicate the species has been extirpated. Additional populations must be discovered or established in order to delist.	

Common name(s) Scientific name (status) Recovery step	Percent occurrences to protect [1]	Percent suitable vernal pool habitat to be protected within each core area, listed by Vernal Pool Region (recovery priority of core area in parentheses) [2]	Reintroductions / Introductions recommended within vernal pool regions or core area.	Collection sources for seed / cyst banking [3]
vernal pool fairy shrimp *Branchinecta lynchi* (T) Delist	80%	<u>Carrizo</u> Carrizo Plain (2) 85% Paso Robles (2) 85% Central Coast Ranges (2) 85% <u>Central Coast</u> San Benito (2) 85% Fort Hunter-Liggett (2) 85% <u>Klamath Mtn.</u> Agate Desert (2) 85% Table Rocks (2) 85% White City (2) 85% <u>Lake-Napa</u> Napa River (2) 85% <u>Livermore</u> Altamont Hills (1) 95% <u>NE Sac</u> Chico (1) 95% Oroville (1) 95% Vina Plains (1) 95% Doe Mill (1) 95% <u>NW Sac</u> Red Bluff (2) 85% Redding (2) 85% Orland (2) 85% <u>San Joaquin</u> Caswell (1) 95% Grasslands Ecological Area (1) 95%	Reintroduce to vernal pool regions and soil types from which status surveys indicate the species has been extirpated.	

Common name(s) Scientific name (status) Recovery step	Percent occurrences to protect [1]	Percent suitable vernal pool habitat to be protected within each core area, listed by Vernal Pool Region (recovery priority of core area in parentheses) [2]	Reintroductions / Introductions recommended within vernal pool regions or core area.	Collection sources for seed / cyst banking [3]
vernal pool fairy shrimp *Branchinecta lynchi* (T) Delist (Continued)		<u>Santa Barbara</u> Ventura (2) 85% Lake Cachuma (2) 85% <u>Solano-Colusa</u> Jepson Prairie (1) 95% Sacramento NWR (1) 95% Vacaville (2) 85% <u>SE Sac</u> Beale (2) 85% Cosumnes/Rancho Seco (1) 95% Mather (1) 95% Western Placer County (2) 85% <u>So. Sierra Foothills</u> Fresno (2) 85% San Joaquin (2) 85% Madera (1) 95% Merced (1) 95% Table Mountain (1) 95% Cottonwood Creek (2) 85% <u>W. Riverside</u> Skunk Hollow (2) 95% Santa Rosa Plateau (1) 85% San Jacinto-Hemet (2) 85%		
delta green ground beetle *Elaphrus viridis* (T) Delist	100%	<u>Solano-Colusa</u> Jepson Prairie (1) 95%	Additional populations must be discovered or established through reintroduction to or colonization of restored habitat in order to delist.	

Common name(s) Scientific name (status) Recovery step	Percent occurrences to protect [1]	Percent suitable vernal pool habitat to be protected within each core area, listed by Vernal Pool Region (recovery priority of core area in parentheses) [2]	Reintroductions / Introductions recommended within vernal pool regions or core area.	Collection sources for seed / cyst banking [3]
vernal pool tadpole shrimp *Lepidurus packardi* (E) Downlist	80%	<u>Central Coast</u> SE San Francisco Bay (2) 85% <u>NE Sac</u> Chico (1) 95% Dales (2) 85% Doe Mill (2) 85% Oroville (1) 95% Vina Plains (1) 95% <u>NW Sac</u> Red Bluff (2) 85% Redding (2) 85% <u>San Joaquin</u> Grasslands Ecological Area (1) 95% Cross Creek (2) 85% <u>Solano-Colusa</u> Davis Communications Annex (1) 95% Jepson Prairie (1) 95% Collinsville (1) 95% Sacramento NWR (1) 95% Dolan (2) 85% <u>SE Sac</u> Beale (2) 85% Cosumnes/Rancho Seco (1) 95% Mather (1) 95% Western Placer County (2) 85% <u>So. Sierra Foothills</u> Madera (1) 95% Merced (1) 95% Table Mountain (1) 95% Cottonwood Creek (2) 85% Turlock (2) 85%		

Common name(s) Scientific name (status) Recovery step	Percent occurrences to protect [1]	Percent suitable vernal pool habitat to be protected within each core area, listed by Vernal Pool Region (recovery priority of core area in parentheses) [2]	Reintroductions / Introductions recommended within vernal pool regions or core area.	Collection sources for seed / cyst banking [3]
vernal pool tadpole shrimp *Lepidurus packardi* (E) Delist	100% of reintroduced populations		Reintroduce to vernal pool regions and soil types from which status surveys indicate the species has been extirpated.	
Plant Species of Concern				
Ferris' milk vetch *Astragalus tener* var. *ferrisiae* (none) Conserve	100%	<u>NE Sac</u> Llano Seco 95% Upper Butte Basin 95% <u>Solano-Colusa</u> Dolan (2) 85% Sacramento NWR (1) 95%	none / 2 introductions	each population
alkali milk vetch[4] *Astragalus tener* var. *tener* (none) Conserve	80%	<u>Central Coast</u> SE San Francisco Bay (2) 85% <u>Livermore</u> Altamont Hills (1) 95% <u>San Joaquin</u> Grasslands Ecological Area (1) 95% <u>Solano-Colusa</u> Collinsville (1) 95% Davis Communications Annex (1) 95% Jepson Prairie (1) 95% Suisun Marsh (2) 85% Woodland (2) 85%	none / introduction none / introduction none / introduction none / introduction 1other introduction on appropriate soil type to replace extirpated occurrence	at least one population from each core area
vernal pool smallscale *Atriplex persistens* (none) Conserve	90%	<u>San Joaquin</u> Grasslands Ecological Area (1) 95% <u>Solano-Colusa</u> Jepson Prairie (1) 95% Sacramento NWR (1) 95%	Reintroduce to vernal pool regions and soil types from which status surveys indicate the species has been extirpated.	at least one population from each core area

Common name(s) Scientific name (status) Recovery step	Percent occurrences to protect [1]	Percent suitable vernal pool habitat to be protected within each core area, listed by Vernal Pool Region (recovery priority of core area in parentheses) [2]	Reintroductions / Introductions recommended within vernal pool regions or core area.	Collection sources for seed / cyst banking [3]
spiny-sepaled button-celery *Eryngium spinosepalum* (none) Conserve	90%	So. Sierra Foothills Fresno (2) 85% Kaweah (2) 85% Kings (2) 85% Madera (1) 95% Shotgun Creek (2) 85% Tulare (2) 85% Table Mountain (1) 95% Yokohl (2) 85% Lake Success (2) 85% Cottonwood Creek (2) 85%	Reintroduce to vernal pool regions and soil types from which status surveys indicate the species has been extirpated.	at least one population from each core area
Boggs Lake hedge-hyssop *Gratiola heterosepala* (State endangered) Conserve	80%	Lake-Napa Boggs Lake- Clear Lake (1) 95% Modoc Plateau Northern Modoc Plateau (2) 85% Western Modoc Plateau (2) 85% Southwestern Modoc Plateau (2) 85% NE Sac Dales (2) 85% Vina Plains (1) 95% NW Sac Black Butte (2) 85% Red Bluff (2) 85% Solano-Colusa Jepson Prairie (1) 95% SE Sac Mather (1) 95% Western Placer County (2) 85% So. Sierra Foothills Madera (1) 95% Table Mountain (1) 95%	Reintroduce to vernal pool regions and soil types from which status surveys indicate the species has been extirpated.	at least one population from each core area

Common name(s) Scientific name (status) Recovery step	Percent occurrences to protect [1]	Percent suitable vernal pool habitat to be protected within each core area, listed by Vernal Pool Region (recovery priority of core area in parentheses) [2]	Reintroductions / Introductions recommended within vernal pool regions or core area.	Collection sources for seed / cyst banking [3]
Ahart's dwarf rush *Juncus leiospermus* var. *ahartii* (none) Conserve	100%	<u>NE Sac</u> Honcut (2) 85% <u>SE Sac</u> Jenny Lind (2) 85% Mather (1) 95% Western Placer County (2) 85%	Reintroduce to vernal pool regions and soil types from which status surveys indicate the species has been extirpated.	each population
legenere[4] *Legenere limosa* (none) Conserve	80%	<u>Central Coast</u> Coal Mine Ridge (3) tbd <u>Lake-Napa</u> Boggs Lake - Clear Lake (1) 95% Napa River (2) 85% <u>NE Sac</u> Dales (2) 85% <u>NW Sac</u> Black Butte (2) 85% Red Bluff (2) 85% Redding (2) 85% <u>Solano-Colusa</u> Jepson Prairie (1) 95% <u>SE Sac</u> Beale (2) 85% Cosumnes-Rancho Seco (1) 95% Mather (1) 95% Stone Lakes (2) 85% Western Placer County (2) 85%	Reintroduce to vernal pool regions and soil types from which status surveys indicate the species has been extirpated.	at least one population from each core area

Common name(s) Scientific name (status) Recovery step	Percent occurrences to protect [1]	Percent suitable vernal pool habitat to be protected within each core area, listed by Vernal Pool Region (recovery priority of core area in parentheses) [2]	Reintroductions / Introductions recommended within vernal pool regions or core area.	Collection sources for seed / cyst banking [3]
little mousetail *Myosurus minimus* var. *apus* (none) Conserve	90%	<u>San Diego</u> Ramona (2) 85% Otay Mesa (2) 85% Tierrasanta South (2) 85% <u>W. Riverside</u> Harford Springs (2) 85% San Jacinto-Hemet (2) 85% Santa Rosa Plateau (1) 85%		at least one population from each core area
small pincushion navarretia *Navarretia myersii* ssp. *deminuta* (none) Conserve	100%	<u>Lake-Napa</u> Long Valley (1) 95% (note: only known locality for this taxon)	none / introduction in Lake County	only known population
bearded popcorn flower *Plagiobothrys hystriculus* (none) Conserve	100%	<u>Solano-Colusa</u> Montezuma Hills (1) 95% (note: only known locality for this species; must be rediscovered)		only known population

Common name(s) Scientific name (status) Recovery step	Percent occurrences to protect [1]	Percent suitable vernal pool habitat to be protected within each core area, listed by Vernal Pool Region (recovery priority of core area in parentheses) [2]	Reintroductions / Introductions recommended within vernal pool regions or core area.	Collection sources for seed / cyst banking [3]
Animal Species of Concern				
mid-valley fairy shrimp *Branchinecta mesovallensis* (none) Conserve	80%	<u>Livermore</u> Altamont Hills (1) 95% <u>San Joaquin</u> Grasslands Ecological Area (1) 95% <u>Solano-Colusa</u> Jepson Prairie (1) 95% <u>SE Sac</u> Cosumnes-Ranch Seco (1) 95% Mather (1) 95% <u>So. Sierra Foothills</u> Fresno (2) 85% Madera (1) 95%		

Common name(s) Scientific name (status) Recovery step	Percent occurrences to protect [1]	Percent suitable vernal pool habitat to be protected within each core area, listed by Vernal Pool Region (recovery priority of core area in parentheses) [2]	Reintroductions / Introductions recommended within vernal pool regions or core area.	Collection sources for seed / cyst banking [3]
California fairy shrimp[4] *Linderiella occidentalis* (none) Conserve	80%	<u>Central Coast</u> Fort Ord (2) 85% <u>NE Sac</u> Chico (1) 95% Dales (2) 85% Vina Plains (1) 95% <u>NW Sac</u> Red Bluff (2) 85% Redding (2) 85% <u>San Joaquin</u> Caswell (1) 95% Grasslands Ecological Area (1) 95% <u>Solano-Colusa</u> Jepson Prairie (1) 95% <u>SE Sac</u> Beale (3) tbd Cosumnes-Rancho Seco (1) 95% Mather (1) 95% Phoenix Field/Phoenix Park (1) 95% Western Placer County (2) 85% <u>So. Sierra Foothills</u> Fresno (2) 85% Madera (1) 95% Merced (1) 95% Table Mountain (1) 95%		

Common name(s) Scientific name (status) Recovery step	Percent occurrences to protect [1]	Percent suitable vernal pool habitat to be protected within each core area, listed by Vernal Pool Region (recovery priority of core area in parentheses) [2]	Reintroductions / Introductions recommended within vernal pool regions or core area.	Collection sources for seed / cyst banking [3]
western spadefoot toad [5] *Spea hammondii* (none) Conserve	80% (where it co-occurs with other vernal pool species)	8 of 16 vernal pool regions Carrizo Central Coast NE Sac San Diego San Joaquin SE Sac Southern Sierra Foothills Western Riverside County		

[1] Percent occurrences to protect, unless additional occurrences are found (see text for description of how values were derived).

[2] tbd = To be determined. Priority 3 core areas include historic localities (most recent report at least 40 years old) where populations must be rediscovered or reintroduced. Ability to reintroduce may depend on amount and condition of suitable habitat and on success criteria that must be met to demonstrate for successful reintroductions. Protection of suitable habitat will be based on status surveys and assessment of habitat needs for successful reintroduction.

[3] Store seeds (plants) in at least two Center for Plant Conservation certified facilities.

[4] See the Draft Santa Rosa Plains Recovery Plan (in development) for additional criteria for populations of this species in the Santa Rosa area.

[5] Western spadefoot toads occurs in a broader range of habitat types than the other species addressed in this draft recovery plan. Percent protection recommended for this species applies to those areas where it co-occurs with other vernal pool species within vernal pool habitats.

and appropriate upland buffers around and between vernal pool complexes and can be effectively managed to maintain hydrologic function and prevent domination by invasive species. Because some species currently are made up of only a small number of populations, reintroduction, introduction, or discovery of additional populations also will be necessary to guard against extinction events.

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

   Percentages required for each prioritized core area are listed by species in **Table III-1**. This habitat includes both occupied and suitable habitat. Suitable habitat that is not currently known to be occupied must be protected to provide for corridors and dispersal habitat, metapopulation dynamics, provide for reintroduction/introduction sites, and to protect currently undiscovered populations.

B. Species occurrences distributed across the species' geographic and genetic range are protected.

   Table III-1 lists the percentage of occurrences that must be protected for each species. **Table III-1** also lists the vernal pool regions and core areas within which occurrences and occupied and suitable habitat for each species should be protected to ensure occurrences are distributed across the species range.

C. Reintroductions and introductions must be carried out and meet success criteria established in actions 2.5.3.7. **Table III-1** indicates which species will require specific reintroductions or introductions (introductions replace extirpated occurrences that cannot be restored to the same site as the original occurrence) and within which vernal pool regions, core areas, or counties.

D. Additional occurrences identified through future site assessments, GIS and other analyses, and status surveys that are determined essential to recovery are protected.

E. 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 as defined above, a multi-year drought, and a minimum of 5 years of post-drought monitoring.

2. Adaptive Habitat Management and Monitoring:

A. Habitat management and monitoring plans that ensure maintenance of vernal pool ecosystem function and population viability have been developed and implemented for all habitat protected in 1. A-E. above. Plans must be developed and implemented within 5 years of protection of individual parcels/properties/areas to ensure that populations are stable or increasing and progress toward reaching recovery goals is being made while additional habitat protections are being developed. Plans must include provisions for managing nonnative and native competitors, appropriate grazing regimes, adaptive habitat management, incorporation of new information resulting from implementation of research actions, and addressing site-specific threats.

B. Mechanisms are in place to provide for management in perpetuity and long-term monitoring of 1A-E. above (*e.g*. funding, personnel, *etc*.).

C. Monitoring indicates 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 as defined above, a multi-year drought, and a minimum of 5 years of post-drought monitoring.

D. Seed banking actions have been completed for species that would require it as insurance against risk of stochastic extirpations or that will require reintroductions or introductions to contribute to meeting recovery criteria (see **Table III-1**).

3. Status surveys:

A. Status surveys, 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 as defined above, a multi-year drought, and a minimum of 5 years of post-drought monitoring. (Determining when this criterion is met may rely partly on completion of research actions to model population viability or development of standardized monitoring and survey protocols to determine appropriate parameters to measure during status surveys).

B. 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.

4. Research:

A. 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.

B. 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 represented by populations protected in Habitat Protection 1.A.-E. above.

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

5. Participation and Outreach:

A. Recovery Implementation Team is established and functioning to oversee rangewide recovery efforts.

B. Vernal Pool Region working groups are established and functioning to oversee regional recovery efforts.

C. Participation plans for each Vernal Pool Region have been completed and implemented.

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

3. Rationale for Species-specific Recovery Criteria

Table III-1 lists specific downlisting and delisting criteria by species. The values presented were derived using information on the known occurrences, distribution, and status of the species across their ranges. The rationale for the criteria in **Table III-1** are described below.

Percent of occurrences to protect

Table III-1 lists specific percentages of known occurrences to protect for each species. These percentages range from 80 percent to 100 percent. Generally, species with currently fewer than 20 known occurrences (particularly those with disjunct occurrences) and that occur in less than 3 vernal pool regions require that 100 percent of the occurrences be protected, unless additional occurrences are discovered or established (*i.e.*, replacements for known occurrences). Fewer than 100 percent of all currently identified occurrences may be protected for species with greater numbers of occurrences and wider distributions, as long as the species is protected throughout its geographic and ecological range.

Species with less than 20 occurrences distributed within 3 or fewer vernal pool regions - For all species with fewer than 20 known occurrences distributed within 3 or fewer vernal pool regions, the preliminary recovery criteria recommend protection of 100 percent of all known occurrences, unless additional populations are found or can be established. These species include 9 listed species and 4 species of concern. The majority of the species with fewer than 20 occurrences actually have fewer than 10 occurrences and most are distributed very narrowly in only 1 or 2 counties. The remaining species are distributed in more than 1 or 2 counties, but have disjunct ranges with less than 10 occurrences in each portion of the species range. For these species, 100 percent of all known occurrences must be protected to assist in minimizing the risk of extinction from random events, and to maintain as much genetic variation as possible to maintain the species ability to respond to changing environmental conditions.

The habitat requirements for these species are poorly understood, so the likelihood that additional populations exist in unsurveyed vernal pool habitat is unknown. Because these species are narrowly endemic, it also is possible that habitat conditions necessary to support the species are very specific. The likelihood of successfully reintroducing or introducing the species to additional areas, or locating new populations may be very low. Thus we are recommending that, in addition to 100 percent protection of all known occurrences, a given percentage of all suitable habitat also must be protected (see discussion below).

Species with greater than 20 occurrences - For species with greater than 20 currently known occurrences (including 10 listed species and 9 species of concern), the preliminary recovery criteria recommend protection of 80 to 90 percent of occurrences, unless additional populations are found or established, depending on the species. Most of these species occur in several counties, have relatively contiguous distributions, and are distributed in multiple vernal pool regions. The level of protection corresponds to the number of known occurrences and the distributions of the species. Greater protection is recommended for species with more narrow distributions. Generally, the recovery criteria recommend protection of 90 percent of all known occurrences for species with greater than 20 known occurrences but that occur in 3 or fewer vernal pool regions. The recovery criteria also recommend protection of 80 percent of all known occurrences for species that occur in more than 3 vernal pool regions and with greater than 20 known occurrences. Although specific habitat requirements and successful reintroduction techniques are not known for these species, it is possible that these more widespread species have a wider range of habitat tolerances that may increase the potential for successful reintroductions/introductions and discovery of additional populations. As above, and discussed below, a given percentage of suitable habitat also must be protected.

Percent of suitable habitat within core areas to protect:

Table III-1 lists the percentages of suitable vernal pool habitat to be protected for each core area. Most core areas contain populations of more than one vernal pool species, so percentages of suitable habitat to protect within core areas are based on the number of species that occur in that core area and the relative rarity of species within that core area. These percentages also correspond with the recovery priority of the core area. The recovery criteria recommend protection of 95 percent of suitable habitat within Priority 1 core areas. Priority 1 core areas contain occurrences of species with few populations and narrow or disjunct distributions that are known to be, or are likely to be, genetically or ecologically distinct. Additional Priority 1 core areas include those that represent high diversity of vernal pool species. The recovery criteria recommend protection of 85 percent of suitable habitat within Priority 2 core areas. Priority 2 core areas contain occurrences of more widespread species with greater numbers of occurrences, but include representative occurrences of these species across their ranges. The amount and location of habitat to be protected in core areas that only include reintroductions (Priority 3 core areas) must be determined through standardized assessment of available habitat, status surveys, and development of captive propagation and reintroduction plans.

Reintroductions and introductions: Reintroductions are recommended for many species with very few occurrences or for species that have experienced multiple extirpations. Reintroductions also are recommended if status surveys indicate a species has been extirpated from a particular vernal pool region or soil type. Generally, reintroductions or introductions are recommended if any loss in number of known occurrences is, or has been, experienced for those species with less than 20 occurrences distributed in 3 or fewer vernal pool regions. Reintroductions or introductions are recommended for species with greater than 20 occurrences if greater than 10 percent loss in number of known occurrences is, or has been, experienced for those species that occur in 3 or fewer vernal pool regions. If greater than 20 percent loss in number of known occurrences is, or has been, experienced for those species that occur in more than 3 vernal pool regions, reintroductions or introductions are recommended. At this time, the current status of many populations and occurrences are unknown, so it is not possible to accurately define the numbers and locations of all reintroductions necessary to achieve recovery. Reintroductions are intended to reduce the risk of extinction due to stochastic events and/or to ensure that the species is distributed across its geographic and ecological range such that a species adaptive potential and metapopulation dynamics can be maintained. These actions will require protection of the habitat on which reintroductions or introductions will occur and may require restoration of habitat as well.

Seed banking

Seed banking is recommended for many species addressed in this draft recovery plan as insurance against risk of random extirpations, or for species that will require reintroductions or introductions to contribute to meeting recovery criteria. Seed banking is one means to ensure that genetic variation can be restored if extirpations or extinctions from random events occur. Seed banking is recommended for each population for species that have few occurrences and are narrowly distributed. Seed or cyst banking is recommended only from each vernal pool region for more widely distributed species.

IV. STEPDOWN NARRATIVE

1 Protect vernal pool habitat in the largest blocks possible from loss, fragmentation, degradation, and incompatible uses.

Protection of vernal pool habitat is the highest priority action (Priority 1) in this draft recovery plan. Therefore, actions contributing to, or necessary prior to, the actual protection of the vernal pool habitat are, by default, designated as Priority 1 actions as well.

For the recovery of species addressed in this draft recovery plan, we define "vernal pool habitat" to include vernal pool complexes, occupied and unoccupied vernal pools within a vernal pool complex, appropriate upland buffers around and between vernal pools, and local contributing watersheds.

1.1 Develop standardized vernal pool habitat site assessment guidance. (Priority 1)

A standardized, scientifically based methodology should be developed to conduct vernal pool habitat site assessments. It is important to use a standardized methodology to ensure consistency and continuity of data between observers, between vernal pool sites, and over time. A standardized site assessment should, at a minimum, establish parameters that 1) evaluate whether or not the site is within the range of at least one species covered in this draft recovery plan, 2) evaluate the known localities of each species present on or near the site being assessed, 3) evaluate the historical locations or potential locations of species on or near the site being assessed, 4) evaluate the type and degree of existing, and newly identified, site-specific threats to species occurring on or near the site being assessed, 5) evaluate the habitat conditions in terms of important processes and functions, and 6) evaluate historic and current land use and management regimes as they relate to habitat condition.

1.2 Use existing (and newly available) information to conduct data analysis using Geographic Information Systems, remote sensing, and other techniques to facilitate vernal pool habitat protection efforts. (Priority 1)

Preparation prior to data analysis includes assembling, organizing, and managing all available existing Geographic Information Systems, remote sensing, and other data pertinent to vernal pool habitat protection. Additional Geographic Information Systems, remote sensing, and other data that is lacking, but deemed essential to vernal pool habitat protection, must be obtained. Data must be reviewed and analyzed to determine appropriate habitat to protect (occupied, potential, historical, linkages, buffer areas, *etc*.), the degree of existing protection, and threats to vernal pool habitat. In coordination with the Sacramento Fish and Wildlife Office, a prioritized list of vernal pool habitat to protect should be developed after analyses are completed. The areas with the highest priority for protection are those with the rarest species/genetics, most unique conditions, highest biodiversity, and greatest threat of destruction.

1.3 Conduct standardized vernal pool habitat site assessments (including standardized species surveys, Action 3.1.2)
(Priority 1)

This action serves to identify prioritized sites for protection within each vernal pool region (**Table IV-1**), focusing on core areas initially and working outwards to each vernal pool region boundary.

The vernal pool regions described in this draft recovery plan are based on the vernal pool regions identified by the California Department of Fish and Game (Keeler-Wolf *et al.* 1998). This classification system should be used as the basis of the Geographic Information Systems approach described above. The vernal pool classification system developed by Keeler-Wolf *et al.* (1998) was chosen because it is widely available, incorporates a variety of information, and encompasses the entire State of California. It is based primarily on the distributions of endemic vernal pool species and secondarily on soils, landforms, and vernal pool types. Included in this draft recovery plan is a vernal pool region located in Oregon, which is not based on Keeler-Wolf *et al.* (1998). In addition, some vernal pool region boundaries have been modified by incorporating outlying areas that contain core areas important to recovery of certain species. Chapter III, “Recovery” has a detailed description of each vernal pool region, core areas, and explanation for how boundaries were established.

Table IV-1. Areas for vernal pool site assessments.

ACTION	VERNAL POOL REGION	REGION NAME
1.3.1	1	Carrizo
1.3.2	2	Central Coast
1.3.3	3	Klamath Mountains
1.3.4	4	Lake-Napa
1.3.5	5	Livermore
1.3.6	6	Mendocino
1.3.7	7	Modoc
1.3.8	8	Northeastern Sacramento Valley
1.3.9	9	Northwestern Sacramento Valley
1.3.10	10	San Joaquin Valley
1.3.11	11	Santa Barbara
1.3.12	12	Solano-Colusa
1.3.13	13	Southeastern Sacramento Valley
1.3.14	14	Southern Sierra Foothills
1.3.15	15	Western Riverside County
1.3.16	16	San Diego

1.4 Protect vernal pool species through habitat protection.

Protect known species occurrences, newly identified species occurrences, potential species occurrences, and their vernal pool habitat, as identified using standardized vernal pool species surveys (Action 3.2) and standardized vernal pool habitat site assessments (Action 1.3).

The network of conservation areas will include small, large, and intermediate-sized reserves. Large reserves are preferred because they minimize per-acre management costs, make it possible to preserve historic management regimes, where appropriate, for listed and special status species, reduce edge effect, and increase the likelihood of survival for their resident species by maintaining more ecosystem functions. However, small reserves also can

contribute to recovery. Often, these small areas are all that remain of formerly large vernal pool ecosystems and represent unique genotypes or ecological conditions. Results of research into habitat needs described in Action 4 will help determine minimum reserve size and optimal buffer size.

Much of the natural land that contains species covered in this draft recovery plan needs to be protected in perpetuity. Protection in perpetuity of these lands includes the amelioration or elimination of the threats in perpetuity, and application of appropriate and adaptive management to ensure species survival and recovery. In other cases, there may be lands that can contribute to the recovery or long-term conservation of vernal pool species that does not need protection in perpetuity. For example, for some vernal pool plant species, including some plants and shrimp, lands that occur within modern urban areas may need to be preserved only until species occurring in those areas can be translocated, providing that scientifically collected data have shown that translocation of these species is successful and will benefit the species, appropriate habitat is available, and that strict success criteria have been developed.

Priority levels for habitat protection in each core area are summarized in **Table IV-2** below. Appendix F describes numerous tools available to assist in the protection of habitat for vernal pool species.

1.4.1 Ensure Federal agencies managing land use their authorities to protect habitat and promote the recovery and conservation of the species addressed in this draft recovery plan.

For example, Federal agencies can enter into cooperative partnerships, ensure adequate management plans are developed and implemented, develop conservation programs through section 7(a)(1), and minimize and avoid habitat loss through section 7(a)(2) consultations.

1.4.1.1 Protect species occurrences and their vernal pool habitat in Priority 1 core areas. (Priority 1)

Table IV-2. Core areas for recovery of vernal pool plants and animals, organized by vernal pool region, species within each core area, and the priority of habitat protection of each core area.

Core Area Name	County	Listed and Proposed Taxa ---------- Taxa of Concern	Comments	Priority[1]
CARRIZO VERNAL POOL REGION				
Carrizo Plain (1 area)	San Luis Obispo	longhorn fairy shrimp vernal pool fairy shrimp ---------- western spadefoot toad	Includes the National Monument and State and private lands. *Myosurus minimus* var. *apus* last reported in 1952. Reintroduction may be necessary.	2
Paso Robles (1 area)	San Luis Obispo, Monterey	vernal pool fairy shrimp ---------- western spadefoot toad		2
Central Coastal Ranges (2 areas)	San Luis Obispo, Monterey	vernal pool fairy shrimp ---------- western spadefoot toad	Includes Camp Roberts, Paso Robles.	2
CENTRAL COAST VERNAL POOL REGION				
Coal Mine Ridge (1 area)	San Mateo, Santa Clara	no listed taxa covered in this recovery plan ---------- *Legenere limosa*	Historical locality. Population last reported in 1906. Reintroduction may be necessary if status surveys indicate need.	3
Fort Ord (1 area)	Monterey	*Lasthenia conjugens* ---------- California fairy shrimp		2
San Benito (1 area)	San Benito Monterey	vernal pool fairy shrimp ---------- western spadefoot toad		2

Core Area Name	County	Listed and Proposed Taxa ---------- Taxa of Concern	Comments	Priority[1]
Fort Hunter-Liggett (1 area)	Monterey	vernal pool fairy shrimp ---------- western spadefoot toad		2
Southeastern San Francisco Bay (1 area)	Alameda	*Lasthenia conjugens* vernal pool tadpole shrimp ---------- *Astragalus tener* var. *tener*		2
KLAMATH MOUNTAINS VERNAL POOL REGION				
Agate Desert (9 areas)	Jackson (Oregon)	vernal pool fairy shrimp		2
Table Rocks (2 areas)	Jackson (Oregon)	vernal pool fairy shrimp		2
White City (11 areas)	Jackson (Oregon)	vernal pool fairy shrimp		2
LAKE-NAPA VERNAL POOL REGION				
Berryessa (1 area)	Napa	*Lasthenia conjugens* *Navarretia leucocephala* ssp. *pauciflora*	Includes Mead Ranch, Milliken Canyon.	2
Boggs Lake-Clear Lake (7 areas)	Lake	*Eryngium constancei* *Navarretia leucocephala* ssp. *pauciflora* *Navarretia leucocephala* ssp. *plieantha* *Orcuttia tenuis* *Parvisedum leiocarpum* ---------- *Gratiola heterosepala* *Legenere limosa*	Includes Boggs Lake Preserve, Cobb, Little High Valley, Loch Lomond Ecological Reserve, Manning Flat, Seigler Springs, Snows Lake, Steinhart Lakes, Whispering Pines.	1

Core Area Name	County	Listed and Proposed Taxa ---------- Taxa of Concern	Comments	Priority[1]
Diamond Mountain (1 area)	Sonoma	*Eryngium constancei*		1
Dry Lake (1 area)	Lake	*Eryngium constancei* *Navarretia leucocephala* ssp. *pauciflora*		1
Jordan Park (1 area)	Lake	*Navarretia leucocephala* ssp. *pauciflora*	Historical locality. Population last reported in 1932. Reintroduction may be necessary.	3
Long Valley (1 area)	Lake	no listed taxa covered in this recovery plan ---------- *Navarretia myersii* ssp. *deminuta*	Only known locality for this taxon.	1
Napa River (2 areas)	Napa	*Lasthenia conjugens* vernal pool fairy shrimp ---------- *Legenere limosa*	Includes Fagan Marsh Ecological Area, Napa-Sonoma Marshes Wildlife Area, Suscol Ridge, and private lands.	2
LIVERMORE VERNAL POOL REGION				
Altamont Hills (5 areas)	Alameda Contra Costa	*Lasthenia conjugens* longhorn fairy shrimp vernal pool fairy shrimp ---------- *Astragalus tener* var. *tener* midvalley fairy shrimp	Includes Altamont Hills and Byron Hot Springs area. Historical locality. *Lasthenia conjugens* last reported in 1884. *Astragalus tener* var. *tener* last reported in 1957. Spiny-sepaled button-celery last reported in 1937. Reintroduction may be necessary.	1
MENDOCINO VERNAL POOL REGION				

Core Area Name	County	Listed and Proposed Taxa ---------- Taxa of Concern	Comments	Priority[1]
Manchester (1 area)	Mendocino	*Lasthenia conjugens*	Historical locality. Population last reported in 1937. Reintroduction may be necessary.	3
MODOC PLATEAU VERNAL POOL REGION				
Northern Modoc Plateau (2 areas)	Modoc	*Orcuttia tenuis* ---------- *Gratiola heterosepala*	Vernal pool region includes the occurrence of *Gratiola heterosepala* in Lake County, Oregon.	2
Western Modoc Plateau (6 areas)	Modoc Siskiyou Shasta	*Orcuttia tenuis* *Tuctoria mucronata* ---------- *Gratiola heterosepala*		2
Southwestern Modoc Plateau (5 areas)	Lassen Shasta	*Orcuttia tenuis* ---------- *Gratiola heterosepala*		2
Southern Modoc Plateau (1 area)	Plumas	*Orcuttia tenuis*		2
NORTHEASTERN SACRAMENTO VALLEY VERNAL POOL REGION				
Chico (1 area)	Butte	*Limnanthes floccosa* ssp. *californica* vernal pool fairy shrimp vernal pool tadpole shrimp _____ California fairy shrimp western spadefoot toad	Priority 1 because center of concentration for *Limnanthes floccosa* ssp. *californica*.	1

Core Area Name	County	Listed and Proposed Taxa ---------- Taxa of Concern	Comments	Priority[1]
Dales (1 area)	Shasta Tehama	*Orcuttia tenuis* vernal pool tadpole shrimp ---------- *Gratiola heterosepala* *Legenere limosa* California fairy shrimp	Includes Dales Lake Ecological Reserve, Battle Creek Wildlife Area, Table Mountain, Table Mountain Lake, and other private lands.	2
Doe Mill (1 area)	Butte	*Limnanthes floccosa* ssp. *californica* vernal pool fairy shrimp vernal pool tadpole shrimp	Priority 1 because center of concentration for *Limnanthes floccosa* ssp. *californica*.	1
Honcut (2 areas)	Butte, Yuba	no listed taxa covered in this recovery plan ---------- *Juncus leiospermus* var. *ahartii*		2
Oroville (1 area)	Butte	*Chamaesyce hooveri* *Limnanthes floccosa* ssp. *californica* *Orcuttia pilosa* *Tuctoria mucronata* vernal pool fairy shrimp vernal pool tadpole shrimp	Includes Shippee area. Priority 1 because center of concentration for *Limnanthes floccosa* ssp. *californica*.	1
Palermo (1 area)	Butte	*Orcuttia tenuis*	Between Honcut and Richvale core areas.	2
Richvale (1 area)	Butte	*Tuctoria mucronata*		2
Llano Seco (1 area)	Butte	vernal pool fairy shrimp vernal pool tadpole shrimp ---------- *Astragalus tener* var. *ferrisiae*	Priority 1 due to presence of *Astragalus tener* var. *ferrisiae*.	1

Core Area Name	County	Listed and Proposed Taxa ---------- Taxa of Concern	Comments	Priority[1]
Upper Butte Basin (1 area)	Butte	*Astragalus tener* var. *ferrisiae*	Priority 1 due to presence of *Astragalus tener* var. *ferrisiae*.	1
Vina Plains (1 area)	Butte Tehama	*Chamaesyce hooveri* *Limnanthes floccosa* ssp. *californica* *Orcuttia pilosa* *Orcuttia tenuis* *Tuctoria mucronata* Conservancy fairy shrimp vernal pool fairy shrimp vernal pool tadpole shrimp ---------- *Gratiola heterosepala* California fairy shrimp	Priority 1 due to presence of Conservancy fairy shrimp and *Limnanthes floccosa* ssp. *californica*. Includes Rock Creek.	1
NORTHWESTERN SACRAMENTO VALLEY VERNAL POOL REGION				
Black Butte (1 area)	Tehama	no listed taxa covered in this recovery plan ---------- *Gratiola heterosepala* *Legenere limosa*	Between Orland and Red Bluff core areas.	2
Millville Plains (1 area)	Shasta	*Orcuttia tenuis*	East of Redding and Stillwater Plains areas.	2
Orland (1 area)	Tehama	vernal pool fairy shrimp		2
Red Bluff (1 area)	Tehama	vernal pool fairy shrimp vernal pool tadpole shrimp ---------- *Gratiola heterosepala* *Legenere limosa* California fairy shrimp	Includes Thomes Creek Ecological Reserve and private lands.	2

Core Area Name	County	Listed and Proposed Taxa ---------- Taxa of Concern	Comments	Priority[1]
Redding (3 areas)	Shasta	*Orcuttia tenuis* vernal pool fairy shrimp vernal pool tadpole shrimp ---------- *Legenere limosa* California fairy shrimp	Includes Stillwater Plain area.	2
SAN JOAQUIN VALLEY VERNAL POOL REGION				
Caswell (1 area)	Stanislaus	Conservancy fairy shrimp vernal pool fairy shrimp ---------- California fairy shrimp	Includes San Joaquin River National Wildlife Refuge. *Myosurus minimus* var. *apus* last reported in 1952. Reintroduction may be necessary.	1
Grassland Ecological (13 areas)	Merced	*Chamaesyce hooveri* *Neostapfia colusana* Conservancy fairy shrimp longhorn fairy shrimp vernal pool fairy shrimp vernal pool tadpole shrimp ---------- *Astragalus tener* var. *tener* *Atriplex persistens* midvalley fairy shrimp California fairy shrimp western spadefoot toad	Includes Kesterson, San Luis, and Merced National Wildlife Refuges; Great Valley Grasslands State Park; and private lands. *Myosurus minimus* var. *apus* last reported in 1952. Reintroduction may be necessary.	1
Pixley (2 areas)	Tulare	vernal pool fairy shrimp ---------- western spadefoot toad	Includes Pixley National Wildlife Refuge and Pixley Vernal Pools Preserve.	2

Core Area Name	County	Listed and Proposed Taxa ---------- Taxa of Concern	Comments	Priority[1]
Cross Creek (1 area)	Tulare, Kings	vernal pool fairy shrimp vernal pool tadpole shrimp ---------- western spadefoot toad		2
SANTA BARBARA VERNAL POOL REGION				
Lake Cachuma (1 area)	Santa Barbara	vernal pool fairy shrimp		2
Ventura County (1 area)	Ventura	Conservancy fairy shrimp vernal pool fairy shrimp	In Los Padres National Forest.	2
SOLANO-COLUSA VERNAL POOL REGION				
Collinsville (1 area)	Solano	Conservancy fairy shrimp vernal pool tadpole shrimp ---------- *Astragalus tener* var. *tener*		1
Davis Communications Annex (1 area)	Yolo	*Neostapfia colusana* *Tuctoria mucronata* vernal pool tadpole shrimp ---------- *Astragalus tener* var. *tener*		1
Dolan (2 areas)	Colusa	vernal pool tadpole shrimp ---------- *Astragalus tener* var. *ferrisiae*		2

Core Area Name	County	Listed and Proposed Taxa ---------- Taxa of Concern	Comments	Priority[1]
Jepson Prairie (1 area)	Solano	*Neostapfia colusana* *Lasthenia conjugens* *Tuctoria mucronata* delta green ground beetle Conservancy fairy shrimp vernal pool fairy shrimp vernal pool tadpole shrimp ---------- *Astragalus tener* var. *tener* *Atriplex persistens* *Gratiola heterosepala* *Legenere limosa* midvalley fairy shrimp California fairy shrimp	Includes Jepson Prairie Preserve, Calhoun Cut Ecological Reserve, Glide Tule Ranch, parts of Travis Air Force Base, and other public and private lands.	1
Montezuma Hills (1 area)	Solano	no listed taxa covered in this recovery plan ---------- *Plagiobothrys hystriculus*	Priority 1 due to presence of only known location of *Plagiobothrys hystriculus*.	1
Rodeo Creek (1 area)	Contra Costa	*Lasthenia conjugens*		2
Sacramento National Wildlife Refuge (11 areas)	Colusa Glenn	*Chamaesyce hooveri* *Orcuttia pilosa* *Tuctoria mucronata* Conservancy fairy shrimp vernal pool fairy shrimp vernal pool tadpole shrimp ---------- *Astragalus tener* var. *ferrisiae* *Atriplex persistens*	Includes nearby private lands. Priority 1 due to the presence of Conservancy fairy shrimp and *Astragalus tener* var. *ferrisiae*.	1

Core Area Name	County	Listed and Proposed Taxa ---------- Taxa of Concern	Comments	Priority[1]
Suisun Marsh (2 areas)	Solano	*Lasthenia conjugens* ---------- *Astragalus tener* var. *tener*		2
Vacaville (1 area)	Solano	vernal pool fairy shrimp		2
Woodland (1 area)	Yolo	no listed taxa covered in this recovery plan ---------- *Astragalus tener* var. *tener*		2
SOUTHEASTERN SACRAMENTO VERNAL POOL REGION				
Beale (1 area)	Yuba	Conservancy fairy shrimp vernal pool fairy shrimp vernal pool tadpole shrimp ---------- California fairy shrimp *Legenere limosa*	Includes Beale Air Force Base, Bureau of Land Management, and private lands.	2
Cosumnes/Rancho Seco (1 area)	Sacramento, Amador	*Orcuttia viscida* vernal pool fairy shrimp vernal pool tadpole shrimp ---------- *Legenere limosa* California fairy shrimp midvalley fairy shrimp western spadefoot toad	Includes Cosumnes River Preserve, Rancho Seco, Howard Ranch, Valensin Ranch, Clay Station mitigation bank, Borden Ranch mitigation site, and other private lands.	1
Jenny Lind (1 area)	Calaveras	no listed taxa covered in this recovery plan ---------- *Juncus leiospermus* var. *ahartii*		2

Core Area Name	County	Listed and Proposed Taxa ---------- Taxa of Concern	Comments	Priority[1]
Mather (1 area)	Sacramento	*Orcuttia tenuis* *Orcuttia viscida* vernal pool fairy shrimp vernal pool tadpole shrimp ---------- *Gratiola heterosepala* *Juncus leiospermus* var. *ahartii* *Legenere limosa* midvalley fairy shrimp California fairy shrimp western spadefoot toad	Includes Mather Regional Park, the former Mather Air Force Base, Sunrise Douglas Conservation Bank, Arroyo Seco Conservation Bank, Churchill Downs mitigation area, Teichert mitigation area, and private lands	1
Phoenix Field and Phoenix Park (1 area)	Sacramento	*Orcuttia viscida* vernal pool tadpole shrimp vernal pool fairy shrimp ---------- California fairy shrimp western spadefoot toad		1
Southeast Sacramento Valley (1 area)	San Joaquin	*Castilleja campestris* ssp. *succulenta*	Includes University of California Angraves Nature Study Area.	2
Stone Lake (1 area)	Sacramento	no listed taxa covered in this recovery plan ---------- *Legenere limosa*		2

Core Area Name	County	Listed and Proposed Taxa ---------- Taxa of Concern	Comments	Priority[1]
Western Placer County (2 areas)	Placer, Sacramento	vernal pool fairy shrimp vernal pool tadpole shrimp ---------- *Gratiola heterosepala* *Juncus leiospermus* var. *ahartii* *Legenere limosa* California fairy shrimp western spadefoot toad	Includes Ahart Preserve, Orchard Creek Conservation Bank, and private lands.	2
SOUTHERN SIERRA FOOTHILLS VERNAL POOL REGION				
Farmington (1 area)	Stanislaus, Tuolumne	*Neostapfia colusana* ---------- western spadefoot toad	Historical locality for *Tuctoria mucronata*; population last reported in 1936. Reintroduction may be necessary.	2
Fresno (3 areas)	Fresno	*Castilleja campestris* ssp. *succulenta* *Tuctoria mucronata* *Orcuttia inaequalis* vernal pool fairy shrimp ---------- *Eryngium spinosepalum* midvalley fairy shrimp California fairy shrimp western spadefoot toad		2
San Joaquin (1 area)	San Joaquin, Stanislaus	vernal pool fairy shrimp ---------- western spadefoot toad		2

Core Area Name	County	Listed and Proposed Taxa ---------- Taxa of Concern	Comments	Priority[1]
Kaweah (2 areas)	Tulare	no listed taxa covered in this recovery plan ---------- *Eryngium spinosepalum*		2
Kings (3 areas)	Fresno Tulare	no listed taxa covered in this recovery plan ---------- *Eryngium spinosepalum*		2
Madera (7 areas)	Merced, Madera, Mariposa	*Castilleja campestris* ssp. *succulenta* *Neostapfia colusana* *Orcuttia inaequalis* *Orcuttia pilosa* *Tuctoria mucronata* Conservancy fairy shrimp vernal pool fairy shrimp vernal pool tadpole shrimp ---------- *Gratiola heterosepala* *Eryngium spinosepalum* California fairy shrimp midvalley fairy shrimp western spadefoot toad	Priority 1 due to presence of Conservancy fairy shrimp	1

Core Area Name	County	Listed and Proposed Taxa ---------- Taxa of Concern	Comments	Priority[1]
Merced (2 areas)	Stanislaus, Tuolumne	*Castilleja campestris* ssp. *succulenta* *Chamaesyce hooveri* *Neostapfia colusana* *Tuctoria mucronata* *Orcuttia pilosa* vernal pool fairy shrimp vernal pool tadpole shrimp ---------- California fairy shrimp western spadefoot toad		1
Shotgun Creek (1 area)	Tuolumne Calaveras	no listed taxa covered in this recovery plan ---------- *Eryngium spinosepalum*		2
Table Mountain (2 areas)	Fresno Madera	*Castilleja campestris* ssp. *succulenta* *Orcuttia inaequalis* vernal pool fairy shrimp vernal pool tadpole shrimp ---------- *Gratiola heterosepala* *Eryngium spinosepalum* California fairy shrimp	Includes Big Table and Kennedy Table.	1
Tulare (2 areas)	Tulare	*Chamaesyce hooveri* *Orcuttia inaequalis* ---------- *Eryngium spinosepalum*	Includes Stone Corral and Sequoia Field Ecological Reserves, and Cross Creek area	2

Core Area Name	County	Listed and Proposed Taxa ---------- Taxa of Concern	Comments	Priority[1]
Turlock (2 areas)	Stanislaus	vernal pool fairy shrimp *Neostapfia colusana* *Orcuttia pilosa* *Chamaesyce hooveri*	Includes Hickman vernal pool complex.	2
Yokohl (2 areas)	Tulare	no listed taxa covered in this recovery plan ---------- *Eryngium spinosepalum*		2
Lake Success (1 area)	Tulare	no listed taxa covered in this recovery plan ---------- *Eryngium spinosepalum*		2
Cottonwood Creek (3 areas)	Tulare	*Chamaesyce hooveri* vernal pool fairy shrimp vernal pool tadpole shrimp ---------- *Eryngium spinosepalum* western spadefoot toad		2
Waterford (1 area)	Stanislaus	*Neostapfia colusana* *Tuctoria mucronata*		2
WESTERN RIVERSIDE COUNTY VERNAL POOL REGION				
Harford Springs (1 area)	Riverside	no listed taxa covered in this recovery plan ---------- *Myosurus minimus* var. *apus*	In the Riverside Management Area of the Recovery Plan for Vernal Pools of Southern California (U.S. Fish and Wildlife Service 1998b).	2
San Jacinto-Hemet (4 areas)	Riverside	vernal pool fairy shrimp ---------- *Myosurus minimus* var. *apus* western spadefoot toad	In the Riverside Management Area of the Recovery Plan for Vernal Pools of Southern California (U.S. Fish and Wildlife Service 1998b).	2

Core Area Name	County	Listed and Proposed Taxa ---------- Taxa of Concern	Comments	Priority[1]
Santa Rosa Plateau (1 area)	Riverside	vernal pool fairy shrimp ---------- *Myosurus minimus* var. *apus*	In the Riverside Management Area of the Recovery Plan for Vernal Pools of Southern California (U.S. Fish and Wildlife Service 1998b).	2
Skunk Hollow (1 area)	Riverside	vernal pool fairy shrimp		2
SAN DIEGO VERNAL POOL REGION				
Tierrasanta south (1 area)	San Diego	no listed taxa covered in this recovery plan ---------- *Myosurus minimus* var. *apus*	Includes Penasquitos and Tierrasanta areas. See Recovery Plan for Vernal Pools of Southern California (U.S. Fish and Wildlife Service 1998b).	2
Ramona (1 area)	San Diego	no listed taxa covered in this recovery plan ---------- *Myosurus minimus* var. *apus* western spadefoot toad	Includes Ramona area. See Recovery Plan for Vernal Pools of Southern California (U.S. Fish and Wildlife Service 1998b).	2
Otay Mesa (1 area)	San Diego	no listed taxa covered in this recovery plan ---------- *Myosurus minimus* var. *apus*	Includes Chula Vista, Otay Mesa, Marron Valley. See Recovery Plan for Vernal Pools of Southern California (U.S. Fish and Wildlife Service 1998b).	2

[1] Priority designations were assigned according to those species or localities representing the rarest species/genetics, most unique conditions, highest biodiversity, and greatest threat of destruction.

1.4.1.2 Protect species occurrences and their vernal pool habitat in Priority 2 core areas. (Priority 2)

1.4.1.3 Protect species occurrences and their vernal pool habitat in Priority 3 core areas. (Priority 3)

1.4.1.4 Protect species occurrences and their vernal pool habitat that do not occur within a core area, but do occur within a vernal pool region. (Priority 3)

1.4.1.5 Protect all other species occurrences and their vernal pool habitat that do not occur within a vernal pool region, but do contribute to recovery and long-term conservation of species addressed in this draft recovery plan. (Priority 3)

1.4.2 Ensure State and local agencies managing land use their authorities to protect habitat and promote the recovery and conservation of the species addressed in this draft recovery plan.

For example, State and local agencies can enter into cooperative partnerships, ensure adequate management plans are developed and implemented, or develop conservation programs through the Natural Community Conservation Planning process.

1.4.2.1 Protect species occurrences and their vernal pool habitat in Priority 1 core areas. (Priority 1)

1.4.2.2 Protect species occurrences and their vernal pool habitat in Priority 2 core areas. (Priority 2)

1.4.2.3 Protect species occurrences and their vernal pool habitat in Priority 3 core areas. (Priority 3)

1.4.2.4 Protect species occurrences and their vernal pool habitat that do not occur within a core area, but do occur within a vernal pool region. (Priority 3)

1.4.2.5 Protect all other species occurrences and their vernal pool habitat that does not occur within a

vernal pool region, but do contribute to recovery and long-term conservation of species addressed in this draft recovery plan. (Priority 3)

1.4.3 Work with willing private landowners with current conservation easements to implement management measures or practices to protect vernal pool habitat and promote the recovery and conservation of the species addressed in this draft recovery plan.

For example, agencies or private entities responsible for overseeing existing conservation agreements can conduct periodic reviews of existing agreements, update agreements as necessary, and conduct periodic site visits on private lands.

1.4.3.1 Protect species occurrences and their vernal pool habitat in Priority 1 core areas. (Priority 1)

1.4.3.2 Protect species occurrences and their vernal pool habitat in Priority 2 core areas. (Priority 2)

1.4.3.3 Protect species occurrences and their vernal pool habitat in Priority 3 core areas. (Priority 3)

1.4.3.4 Protect species occurrences and their vernal pool habitat that do not occur within a core area, but do occur within a vernal pool region. (Priority 3)

1.4.3.5 Protect all other species occurrences and their vernal pool habitat that does not occur within a vernal pool region, but do contribute to recovery and long-term conservation of species addressed in this draft recovery plan. (Priority 3)

1.4.4 As appropriate, protect habitat through acquisition of private land from willing sellers, new conservation agreements with willing private landowners, or other protection mechanisms (Appendix F) to promote the recovery and conservation of the species addressed in this draft recovery plan.

1.4.4.1 Protect species occurrences and their vernal pool habitat in Priority 1 core areas. (Priority 1)

1.4.4.2 Protect species occurrences and their vernal pool habitat in Priority 2 core areas. (Priority 2)

1.4.4.3 Protect species occurrences and their vernal pool habitat in Priority 3 core areas. (Priority 3)

1.4.4.4 Protect species occurrences and their vernal pool habitat that do not occur within a core area, but do occur within a vernal pool region. (Priority 3)

1.4.4.5 Protect all other species occurrences and their vernal pool habitat that does not occur within a vernal pool region, but do contribute to recovery and long-term conservation of species addressed in this draft recovery plan. (Priority 3)

2 Manage, restore, and monitor vernal pool habitat to promote the recovery of listed species and the long-term conservation of the species of concern.

Protecting vernal pool habitat from further destruction or fragmentation is merely the first step in the recovery strategy presented in this draft recovery plan. Following protection, the habitat must be managed and monitored to ensure the protected habitat is functioning properly and contributing to the recovery of the listed species and the long-term conservation of the species of concern. This management may include maintaining historical management regimes when appropriate for listed and special status species. In specific instances, it may be necessary to restore the habitat prior to being able to properly manage it for the benefit of vernal pool species.

2.1 Conduct interim habitat management to maintain, stabilize, or enhance ecosystem function and declining populations.

Each protected site will be subjected to threats that should be addressed while long-term, comprehensive habitat management plans are being compiled, reviewed, revised, and developed (Action 2.3), and additional research (Action 4) is underway; otherwise, the damage to these sites and the vernal pool biota present may be irreversible. In some cases, the appropriate

interim habitat management is obvious and should be implemented. In other cases, scoping should begin to evaluate possible interim habitat management measures, their effectiveness, and their relative implementation costs. Stabilization may include managing habitat to enhance and/or restore vernal pool function; reintroducing or enhancing seeds, vernal pool branchiopod cysts or mature individuals, pollinators or other symbionts; or other actions. If populations are enhanced by adding seeds, cysts, or mature individuals, only genotypes and ecotypes similar to the existing population should be used (see Action 4.1.1). In some cases amplifying populations under laboratory conditions may be preferable.

2.1.1 Ensure Federal agencies managing land use their authorities to conduct interim management to promote the recovery of listed species and the long-term conservation of the species of concern addressed in this draft recovery plan.

2.1.1.1 Conduct interim management on lands in Priority 1 core areas. (Priority 1)

2.1.1.2 Conduct interim management on lands in Priority 2 core areas. (Priority 2)

2.1.1.3 Conduct interim management on lands in Priority 3 core areas. (Priority 3)

2.1.1.4 Conduct interim management on lands that do not occur in a core area, but do occur within a vernal pool region. (Priority 3)

2.1.1.5 Conduct interim management on lands that do not occur within a vernal pool region, but do contribute to recovery and long-term conservation of the species addressed in this draft recovery plan. (Priority 3)

2.1.2 Ensure State and local agencies managing land use their authorities to conduct interim management to promote the recovery of listed species and the long-term conservation of the species of concern addressed in this draft recovery plan.

2.1.2.1 Conduct interim management on lands in Priority 1 core areas. (Priority 1)

2.1.2.2 Conduct interim management on lands in Priority 2 core areas. (Priority 2)

2.1.2.3 Conduct interim management on lands in Priority 3 core areas. (Priority 3)

2.1.2.4 Conduct interim management on lands that do not occur in a core area, but do occur within a vernal pool region. (Priority 3)

2.1.2.5 Conduct interim management on lands that do not occur within a vernal pool region, but do contribute to recovery and long-term conservation of the species addressed in this draft recovery plan. (Priority 3)

2.1.3 Ensure private landowners with existing conservation agreements are conducting interim management to promote the recovery of listed species and long-term conservation of the species of concern addressed in this draft recovery plan.

2.1.3.1 Conduct interim management on lands in Priority 1 core areas. (Priority 1)

2.1.3.2 Conduct interim management on lands in Priority 2 core areas. (Priority 2)

2.1.3.3 Conduct interim management on lands in Priority 3 core areas. (Priority 3)

2.1.3.4 Conduct interim management on lands that do not occur in a core area, but do occur within a vernal pool region. (Priority 3)

2.1.3.5 Conduct interim management on lands that do not occur within a vernal pool region, but do contribute to recovery and long-term conservation of the species addressed in this draft recovery plan. (Priority 3)

2.2 Develop and implement standardized monitoring techniques to evaluate ecosystem function and response, species response, and threat response to interim management activities.

Standardized monitoring techniques need to be developed to ensure consistency and continuity of data between observers and over time. Standardized monitoring must be based on multiple criteria. No single criterion will reliably measure trends consistently over time. Standardized monitoring techniques should include criteria such as the degree of habitat fragmentation, degree of threat, shifts in vegetation type, establishment and extirpation of plant and animal occurrences, number of individuals, photopoints, estimates of acreage occupied, density, co-occurring species including nonnatives, time since last disturbance, and some estimate of seedbank or cystbank dynamics.

Baseline conditions of habitat, species, and threats responsible for effects on ecosystem function and species decline must be documented prior to implementing changes to interim habitat management techniques.

2.2.1 Develop standardized monitoring techniques to evaluate ecosystem function and response, species response, and threat response to interim management activities. (Priority 2)

Per Action 2.1, conduct interim habitat management activities to maintain, stabilize, or enhance ecosystem function and declining populations during the development of standardized monitoring techniques.

2.2.2 Implement standardized monitoring to document ecosystem and species responses to interim habitat management activities. (Priority 2)

It may be necessary to modify interim habitat management activities according to monitoring results. This strategy is referred to as “adaptive” management and it is essential to the recovery and long-term conservation of vernal pool species as new information becomes available.

Castilleja campestris ssp. *succulenta*, *Chamaesyce hooveri*, *Lasthenia conjugens*, *Tuctoria mucronata*, *Neostapfia colusana*, *Tuctoria mucronata*, *Astragalus tener* var. *ferrisiae*, *Astragalus tener* var. *tener*, *Navarretia leucocephala* ssp. *pauciflora*, and *Legenere limosa* require interim monitoring at 13 different locations (**Table IV-2**) because they are small populations and are the only representatives from a given vernal pool region or vernal pool type. Monitoring and subsequent protection of these populations prior to completion of other recovery actions for those species is necessary to ensure the species distributions throughout their range.

2.3 Compile, review, develop, and implement existing long-term, comprehensive habitat management and monitoring plans, where necessary, for all land contributing to the recovery and long-term conservation of vernal pool species.

2.3.1 Compile, review, and analyze existing long-term, comprehensive habitat management and monitoring plans, or pertinent information from those plans, as necessary. (Priority 2)

Compiling existing habitat management and monitoring plans and/or pertinent information from those plans is essential for understanding what exists, what is relevant and useful, and what needs to be developed in the future. One alternative to actually compiling existing long-term, comprehensive habitat management and monitoring plans is to develop a standardized survey form with specific questions or requests for information about existing long-term, comprehensive habitat management and monitoring plans. These surveys can be sent to all land managers and the responses analyzed to determine gaps in plan development.

2.3.2 Where necessary, develop new, or improve existing, long-term, comprehensive habitat management and monitoring plans.

Long-term, comprehensive habitat management and monitoring plans are necessary to ensure that protected

lands are managed to ameliorate and eliminate the threats that caused the species addressed in this draft recovery plan to become listed or species of concern. Long-term, comprehensive habitat management and monitoring plans should be developed and implemented to address habitat management activities (*e.g.*, prescriptions for control or removal of invasive species), existing threats (*e.g.*, habitat degradation due to inappropriate levels of recreational use), species and habitat responses to habitat management activities, incorporation of monitoring results into habitat management plans, and schedule for the completion of operations and maintenance of ongoing routine tasks and one-time tasks.

The development of a long-term, comprehensive habitat management and monitoring plan is imperative. For example, military installations that have vernal pool conservation areas that are currently being managed and monitored, may not have permanent long-term conservation strategies in place. If an installation were subject to closure, there would be no guarantee that conservation of these areas would continue after the military presence departed the installation. A long-term, comprehensive habitat management and monitoring plan that included the use of conservation easements, for example, would ensure that these habitats are protected in perpetuity, regardless of the military presence at the installation.

Land managers should ensure that mechanisms (*e.g.*, funding, personnel, *etc.*) are not only in place, but are fully implemented to facilitate the development of long-term, comprehensive habitat management and monitoring plans.

Long-term, comprehensive habitat management and monitoring plans should be reviewed regularly and adjusted as necessary to maximize the potential for survival, conservation, and recovery of listed species and the species of concern addressed in this draft recovery plan. This process of evaluating and adjusting management and monitoring activities as needed is termed “adaptive

management". Results of new biological research also should be considered in adaptive management.

2.3.2.1 Ensure Federal agencies managing land use their authorities to develop new, or improve existing, long-term, comprehensive habitat management and monitoring plans to the benefit of species addressed in this draft recovery plan. (Priority 1)

2.3.2.2 Ensure State and local agencies managing land use their authorities to develop new, or improve existing, long-term, comprehensive habitat management and monitoring plans to the benefit of species addressed in this draft recovery plan. (Priority 1)

2.3.2.3 Ensure private landowners with existing conservation agreements develop new, or improve existing, long-term, comprehensive habitat management and monitoring plans to the benefit of species addressed in this draft recovery plan. (Priority 1)

2.3.2.4 Ensure responsible parties of newly protected lands develop new, long-term, comprehensive habitat management and monitoring plans to the benefit of species addressed in this draft recovery plan. (Priority 1)

2.3.3 Implement existing, and any newly developed or revised, long-term, comprehensive habitat management and monitoring plans.

2.3.3.1 Ensure Federal agencies managing land are implementing existing, and any newly developed or revised, long-term, comprehensive habitat management and monitoring plans to the fullest extent of their authorities.

2.3.3.1.1 Implement existing and any newly developed or revised, long-term comprehensive habitat management and

monitoring plans on lands in Priority 1 core areas. (Priority 1)

2.3.3.1.2 Implement existing and any newly developed or revised, long-term comprehensive habitat management and monitoring plans on lands in Priority 2 core areas. (Priority 2)

2.3.3.1.3 Implement existing and any newly developed or revised, long-term comprehensive habitat management and monitoring plans on lands in Priority 3 core areas. (Priority 3)

2.3.3.1.4 Implement existing and any newly developed or revised, long-term comprehensive habitat management and monitoring plans on lands that do not occur within a core area, but do occur within a vernal pool region. (Priority 3)

2.3.3.1.5 Implement existing and any newly developed or revised, long-term comprehensive habitat management and monitoring plans on lands that do not occur within a vernal pool region, but do contribute to recovery and long-term conservation of species addressed in this draft recovery plan. (Priority 3)

2.3.3.2 Ensure State and local agencies managing land are implementing existing, and any newly developed or revised, long-term, comprehensive habitat management and monitoring plans to the fullest extent of their authorities.

2.3.3.2.1 Implement existing and any newly developed or revised, long-term comprehensive habitat management and monitoring plans on lands in Priority 1 core areas. (Priority 1)

2.3.3.2.2 Implement existing and any newly developed or revised, long-term comprehensive habitat management and monitoring plans on lands in Priority 2 core areas. (Priority 2)

2.3.3.2.3 Implement existing and any newly developed or revised, long-term comprehensive habitat management and monitoring plans on lands in Priority 3 core areas. (Priority 3)

2.3.3.2.4 Implement existing and any newly developed or revised, long-term comprehensive habitat management and monitoring plans on lands that do not occur within a core area, but do occur within a vernal pool region. (Priority 3)

2.3.3.2.5 Implement existing and any newly developed or revised, long-term comprehensive habitat management and monitoring plans on lands that do not occur within a vernal pool region, but do contribute to recovery and long-term conservation of species addressed in this draft recovery plan. (Priority 3)

2.3.3.3 Ensure private landowners with existing conservation agreements are implementing existing, and any newly developed or revised, long-term, comprehensive habitat management and monitoring plans to the fullest extent possible.

2.3.3.3.1 Implement existing and any newly developed or revised, long-term comprehensive habitat management and monitoring plans on lands in Priority 1 core areas. (Priority 1)

2.3.3.3.2 Implement existing and any newly developed or revised, long-term comprehensive habitat management and monitoring plans on lands in Priority 2 core areas. (Priority 2)

2.3.3.3.3 Implement existing and any newly developed or revised, long-term comprehensive habitat management and monitoring plans on lands in Priority 3 core areas. (Priority 3)

2.3.3.3.4 Implement existing and any newly developed or revised, long-term comprehensive habitat management and monitoring plans on lands that do not occur within a core area, but do occur within a vernal pool region. (Priority 3)

2.3.3.3.5 Implement existing and any newly developed or revised, long-term comprehensive habitat management and monitoring plans on lands that do not occur within a vernal pool region, but do contribute to recovery and long-term conservation of species addressed in this draft recovery plan. (Priority 3)

2.3.3.4 Ensure responsible parties of newly protected lands implement any newly developed long-term, comprehensive habitat management and monitoring plans to the benefit of species addressed in this draft recovery plan.

2.3.3.4.1 Implement existing and any newly developed or revised, long-term comprehensive habitat management and monitoring plans on lands in Priority 1 core areas. (Priority 1)

2.3.3.4.2 Implement existing and any newly developed or revised, long-term

comprehensive habitat management and monitoring plans on lands in Priority 2 core areas. (Priority 2)

2.3.3.4.3 Implement existing and any newly developed or revised, long-term comprehensive habitat management and monitoring plans on lands in Priority 3 core areas. (Priority 3)

2.3.3.4.4 Implement existing and any newly developed or revised, long-term comprehensive habitat management and monitoring plans on lands that do not occur within a core area, but do occur within a vernal pool region. (Priority 3)

2.3.3.4.5 Implement existing and any newly developed or revised, long-term comprehensive habitat management and monitoring plans on lands that do not occur within a vernal pool region, but do contribute to recovery and long-term conservation of species addressed in this draft recovery plan. (Priority 3)

2.4 Enhance, restore, and create vernal pool habitats, as necessary, to promote the recovery and long-term conservation of the species addressed in this draft recovery plan.

Enhancement, restoration, and creation of vernal pool habitat may be necessary when natural vernal pools representing certain ecological conditions have been degraded or destroyed. In all cases practicable, existing pools should be used as a model for enhancement, restoration, and creation.

Vernal pools should only be created when enhancement and restoration activities are not sufficient, and where creation is ecologically appropriate. Pools should not be created within existing vernal pool landscapes because of the risk of disrupting hydrologic function and the surrounding upland habitat that is important to many vernal pool species.

2.4.1 Establish scientifically based, and site-specific appropriate, mechanisms and success criteria for the enhancement, restoration, and creation of vernal pool habitat.

Both the actual mechanisms and the success criteria for enhancement, restoration, and creation of vernal pool habitat may differ from one vernal pool region to another based on geographic, topographic and edaphic characteristics of the individual pools. However, they should be developed as uniformly as possible (*i.e.*, standardized) to minimize ambiguity between regions. Also, mechanisms and success criteria should have both Federal and State interagency endorsement to ensure they are regionally applicable and accepted.

2.4.1.1 Review existing enhancement, restoration, and creation mechanisms and success criteria. (Priority 3)

2.4.1.2 In coordination with the Sacramento Fish and Wildlife Office, and if necessary, develop scientifically based and site-specific appropriate mechanisms and success criteria based on review of existing mechanisms and the results of ecological research. (Priority 3)

2.4.2 Establish scientifically based, and site-specific appropriate, mechanisms and success criteria for the collection, storage, and use of soil containing shrimp cysts for the purpose of inoculating restored or created vernal pool habitat.

Both the actual mechanisms and the success criteria for collection, storage, and use of vernal pool soils containing shrimp cysts may differ from one vernal pool region to another based on topographic and edaphic characteristics of the individual pools and the biological needs of the target species. However, the mechanisms and success criteria should be developed as uniformly as possible (*i.e.*, standardized) to minimize ambiguity between regions. Also, mechanisms and success criteria should have both

Federal and State interagency endorsement to ensure they are regionally applicable and accepted.

2.4.2.1 Review existing mechanisms of collection of soils bearing shrimp cysts, storage, and application and success criteria. (Priority 3)

2.4.2.2 In coordination with the Sacramento Fish and Wildlife Office, and if necessary, develop scientifically based and site-specific appropriate mechanisms and success criteria based on review of existing mechanisms and the results of ecological research. (Priority 3)

2.4.3 Collect vernal pool soils bearing shrimp cysts.

2.4.3.1 In coordination with the Sacramento Fish and Wildlife Office, develop a prioritized list of sites from which shrimp cysts need to be collected to further the recovery and long-term conservation of vernal pool species. (Priority 3)

2.4.3.2 Implement introduction of cyst-bearing soils to restored or created habitat based on scientifically sound, and site-specific appropriate, mechanisms. (Priority 3)

2.4.3.3 Apply success criteria in a monitoring program to determine if cysts hatch and complete full life cycle of the shrimp. (Priority 3)

It may be necessary to modify cyst-bearing soil collection, storage, or application mechanisms and success criteria, as necessary, to achieve recovery and long-term conservation of the species addressed in this draft recovery plan. This “adaptive” approach is essential to the recovery and long-term conservation of vernal pool species as new information becomes available.

2.4.4 Enhance, restore, and/or create vernal pool habitat.

2.4.4.1 In coordination with the Sacramento Fish and Wildlife Office, develop a prioritized list of sites that need to be enhanced, restored, and/or created to further the recovery and long-term conservation of vernal pool species. (Priority 3)

2.4.4.2 In coordination with the Sacramento Fish and Wildlife Office, develop a prioritized list of which aspects of the vernal pool ecosystem function need to be enhanced, restored, and/or created. (Priority 3)

For example, does a site need pools created, upland habitat or swale restoration, *etc.*

2.4.4.3 Implement vernal pool enhancement, restoration, and creation activities based on scientifically sound, and site-specific appropriate, mechanisms. (Priority 3)

2.4.4.4 Apply success criteria in a monitoring program to determine if species and ecosystem respond positively to the enhancement, restoration, and/or creation effort. (Priority 3)

It may be necessary to modify enhancement, restoration, and/or creation mechanisms and success criteria, as necessary, to achieve recovery and long-term conservation of the species addressed in this draft recovery plan. This "adaptive" approach is essential to the recovery and long-term conservation of vernal pool species as new information becomes available.

2.5 Develop and implement reintroduction and introduction programs to restore extirpated populations and protect individual species from the threat of extirpation due to random environmental and/or genetic events.

As a last resort, when necessary, species reintroductions and introductions have utility as part of a sound recovery strategy. Conservation of vernal pool plants and animals requires increasing

their survival prospects, despite foreseeable events. Off-site or ex-situ methods can make the difference between survival and extinction, by preventing unique genotypes from disappearing altogether. While accession of seeds or cysts can be an important component of a comprehensive recovery strategy, it is by no means meant to replace conservation of populations in their natural habitat (in-situ). Ex-situ work is intended to support in-situ conservation. Collection, storage, and propagation of seeds and cysts should only be conducted as a last resort, where necessary to preserve rare or unique genotypes or occurrences in danger of extirpation from stochastic events and only if all other methods of conservation have been insufficient.

Prior to undertaking reintroduction or introduction efforts for extirpated species, genetics studies should be conducted to ensure that new populations will not disrupt unique local gene complexes (Action 4.1.1). Plant reintroductions and introductions should be completed using locally collected seeds or plant propagules grown from locally collected seeds. Animal species reintroductions and introductions should follow the same general principal of protecting local genetic variation by using only local sources of species for stocking programs. In the case where reintroductions and introductions must be conducted using propagated individuals, our policy regarding controlled propagation (U.S. Fish and Wildlife Service 2000*b*) must be followed.

Reintroduction should only be conducted where the species has been extirpated from extant habitat. Introduction (to new localities) should only be done when previously occupied localities are no longer suitable, thus, the introduction serves as a local "surrogate" population to the occurrence it is intended to replace.

2.5.1 Conduct seed collection and banking, as necessary, for plant species covered in this draft recovery plan.

Plant taxa for which seed banking is necessary are given in **Table IV-3**. Priority 1 is given to taxa known only from one or two locations. Priority 2 is given to the disjunct populations of plants that occur in more than two locations.

Table IV-3. Vernal pool plants that require seed collection and storage.

Species	Priority Number
Castilleja campestris ssp. *succulenta*[1]	2
Chamaesyce hooveri[1]: in Stanislaus and Tulare Counties all other locations	 1 2
Eryngium constancei [2]	1
Lasthenia conjugens [1]	2
Limnanthes floccosa ssp. *californica*[1]	2
Navarretia leucocephala ssp. *pauciflora* [2]	1
Navarretia leucocephala ssp. *plieantha* [2]	1
Orcuttia inaequalis[1]	2
Neostapfia colusana[1]: in Solano and Yolo Counties in all other locations	 1 2
Orcuttia pilosa[1]	2
Orcuttia tenuis[1]: in Sacramento County in all other locations	 1 2
Orcuttia viscida [2]	1
Parvisedum leiocarpum [2]	1
Tuctoria mucronata[1]	2
Tuctoria mucronata [2]	1
Astragalus tener var. *ferrisiae* [2]	2
Astragalus tener var. *tener*[1]	2
Atriplex persistens[1]	2
Eryngium spinosepalum[1]	2
Gratiola heterosepala[1]	2
Juncus leiospermus var. *ahartii* [2]	2
Legenere limosa[1]	2
Myosurus minimus var. *apus*[1]	2
Navarretia myersii ssp. *deminuta* [3]	1
Plagiobothrys hystriculus [3]	1

[1] = One collection shall be conducted per core area.
[2] = Collections shall be made from all extant occurrences.
[3] = Collections shall be made from the single extant occurrence.

Initially, seeds should be banked from at least one population in each core area. For plant taxa with 10 extant occurrences or fewer, seeds should be banked from every known occurrence. After genetic studies are completed (Action 4.1.1), additional collections should be made from each population that contains unique genotypes. Repeated, small collections of seed may be necessary over several years to avoid contributing to the decline of very small populations. The Center for Plant Conservation (1991) detailed the considerations for seed collection in its "Genetic Sampling Guidelines for Conservation Collections of Endangered Plants." Seed collections from each population of each taxon should be stored in at least two sites, including the National Center for Genetic Resources Preservation in Fort Collins, Colorado, and a facility certified by the Center for Plant Conservation.

2.5.1.1 Review existing seed bank collections, as needed, to determine need to collect seeds and the number of seeds necessary. (Priority 1)

Seed collections for plant taxa should be representative of both population and species-level genetic diversity.

2.5.1.2 Conduct Priority 1 seed collection and banking as identified in **Table IV-3**, if necessary. (Priority 1)

2.5.1.3 Conduct Priority 2 seed collection and banking as identified in **Table IV-3**, if necessary. (Priority 2)

2.5.2 Conduct collection of soil containing cysts for use in inoculation of created or restored vernal pool habitat, as necessary, for shrimp species covered in this draft recovery plan.

Shrimp taxa for which cyst-bearing soil collection may be necessary are given in **Table IV-4**.

Initially, cyst-bearing soils should be collected from at least one population in each core area. For shrimp taxa with 10 extant occurrences or fewer, soils should be collected from

every known occurrence. After genetic studies are completed (Action 4.1.1), additional collections should be made from each population that contains unique genotypes.

2.5.2.1 Review history of collection of cyst-bearing soils, as needed, to determine need to collect cysts and the number of cysts necessary. (Priority 1)

Cyst collections for shrimp taxa should be representative of both population and species-level genetic diversity.

2.5.2.2 Conduct Priority 1 cyst-bearing soil collection as identified in **Table IV-4**, if necessary. (Priority 1)

2.5.2.3 Conduct Priority 2 cyst-bearing soil collection as identified in **Table IV-4**, if necessary. (Priority 2)

2.5.2.4 Conduct Priority 3 cyst-bearing soil collection as identified in **Table IV-4**, if necessary. (Priority 3)

Table IV-4. Vernal pool shrimp that require collection of cyst-bearing soils.

Species	Priority Number
Conservancy fairy shrimp	1
Longhorn fairy shrimp	1
Vernal pool fairy shrimp	2
Vernal pool tadpole shrimp	2
Midvalley fairy shrimp	2
California fairy shrimp	3

2.5.3 Conduct controlled propagation for reintroductions and/or introductions of plant species, as appropriate.

According to our policy (U.S. Fish and Wildlife Service 2000), a good controlled propagation plan will identify measurable objectives and milestones for the proposed propagation and reintroduction/introduction plan. The controlled propagation plan should be based on strategies identified in the approved recovery plan and include

protocols for health management, disease-free certification, monitoring and evaluation of genetic, demographic, life-history, phenotypic, and behavioral characteristics, data collection, recordkeeping, and reporting, as appropriate.

2.5.3.1 Prepare a controlled propagation plan for Priority 1 reintroductions and introductions indicated in **Table IV-5** and **Table IV-6**, respectively. (Priority 1)

2.5.3.2 Prepare a controlled propagation plan for Priority 2 reintroductions and introductions indicated in **Table IV-5** and **Table IV-6**, respectively. (Priority 2)

2.5.3.3 Prepare a controlled propagation plan for Priority 3 reintroductions and introductions indicated in **Table IV-5** and **Table IV-6**, respectively. (Priority 3)

2.5.3.4 If necessary, conduct germination trials for reintroductions and introductions. (Priority 3)

2.5.3.5 Propagate plants for Priority 1 reintroductions and introductions indicated in **Table IV-5** and **Table IV-6**, respectively. (Priority 1)

2.5.3.6 Propagate plants for Priority 2 reintroductions and introductions indicated in **Table IV-5** and **Table IV-6**, respectively. (Priority 2)

2.5.3.7 Propagate plants for Priority 3 reintroductions and introductions indicated in **Table IV-5** and **Table IV-6**, respectively. (Priority 3)

2.5.4 Reintroduce/introduce and monitor plant species at appropriate sites.

Preparation required prior to reintroduction/introduction work includes a thorough review of existing literature on reintroduction/introduction mechanisms and success criteria for plant species. If applicable information does not exist, scientifically based and site-specific reintroduction/introduction mechanisms and success

Table IV-5. Plant species for which reintroductions should be planned and implemented[1].

Species	Vernal Pool Region	Location	CNDDB Element Occurrence	Priority
Lasthenia conjugens	Lake-Napa	Milliken Canyon	#21	3
Neostapfia colusana	San Joaquin Valley	Arena Plains Unit of Merced NWR	#51, #52	3
Orcuttia viscida	SE Sacramento Valley	Orangevale-Folsom Rancho Seco	#4 #16	2
Tuctoria mucronata	Solano-Colusa	Olcott Lake	#1	1
Orcuttia pilosa	Southern Sierra Nevada	Stanislaus, Merced and Madera Counties	Many	2
Limnanthes floccosa ssp. *californica*	NE Sacramento Valley	Shippee Diesel	#6 #39	2
Navarretia leucocephala ssp. *pauciflora*	Lake-Napa	Jordan Park	#10	2

[1] See the Draft Santa Rosa Plains Recovery Plan (in development) for information regarding reintroduction of *Navarretia leucocephala* ssp. *plieantha* in the Santa Rosa area.

Table IV-6. Plant species for which introductions should be planned and implemented.

Species	Soils	Region	Replaces Element Occurrence #	Priority
Lasthenia conjugens	Haire loam	Lake-Napa Vernal Pool Region	2	3
	Linne clay loam	Livermore Vernal Pool Region	12	
	Crispin loam	Mendocino Vernal Pool Region	16	
	Concepcion fine sandy loam	Santa Barbara Vernal Pool Region	18	
	Los Osos complex	Need not be in a vernal pool region	10	
	Los Robles clay loam	Need not be in a vernal pool region	11	
	Rincon clay loam	Need not be in a vernal pool region	8	
Neostapfia colusana	NA	Colusa County portion of the Solano-Colusa Vernal Pool Region	13	3
	Bear Creek	Southern Sierra Foothills Vernal Pool Region	7 and 61	
Orcuttia inaequalis	Los Robles clay loam	Southern Sierra Foothills Vernal Pool Region	22	3
Tuctoria mucronata	San Joaquin loam	Southern Sierra Foothills Vernal Pool Region	20	3
	San Joaquin sandy loam	Southern Sierra Foothills Vernal Pool Region	22	
	Archerdale clay loam	Southern Sierra Foothills Vernal Pool Region	8	
	Exeter sandy loam	Southern Sierra Foothills Vernal Pool Region	15	
	Ramona loam	Southern Sierra Foothills Vernal Pool Region	16 and 17	
Astragalus tener var. *ferrisiae*	Corning gravelly loam	Solano-Colusa Vernal Pool Region	5	3
	Westfan loam	Solano-Colusa Vernal Pool Region	9	

Species	Soils	Region	Replaces Element Occurrence #	Priority
Astragalus tener var. *tener*[1]	Antioch very fine sandy loam	Central Coast Vernal Pool Region	1	3
	Solano loam	Livermore Vernal Pool Region	9	
	Scribner	San Joaquin Valley Vernal Pool Region	10	
	Orthents	Need not be in a vernal pool region	19	
Navarretia myersii ssp. *deminuta*	appropriate soils	Lake County portion of the Lake-Napa Vernal Pool Region	NA	1
other plant taxa as necessary	appropriate soils	Any Region	NA	3

[1] See the Draft Santa Rosa Plains Recovery Plan (in development) for introduction of this species in the Santa Rosa area

criteria for plant species need to be developed, in coordination with the Sacramento Fish and Wildlife Office. These mechanisms and success criteria need to be based on a review of existing literature and the results of research.

2.5.4.1 Conduct Priority 1 reintroductions and introductions as indicated in **Table IV-5** and **Table IV-6**, respectively. (Priority 1)

2.5.4.2 Conduct Priority 2 reintroductions and introductions as indicated in **Table IV-5** and **Table IV-6**, respectively. (Priority 2)

2.5.4.3 Conduct Priority 3 reintroductions and introductions as indicated in **Table IV-5** and **Table IV-6**, respectively. (Priority 3)

2.5.4.4 Monitor Priority 1 reintroductions and/or introductions. (Priority 1)

2.5.4.5 Monitor Priority 2 reintroductions and/or introductions. (Priority 2)

2.5.4.6 Monitor Priority 3 reintroductions and/or introductions. (Priority 3)

2.5.4.7 Apply success criteria to reintroductions and/or introductions and modify techniques as necessary to achieve recovery and long-term conservation of vernal pool species. (Priority 3)

2.5.5 Reintroduce/introduce and monitor shrimp species at appropriate sites.

Preparation required prior to reintroduction/introduction work includes a thorough review of existing literature on reintroduction/introduction mechanisms and success criteria for shrimp species. If applicable information does not exist, scientifically based and site-specific reintroduction/introduction mechanisms and success criteria for shrimp species need to be developed, in coordination with the Sacramento Fish and Wildlife Office. These mechanisms and success criteria need to be based on a review of existing literature and the results of research.

2.5.5.1 Determine appropriate locations for reintroduction/introduction of the shrimp species covered in this plan. (Priority 1)

2.5.5.2 Conduct Priority 1 reintroductions and introductions as indicated in **Table IV-4**. (Priority 1)

2.5.5.3 Conduct Priority 2 reintroductions and introductions as indicated in **Table IV-4**. (Priority 2)

2.5.5.4 Conduct Priority 3 reintroductions and introductions as indicated in **Table IV-4**. (Priority 3)

2.5.5.5 Monitor Priority 1 reintroductions and/or introductions. (Priority 1)

2.5.5.6 Monitor Priority 2 reintroductions and/or introductions. (Priority 2)

2.5.5.7 Monitor Priority 3 reintroductions and/or introductions. (Priority 3)

2.5.5.8 Apply success criteria to reintroductions and/or introductions and modify techniques as necessary to achieve recovery and long-term conservation of vernal pool species. (Priority 3)

2.5.6 Reintroduce and monitor delta green ground beetle at appropriate sites.

2.5.6.1 Reintroduce delta green ground beetle to appropriate sites (*i.e.*, historical locations that are likely to support populations). (Priority 2)

Reintroduction of delta green ground beetle entails identification of and procurement of appropriate reintroduction sites, determination of need for symbionts, and determination of ecologically and genetically appropriate source material.

2.5.6.2 Monitor delta green ground beetle reintroductions. (Priority 2)

3. Conduct range-wide status surveys and status reviews for all species addressed in this draft recovery plan to determine species statuses and progress toward achieving recovery of listed species and long-term conservation of species of concern.

A status survey is a detailed process comprising a literature review, and examination of herbarium or museum specimens, and a series of surveys conducted throughout a species' range. All historical localities of a species are identified, potential locations where the species may occur are predicted based on distributional and ecological data, all historical and potential locations are surveyed for presence of a species at the appropriate time of year, all known and newly identified locations are surveyed to determine species population sizes and status of threats, and recommendations for improving conservation efforts are made for each locality.

Information from status surveys would be used to conduct status reviews (*e.g.*, 5-year reviews, candidate species reviews) to determine whether a species has met its recovery criteria and warrants downlisting or delisting, or in the case of a species of concern, warrants listing.

3.1 Develop standardized, species-specific guidance for conducting range-wide status surveys for all species addressed in this draft recovery plan.

Where possible, suites of species should be combined within the same guidance (*e.g.*, vernal pool branchiopods, spring flowering plant species, summer flowering plant species, *etc.*).

A standardized, scientifically based methodology should be developed to conduct range-wide status surveys for each species. It is important to use a standardized methodology to ensure consistency and continuity of data between observers, between vernal pool regions, and over time. Standardized status surveys should establish parameters that 1) evaluate population sizes to determine overall trends in species statuses rangewide (*e.g.*, populations stable or increasing), 2) evaluate presence of a species at a historical location or a potential location, 3) evaluate type and degree of existing, and newly identified, site-specific threats to species throughout a significant portion of their range, and 4) collect additional data, as necessary, on species occurrences throughout their range. Standardized surveys must be based on multiple parameters as no single parameter will reliably measure trends consistently over time. Standardized surveys may measure parameters such as the degree of habitat loss or fragmentation, type and degree of threat, shifts in vegetation type, establishment and extirpation of plant and animal occurrences, number of individuals or populations, photopoints, estimates of acreage occupied, density, co-occurring species including nonnatives, time since last disturbance, and some estimate of seedbank or cystbank dynamics (is seedbank stable, depleted, being replenished, *etc.*).

3.1.1 Review existing species survey guidance to determine whether such guidance is adequate. (Priority 1)

3.1.2 If necessary, revise existing guidance or develop new standardized, scientifically based, and species-specific survey guidance. (Priority 1)

3.2 Conduct directed species status surveys.

Status surveys should be conducted at the vernal pool region scale, starting within core areas and working outward to the vernal pool region boundary. Populations within a vernal pool region cannot be reclassified or delisted independently, therefore, status surveys at the vernal pool region scale ensure all vernal pool regions meet the criteria prior to proposing a reclassification or delisting.

3.2.1 Identify and prioritize areas within each vernal pool region, starting with core areas, to conduct standardized status surveys. (Priority 1)

The subset of sites to be surveyed must contribute to a status survey adequate to assess whether a species is stable or declining.

Areas to be surveyed within vernal pool regions that contribute to the recovery of a species should be determined based on the following parameters: 1) core areas; 2) known and newly identified localities of each species within each vernal pool region; 3) historic localities of each species within each vernal pool region; 4) potential habitat locations identified thru implementation of Action 1.2; 5) species statuses within each vernal pool region (*e.g.*, surveying a subset of localities for wide-ranging species versus all known localities for narrowly distributed species); 6) recovery criteria/goals for each species, and 7) standardized survey guidance as developed above in Action 3.1.

Recovery of listed species and long-term conservation of the species of concern addressed in this draft recovery plan may often require relocating historic populations or locating new populations of these species in potential habitat. Historical locations should be surveyed to determine whether suitable habitat remains, the species persists at the sites, and/or the sites may be suitable for repatriation. Suitability of historical locations for repatriation would depend upon (1) whether potential habitat exists, (2) the presence and magnitude of threats, (3) whether the sites can be secured and managed for the

long-term protection of the species and, (4) whether repatriation of the site is necessary to maintain genetic or geographic diversity and/or increase connectivity between larger protected areas. Surveys should also include other potential habitat to determine whether undiscovered populations may exist. If new populations are discovered, they need to be protected and managed as discussed above. During the surveys, potential introduction sites should also be identified.

3.2.2 Conduct standardized status surveys within each vernal pool region, starting with core areas. (Priority 1)

This action is linked to Action 1.3 so it should be completed and implemented concurrently.

3.3 Periodically review progress toward listed species recovery and long-term conservation of species of concern and identify those species warranting a change in status (downlisting, delisting, uplisting, or listing).

These reviews should be based on results of standardized status surveys and other information from research, habitat protection, management, and monitoring actions.

3.3.1 Compile most recent status reviews, or comparable evaluations, for each species and develop a prioritized list for status reviews of the species addressed in this draft recovery plan. (Priority 2)

3.3.2 Conduct status reviews of listed species by vernal pool region (see draft U.S. Fish and Wildlife Service guidance). (Priority 2)

3.3.3 Conduct status reviews of species of concern by vernal pool region. (Priority 3)

3.4 Conduct post-delisting monitoring of recovered species.

4 Conduct research and use results to refine recovery actions and criteria, and guide overall recovery and long-term conservation efforts.

4.1 Conduct research on species addressed in this draft recovery plan.

4.1.1 Conduct research on genetics necessary to make informed habitat protection and management decisions.

Priorities for genetics studies are as follows: 1) species that require reintroduction and/or introduction; 2) species that will require seed or cyst banking because of high risk of extirpations due to random events; 3) species/populations that have experienced extreme reductions in range and/or populations numbers that may now require genetic management to offset deleterious effects of genetic drift, bottlenecks and inbreeding depression, *etc.*

4.1.1.1 Conduct genetics analysis on species slated for reintroductions and introductions (*i.e.,* species requiring seed or cyst banking). (Priority 2)

Refer to **Tables IV-5 and IV-6** for a list of species we are recommending be reintroduced or introduced.

4.1.1.2 In coordination with us, compile and review existing information on genetic and population structure of remaining vernal pool species, and develop a prioritized list of species requiring additional genetics studies to assist in making management decisions. (Priority 3)

4.1.1.3 Conduct genetics analysis on remaining vernal pool species, as necessary. (Priority 2)

Consider other information that can indicate genetic structure, such as morphology, that could be used to inform management decisions without need to conduct additional genetic studies. Ensure all genetic studies are applicable to achieving recovery goals and objectives.

4.1.2 Conduct research on biosystematics.

Taxonomic research is not typically a recovery action, but the distribution of several taxa in this draft recovery plan is uncertain due to confusion over their identification and taxonomy. The lack of certainty concerning the distribution of several taxa of concern has precluded the possibility of listing under the Endangered Species Act. Some uncertainty also remains among listed taxa, particularly those for which populations intermediate in morphology are known. Biosystematic research, including DNA analysis, is needed for these taxa as a whole, or for specified populations, where noted.

4.1.2.1 *Limnanthes floccosa* ssp. *californica*. (Priority 2)

Determine if the historical populations at Nord (Element Occurrence #13) and 10 miles north of Chico (unnumbered) are actually this taxon.

4.1.2.2 *Navarretia leucocephala* spp. complex. (Priority 3)

4.1.2.3 *Astragalus tener* spp. complex. (Priority 3)

4.1.2.4 *Eryngium spinosepalum* spp. complex. (Priority 3)

4.1.2.5 *Myosurus minimus* var. *apus* complex. (Priority 3)

4.1.3 Conduct research on primary dispersal mechanism(s) for vernal pool plants and animals.

Existing data on the dispersal mechanisms of vernal pool species is limited, or in many cases, nonexistent. For a population to survive, individuals must pass their genes on to subsequent generations and colonize appropriate habitat. For plants, this entails dispersal of seeds and pollen. For vernal pool branchiopods this entails dispersing cysts. For species such as the western spadefoot toad, this involves juvenile and adult dispersal to and from breeding locations.

In the absence of data regarding dispersal mechanisms for vernal pool species, there is no appropriate manner to ensure decisions about reserve size and location, habitat management activities, and corridor establishment between

reserves function properly to provide for adequate gene flow to promote population viability. Since much of this information is unknown for a majority of the species covered in this draft recovery plan, we recommend the actions below.

Preparation required prior to dispersal mechanism research includes a thorough review of existing literature on dispersal mechanisms and distances for vernal pool species. Related species will need to be considered where information on listed species does not exist. Known dispersal mechanisms for some species may not be important in other species. For example, some plants are obligate self-fertilizers so gene flow is extremely low, some seeds do not lend themselves to any kind of dispersal mechanism, and dispersal may not be important for species with a very narrow range of environmental tolerances.

4.1.3.1 In coordination with us, and in conjunction with the priorities listed below for specific plant categories or species, develop a prioritized list, by species, of additional research needs on dispersal mechanisms. (Priority 2)

4.1.3.2 Implement research on dispersal mechanisms (see **Table IV-7** for life history categories of plants).

4.1.3.2.1 On annual plants

4.1.3.2.1.1 *Astragalus tener* var. *ferrisiae* and *Navarretia myersii* ssp. *deminuta* (Priority 2)

4.1.3.2.1.2 *Tuctoria mucronata* (Priority 2)

4.1.3.2.2 On perennial plants (*Eryngium* sp.) (Priority 2)

Table IV-7. Life history categories of vernal pool plants (see Action 4.1.3.2)

Species	Comments
Annual herb	*Castilleja campestris* ssp. *succulenta*, *Chamaesyce hooveri*, *Lasthenia conjugens*, *Limnanthes floccosa* ssp. *californica*, *Navarretia leucocephala* ssp. *pauciflora* , *Navarretia leucocephala* ssp. *plieantha*, *Parvisedum leiocarpum*, *Astragalus tener* var. *ferrisiae*, *Astragalus tener* var. *tener*, *Atriplex persistens*, *Gratiola heterosepala*, *Juncus leiospermus* var. *ahartii*, *Legenere limosa*, *Myosurus minimus* var. *apus*, *Navarretia myersii* ssp. *deminuta*, *Plagiobothrys hystriculus*
Annual grass	*Orcuttia inaequalis*, *Neostapfia colusana*, *Orcuttia pilosa*, *Orcuttia tenuis*, *Orcuttia viscida*, *Tuctoria mucronata*, *Tuctoria mucronata*
Annual / perennial herb	*Eryngium constancei*, *Eryngium spinosepalum*

4.1.3.2.3 On branchiopods

4.1.3.2.3.1 Vernal pool fairy shrimp (Priority 1)

4.1.3.2.3.2 California fairy shrimp (Priority 3)

4.1.3.2.4 On delta green ground beetle (Priority 1)

4.1.3.2.5 On western spadefoot toad (Priority 2)

4.1.4 Conduct research on basic biology and ecology of each species, as necessary, to support recovery and long-term conservation efforts.

Preparation required prior to conducting this action includes compiling and reviewing existing literature on the basic biology and ecology of the covered species.

4.1.4.1 In coordination with us, determine and prioritize research needed to inform management and habitat protection decisions. (Priority 2)

4.1.4.2 Conduct research based on priorities ensuring that the research is essential to the recovery or long-term conservation of the species. (Priority 2)

4.1.5 Conduct research on the effects of environmental factors, as necessary, affecting the recovery and long-term conservation of vernal pool species.

Research aspects pertinent to vernal pool species recovery and long-term conservation (*e.g.*, threat amelioration for reintroduction sites, choosing appropriate sites for introductions, *etc.*) include: the range of environmental tolerances of vernal pool animal species to physical (*e.g.*, temperature, depth) and chemical (*e.g.*, pH) characteristics of vernal pools, including synergistic effects, across full geographic range, and environmental conditions such as vernal pool type, soil type, and landform, at current and historical occurrences of each taxon.

Preparation required prior to conducting this action includes compiling and reviewing existing literature on the range of environmental tolerances of the covered species.

4.1.5.1 In coordination with us, determine and prioritize research needed to inform management and habitat protection decisions. (Priority 2)

Priorities should be given to species that will be reintroduced or introduced, or to species for which defining potential habitat and locating new populations is important.

4.1.5.2 Conduct research based on priorities ensuring that the research is essential to the recovery or long-term conservation of the species. (Priority 2)

4.1.6 Perform Population Viability Analysis, demographic monitoring/modeling or other analyses as appropriate to

evaluate the probability of long-term survival, adequacy of management and efficacy of recovery criteria.

Population viability analysis and demographic modeling is the use of quantitative methods to analyze the environmental and demographic factors that affect the survival of populations. Population viability analyses and demographic modeling usually require detailed and specific life history information, such as recruitment, survival, reproductive rates, mortality, and immigration and emigration rates. Some models also require detailed information on extinction and recolonization rates of metapopulations. Modeling of a population's viability over the long-term also requires an understanding of environmental factors (natural or human-made) that affect the populations, their impacts, and their probabilities of occurrence.

Population viability analyses may be used to refine recovery criteria and actions in a number of ways. Population viability analyses may be used to estimate time to extinction to indicate urgency of recovery efforts; establish parameters that should be examined for long-term population monitoring; assess monitoring data to determine recovery success; and identify particular life history stages or demographic processes that are sensitive to management actions or to particular threats and that may require specific management. Population viability analyses or demographic monitoring may not be appropriate or feasible for all species or for all populations of an individual species. The long-lived seed and cyst stages of many of the species addressed in this plan may be especially difficult to model because of the difficulty in gathering data adequate to characterize population size and demography of these life stages. Examination of feasibility of conducting analyses and application of analyses to refining management, recovery criteria and actions, and threat reduction actions is required before expending resources as these actions may be very time- and resource-intensive.

Preparation required prior to conducting this action includes a thorough review of existing literature on performing population viability analyses or demographic modeling. In

addition, data gaps must be identified. In coordination with us, it must also be determined whether a population viability analysis, or demographic monitoring approach, is appropriate or feasible, and readily applicable to refinement of management actions, recovery criteria and actions, and methods used to reduce threats.

During this preparation, rarity of species, risk of losing them, management sensitivity/conflicting uses, suitability of the species to the techniques, and availability of monitoring and research resources should be considered. Also considered should be species life histories and whether species demographics are easily monitored and characterized (difficult for species with long-lived seedbanks, very short or very long life-spans, episodic reproduction, or large populations on heterogeneous habitats). The number and types of assumptions that must be made to conduct a model and likelihood of validity of assumptions (*e.g.*, model assumes no immigration, but no data exists for the species and you suspect dispersal via grazing animals) should be considered.

If population viability analysis or demographic modeling is appropriate, the types of data that should be collected in order to perform the population viability analysis or modeling and develop demographic monitoring or data collection plans need to be determined.

Types of population viability analyses vary in the complexity, quantity, and types of data needed. Prior to initiating efforts to develop a population viability analysis or demographic monitoring program, the adequacy of existing data for conducting population viability analyses should be evaluated. In addition, the types of data that research methodologies can effectively gather should be examined to determine the types of population viability analyses that can realistically be conducted for the species. Finally, appropriate data necessary to conduct population viability analyses into population monitoring and other research activities needs to be collected..

4.1.6.1 In coordination with the Sacramento Fish and Wildlife Office, develop a prioritized list of species that would benefit the most from conducting a population viability analysis. (Priority 2)

4.1.6.2 Conduct population viability analyses as sufficient data is accumulated and apply results to refine recovery actions and criteria, habitat management, and threat reduction actions. (Priority 2)

As sufficient data is gathered, population viability analyses should be conducted and used to evaluate the status of the covered animal populations and modify recovery criteria and recovery actions where appropriate.

4.2 Conduct research on the effects of habitat management practices on vernal pool species and their habitat, and incorporate into management plans developed under Action 2.2.

4.2.1 Conduct research to determine minimum reserve size in order to maintain ecosystem function and population viability of vernal pool species. (Priority 3)

Limiting factors of vernal pool plants, vernal pool branchiopods, the delta green ground beetle, and western spadefoot toad should be considered in determining minimum reserve sizes.

4.2.2 Determine the role and effects of fire in functioning vernal pool ecosystems in relation to component native species. (Priority 3)

4.2.3 Determine the role and effects of livestock grazing in functioning vernal pool ecosystems in relation to component native species. (Priority 3)

Managing grazing is essential to maintaining ecosystem function, especially since most remaining habitat is grazed.

4.2.4 Conduct research into techniques and determination of success criteria for enhancement, restoration, and creation, including feasibility of reintroductions and introductions.

4.2.4.1 Preparation required prior to conducting this action includes compiling and reviewing existing literature on vernal pool enhancement, restoration, and creation.

4.2.4.2 Modify ecologically-based success criteria for enhancement, restoration, and creation (Action 2.4) that define functional vernal pool ecosystems, as necessary, as results from research and monitoring become available. (Priority 3)

4.2.4.3 Develop hydrologic models to predict effects of hydrologic modifications in various situations. (Priority 3)

4.2.4.4 Investigate methods for restoring vernal pool ecosystems that have been degraded by human activities and incorporate results into restoration and management plans. The goal of restoration will be to achieve the level of function defined through Action 4.2.4.2.

4.2.4.4.1 Investigate methods for restoring vernal pool ecosystems that have been degraded by alterations in topography or hydrology, such as leveling, draining, temporary and permanent impoundments, inundation by runoff, contaminants, or inundation by wastewater application. (Priority 3)

4.2.4.5 Conduct research on use of human-made vernal pool wetlands by vernal pool species and compare with natural wetlands. (Priority 3)

4.3 Conduct research on threats to vernal pool species and ecosystems.

4.3.1 Research the effects of environmental contaminants on vernal pools, ecosystem function, and individual species. (Priority 2)

Scientific studies should be conducted to determine the tolerance of listed animals and animal species of concern to contaminants. Contaminants that vernal pool species typically may come in contact with include pesticides and herbicides and those found in urban and agricultural runoff (oil, fertilizers, dust, *etc*.).

4.3.2 Investigate methods for remediating contamination by toxic substances and restoring vernal pool ecosystems and implement methods at the following sites:

4.3.2.1 Lead at the former Castle Air Force Base. (Priority 2)

4.3.2.2 Herbicides, salt, and industrial chemicals at Davis Communications Annex. (Priority 1)

4.3.2.3 Poultry manure at Arena Plains Unit of Merced National Wildlife Refuge. (Priority 2)

4.3.2.4 Other contaminated vernal pool sites identified through threats monitoring activities. (Priority 2)

4.3.3 Study impacts of low frequency noises and vibrations on the western spadefoot toad. (Priority 3)

4.3.4 Determine influence of nonnative aquatic vertebrate predators (bullfrogs, mosquitofish) on population dynamics across full geographic range of vernal pool branchiopods, delta green ground beetle and the western spadefoot toad. (Priority 3)

4.3.5 Determine pollinators and their habitat requirements of vernal pool plants to ensure that essential pollinator populations are not lost. Incorporate results into reserve design and habitat protection and management strategies. (Priority 2)

This action is not necessary for the following taxa because they do not require insects for pollination: *Neostapfia colusana*, *Orcuttia* species, *Tuctoria* species, *Juncus leiospermus* var. *ahartii*, and *Gratiola heterosepala*.

4.3.6 Determine degree of threat from, and identify factors contributing to, excessive grasshopper foraging on specified vernal pool plants and develop remedies.

4.3.6.1 *Neostapfia colusana* (Priority 2)

4.3.6.2 *Orcuttia inaequalis* (Priority 2)

4.3.6.3 *Tuctoria mucronata* (Priority 2)

4.3.7 Investigate methods for controlling invasive plants and restoring vernal pool ecosystems that have been degraded by invasive plants (native or nonnative)

Invasive plants that threaten two or more occurrences of covered taxa are listed below. Competition from other invasive plants may affect individual taxa; these plants are combined under the "other" category below. When an invasive plant threatens a covered taxon that has only one or two extant occurrences, the action is assigned Priority 1.

Methods that should be considered to control invasive plants may include fire, grazing, chemicals, tools, hand-pulling, and restoring hydrology. The approach may vary by site, depending on the potential effect on listed taxa in the area, local concerns such as air quality, and costs. Off-site or greenhouse trials should be conducted before the habitat of rare taxa is manipulated. Results from the research should be incorporated within management plans.

4.3.7.1 Investigate methods to control the following invasive plants: *Crypsis schoenoides* (swamp grass), *Glyceria declinata* (mannagrass), *Lepidium latifolium* (whitetop pepperweed), *Malvella leprosa* (alkali-mallow), *Phyla nodiflora* (lippia), and *Salsola* spp. (Russian thistle). (Priority 1)

4.3.7.2 Investigate methods to control the following invasive plants: *Centaurea solstitialis* (yellow star-thistle), *Convolvulus arvensis* (bindweed), *Eleocharis macrostachya* (spikerush), *Hordeum* spp. (barley), *Lolium multiflorum* (Italian ryegrass), *Medicago polymorpha* (California burclover), *Taeniatherum caput-medusae* (medusahead), *Xanthium strumarium* (cocklebur), and other invasive plants. (Priority 2)

5 Develop and implement participation programs.

We strongly believe that a collaborative approach to the proactive protection and management of vernal pool habitat is critical to achieving the goal of recovery of the listed species and long-term conservation of the species of concern addressed in this draft recovery 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.

5.1 Form a single vernal pool recovery implementation team. (Priority 1)

A recovery implementation team consisting of no more than 10 people from a variety of backgrounds including, but not limited to, State and Federal agencies, agriculture (ranchers and farmers), industry (*e.g.*, building, oil, *etc.*), and others should be formed to implement actions necessary to recover the listed species and conserve the species of concern addressed in this draft recovery plan. Since substantial vernal pool habitat occurs on private land, a key to the recovery of the listed species and the conservation of the species of concern is the participation of the private landowners and other interested stakeholders. Any effort to implement recovery actions must include the input and support of private landowners and land managers mentioned above, as well as interested public and stakeholders, species experts, professional and academic researchers, the California Department of Fish and Game, the California Department of Forestry and Fire Protection, California Native Plant Society, the Biological Resources Division of the U. S. Geological Survey, the Bureau of Land Management, the Bureau of Reclamation, and the U. S. Fish and Wildlife Service. Additionally, for technical advice, the invitation and participation should include

invertebrate zoologists, herpetologists, botanists, ecologists, range scientists, fire effects experts, and other experts as appropriate.

The recovery implementation team's mission should be to establish working groups and ensure recovery is being implemented for each vernal pool region through habitat protection and management, species and habitat monitoring, completion of research actions, and through a strong public participation and outreach program. Additionally, the recovery implementation team should advise us of their needs and the needs of the working groups, and offer recommendations to improve the recovery process for the species addressed in this draft recovery plan. The recovery implementation team may be utilized to assist us in updating the recovery plan in the future.

5.2 Form individual working groups for vernal pool regions and develop participation plans for private landowners, non-governmental target audiences, and Federal, State, and local agencies to promote the recovery of listed species and long-term conservation of the species of concern addressed in this draft recovery plan.

5.2.1 Form individual working groups for each vernal pool region. (Priority 1)

The recovery implementation team should form vernal pool region working groups for each vernal pool region, or in the case of smaller vernal pool regions or geographically isolated or distinct vernal pool regions, two or more vernal pool regions can be combined under the responsibility of a single working group. A vernal pool region working group should work cooperatively to implement specific actions necessary to recover the listed species and conserve the species of concern addressed in this draft recovery plan. Additionally, working groups should provide the recovery implementation team with a participation plan and with annual reports of activities including recommendations for future recovery actions or changes to existing actions to benefit species.

5.2.2 Develop a participation plan and submit to recovery implementation team for review. (Priority 3)

5.2.3 Develop participation and outreach programs for private landowners.

The outreach program should focus on providing information to interested and affected landowners about 1) the Endangered Species Act, 2) endangered species recovery, 3) vernal pool habitats and species, 4) species covered in this draft recovery plan, 5) the need for protection and management of vernal pool habitat, 6) how recovery can be achieved, including economic incentives for conservation of rare species, and 7) any vernal pool region-specific issues.

An effective participation and outreach program will 1) promote programs and activities that give private landowners a feeling of "ownership" in the vernal pool recovery process. Rather than dictating to landowners what they must do, an effective participation and outreach program will foster and support a relationship with landowners that deals with what a landowner is capable of doing on their lands; 2) assist landowners in becoming familiar with special status plant and animal species that occur on their land, 3) provide landowners with information, assistance, and access to conservation tools (*e.g.*, Safe Harbor Agreements) that promote the recovery and long-term conservation of the species addressed in this draft recovery plan, and 4) compile, review (and/or develop), and make available to landowners incentive programs that encourage landowners to assist in endangered species recovery and conservation.

Preparation required prior to conducting this action includes compiling and reviewing existing outreach material targeted for private landowners. It may be necessary to revise existing outreach materials, or develop new outreach materials for private landowners.

A mechanism (*e.g.*, funding, *etc.*) should be established to initiate an effective participation and outreach program for private landowners, then outreach materials should be distributed through existing outreach mechanisms (*i.e.*

newsletters, the Internet, annual meetings of organizations, public meetings).

5.2.3.1 Identify private landowners interested in pursuing recovery and conservation efforts on their lands and prioritize a list of potential participants. **Table IV-8** can be used to supplement the prioritized list. (Priority 3)

5.2.3.2 Work with private landowners to develop Safe Harbor Agreements, Candidate Conservation Agreements, Memoranda of Understanding, or other appropriate tools for conserving listed species or species of concern on their lands. (Priority 3)

5.2.4 Develop specialized programs to facilitate cooperation and information dispersal/exchange to target audiences (*e.g.*, California Farm Bureau, University of California Cooperative Extension, Resource Conservation Districts, County and City Planners, California Builders Association, professional societies, *etc.*).

Preparation required prior to conducting this action includes compiling and reviewing existing audience appropriate materials and, if necessary, developing new or additional materials. Also, funds should be allocated to initiate cooperative programs with audience organizations.

5.2.4.1 Initiate cooperative programs with audience organizations. (Priority 3)

5.2.4.2 Develop Safe Harbor Agreements, Candidate Conservation Agreements, Memoranda of Understanding, or other appropriate documents for conserving taxa of concern on conservancy lands (see **Table IV-8**). (Priority 3)

Table IV-8. Potential landowner agreements on conservancy land.

Agency	Species	Priority
Center for Natural Lands Management	*Atriplex persistens*	3
Merced County Farm Trust	*Eryngium spinosepalum*	3
Sierra Foothill Conservancy	*Gratiola heterosepala*	3
Solano County Farmlands and Open Space Foundation	*Astragalus tener* var. *ferrisiae*	1
Solano County Farmlands and Open Space Foundation	*Astragalus tener* var. *tener*, *Atriplex persistens* *Gratiola heterosepala* *Legenere limosa*	3 3 3 3
The Nature Conservancy	*Gratiola heterosepala* *Legenere limosa* *Myosurus minimus* var. *apus*	3 3 3
Trust for Wildland Communities	*Gratiola heterosepala* *Legenere limosa*	3 3
Various Conservancies	For other species as determined by actions 3 and 4.	3

5.2.5 Develop and implement cooperative programs and partnerships with Federal, State, and local agencies to ensure they utilize their authorities to the fullest extent possible to promote the recovery of listed species and the long-term conservation of the species of concern addressed in this draft recovery plan.

5.2.5.1 Develop tools such as Candidate Conservation Agreements, Memoranda of Understanding, or other appropriate documents for conserving taxa of concern on public lands.

5.2.5.1.1 Develop Priority 1 agreements with landowners/land managers (**Table IV-9**).

Table IV-9. Potential landowner/land manager agreements on public land.

Agency	Species	Priority
California Department of Fish and Game	*Astragalus tener* var. *ferrisiae*	1
California Department of Fish and Game	*Astragalus tener* var. *tener* *Atriplex persistens* *Eryngium spinosepalum* *Gratiola heterosepala* *Legenere limosa* *Myosurus minimus* var. *apus*	3 3 3 3 3 3
California Department of Parks and Recreation	*Astragalus tener* var. *tener* *Atriplex persistens*	3 3
California Department of Transportation	*Eryngium spinosepalum*	3
California Department of Water Resources	*Eryngium spinosepalum* *Myosurus minimus* var. *apus*	3 3
U.S. Army Corps of Engineers	*Eryngium spinosepalum*	3
U.S. Bureau of Land Management	*Gratiola heterosepala* *Legenere limosa* *Myosurus minimus* var. *apus*	3 3 3
U.S. Department of Defense	*Astragalus tener* var. *tener* *Myosurus minimus* var. *apus*	3 3
U.S. Forest Service (Lassen and Modoc National Forests)	*Gratiola heterosepala*	3
Don Edwards San Francisco Bay National Wildlife Refuge	*Lasthenia conjugens* vernal pool tadpole shrimp	3 3
Merced National Wildlife Refuge Complex	*Astragalus tener* var. *tener* *Atriplex persistens*	3 3
Sacramento National Wildlife Refuge Complex	*Astragalus tener* var. *ferrisiae*	1
Sacramento National Wildlife Refuge Complex	*Atriplex persistens*	3
Sacramento River National Wildlife Refuge	*Astragalus tener* var. *ferrisiae*	1
City of Oroville	*Juncus leiospermus* var. *ahartii*	2
City of Woodland	*Astragalus tener* var. *tener*	3
County of Riverside	*Myosurus minimus* var. *apus*	2
County of Sacramento	*Gratiola heterosepala* *Legenere limosa*	3 3
County of Sacramento	*Juncus leiospermus* var. *ahartii*	2
County of San Diego	*Myosurus minimus* var. *apus*	3
Kern County Water Authority	*Myosurus minimus* var. *apus*	3
Sacramento Municipal Utility District	*Legenere limosa*	3

5.2.5.1.2 Develop Priority 2 agreements with landowners/land managers (**Table IV-9**).

5.2.5.1.3 Develop Priority 3 agreements with landowners/land managers (**Table IV-9**).

5.2.5.2 Assist lead agencies and districts in incorporating provisions of this draft recovery plan in local decision-making (*e.g.*, General/Specific Plans, mosquito- and flood-control districts). (Priority 3)

5.3 Review status of covered species and draft recovery plan implementation.

The recovery implementation team should provide us with a summary of findings following periodic reviews of recovery efforts to determine the amount of progress towards recovery goals. Approval of this draft recovery plan does not ensure that even the highest-priority actions will be funded. Moreover, certain actions cannot be started until other actions have been completed, and additional recovery criteria may be developed as data accumulate. Actions may need to be re-prioritized if progress is determined to be too slow. Recovery criteria for each will be reconsidered to determine if adjustments or additional criteria are necessary.

5.3.1 Periodically review progress toward recovery of all listed species and identify those species that require a change in status (downlisting, delisting, uplisting) or emergency actions. (Priority 3)

Section 4(c)(2) of the Endangered Species Act requires that we review the status of all listed species at least once every 5 years to determine if changes in status are warranted. However, some taxa addressed in this draft recovery plan are so rare that we are recommending review is warranted sooner (*i.e.*, on a 3 year basis for *Tuctoria mucronata*, *Navarretia myersii* ssp. *deminuta*, and *Plagiobothrys hystriculus*) and the status of taxa that are not currently listed also should be reviewed periodically.

5.3.2 Periodically review the status of species of concern and identify those species that require a change in status (*e.g.*, listing). (Priority 3)

Listing of species of concern covered in this draft recovery plan may be necessary if actions specific to the needs of these species are not undertaken within a reasonable amount of time.

5.3.3 Evaluate progress towards completing recovery actions and adjust recovery implementation efforts accordingly. (Priority 3)

A tracking process should be developed and implemented to track the completion of recovery actions and progress toward delisting, downlisting, or uplisting.

V. IMPLEMENTATION SCHEDULE

The following implementation schedule outlines actions and estimated costs for this recovery plan. It is a guide for meeting the objectives discussed in Chapter III. This schedule describes and prioritizes actions, provides an estimated timetable for performance of actions, indicates the responsible agencies, and estimates costs of performing actions. These actions, when accomplished, should further the recovery and conservation of the covered species.

Key to terms and acronyms used in the Implementation Schedule:

Definition of action priorities:

Priority 1- an action that must be taken to prevent extinction or to prevent a species from declining irreversibly in the foreseeable future.

Priority 2 - an action that must be taken to prevent a significant decline in the species population/habitat quality or some other significant negative impact short of extinction.

Priority 3 - all other actions necessary to meet recovery or conservation objectives.

Definition of action durations:

Continual - An action that will be implemented on a routine basis once begun.

Ongoing - An action that is currently being implemented and will continue until action is no longer necessary.

Unknown - Either action duration or associated costs are not known at this time.

Total costs:

TBD - to be determined

Responsible Parties:

ALL-	All Applicable Entities
BIA-	Bureau of Indian Affairs
BLM -	U.S. Bureau of Land Management
CARCD -	California Association of Resource Conservation Districts
CDFG -	California Department of Fish and Game
CDPR-	California Department of Parks and Recreation
CNPS -	California Native Plant Society
CONS-	Land Conservation Organization
DOD -	Department of Defense (Includes U.S. Army Corps of Engineers)
DWR -	Department of Water Resources
LOC-	County, City or Other Local Government
NRCS-	Natural Resource Conservation Service
OR-	Oregon State
PVT-	Private Contractor
OWN -	Agency or organization that administers or owns each site
STO -	Organization to Store/Propagate Seeds or Cysts (*e.g.*, Rancho Santa Ana Botanic Garden)
SLC -	State Lands Commission
TEAM-	Vernal Pool Recovery Team
TNC -	The Nature Conservancy
UFID-	Utility, Flood or Irrigation District
UNIV -	University
USBR -	U.S. Bureau of Reclamation
USFS-	U.S. Forest Service
USFWS -	U.S. Fish and Wildlife Service

***** - Lead Agency

Implementation Schedule for Draft Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon											
Action Priority	Action Number	Action Description	Action Duration	Responsible Parties[1]	Cost Estimate (in $1,000 units)						Comments/Notes
					Total Costs	FY 1	FY 2	FY 3	FY 4	FY 5	
1	1.1	Develop standardized vernal pool habitat site assessment guidance.	3 months	USFWS, CDFG	32.21	32.21					
1	1.2	Conduct data analysis using Geographic Information Systems, remote sensing, and other techniques to facilitate vernal pool habitat protection efforts.	Every 5 years until delisting or downlisting	USFWS	747.39	64.43					Assumes 58 years for delisting or downlisting
1	1.3.1	Conduct standardized vernal pool habitat site assessments for Carrizo vernal pool region	2.5 years[2]	BLM, USFWS, OWN, CDFG, CNPS, LOC, CONS, DWR	297.36		113.28	113.28	70.8		Cost estimate for 24,694 hectares (61,018 acres)
1	1.3.2	Conduct standardized vernal pool habitat site assessments for Central Coast vernal pool region	5.5 years[2]	BLM, OWN, USFWS, CDFG, CNPS, LOC, DOD, DWR, USFS	623.04		113.28	113.28	113.28	113.28	Cost estimate for 55,628 hectares (137,456 acres)
1	1.3.3	Conduct standardized vernal pool habitat site assessments for Klamath Mountains vernal pool region	4 months[2]	USFWS, OWN, LOC, DOD	70.8		70.8				Cost estimate for 2,832 hectares (6,998 acres)
1	1.3.4	Conduct standardized vernal pool habitat site assessments for Lake-Napa vernal pool region	1.5 years[2]	USFWS, OWN, LOC, DOD, CDFG, CNPS	184.08		113.28	70.8			Cost estimate for 13,262 hectares (32,771 acres)
1	1.3.5	Conduct standardized vernal pool habitat site assessments for Livermore vernal pool region	4 months[2]	USFWS, CDFG, CNPS, LOC, CONS, OWN	70.8		70.8				Cost estimate for 3,208 hectares (7,482 acres)

[1] Suggested primary participants listed.
[2] Action duration based on size of vernal pool region and the amount of time it might take one biologist to conduct a windshield survey of that area.

Implementation Schedule for Draft Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon											
Action Priority	Action Number	Action Description	Action Duration	Responsible Parties[1]	Cost Estimate (in $1,000 units)						Comments/Notes
					Total Costs	FY 1	FY 2	FY 3	FY 4	FY 5	
1	1.3.6	Conduct standardized vernal pool habitat site assessments for Mendocino vernal pool region	2 months[2]	USFWS, CDFG, CNPS, OWN, DOD	35.4		35.4				Cost estimate for 1,066 hectares (2,636 acres)
1	1.3.7	Conduct standardized vernal pool habitat site assessments for Modoc vernal pool region	3 months[2]	USFWS, USFS, OWN, LOC, DOD, CNPS, CDFG, BLM, PVT, UNIV	42.48		42.48				Cost estimate for 1,609 hectares (3,977 acres)
1	1.3.8	Conduct standardized vernal pool habitat site assessments for Northeastern Sacramento Valley vernal pool region	4 years[2]	USFWS, CNPS, TNC, OWN, LOC, DOD, BLM, CDFG, PVT, UNIV, CONS, USFS, DOD, DPR, USBR	453.12		113.28	113.28	113.28	113.28	Cost estimate for 37,616 hectares (92,948 acres)
1	1.3.9	Conduct standardized vernal pool habitat site assessments for Northwestern Sacramento Valley vernal pool region	3 years[2]	USFWS, CDFG, DOD, DPR, CONS, OWN, PVT, UNIV, LOC, USBR	339.84		113.28	113.28	113.28		Cost estimate for 26,777 hectares (66,167 acres)
1	1.3.10	Conduct standardized vernal pool habitat site assessments for San Diego vernal pool region	3 years[2]	USFWS, CDFG, OWN, PVT, UNIV, CONS	339.84		113.28	113.28	113.28		Cost estimate for 30,295 hectares (74,860 acres)

[1] Suggested primary participants listed.
[2] Action duration based on size of vernal pool region and the amount of time it might take one biologist to conduct a windshield survey of that area.

Implementation Schedule for Draft Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon											
Action Priority	Action Number	Action Description	Action Duration	Responsible Parties[1]	Cost Estimate (in $1,000 units)						Comments/Notes
					Total Costs	FY 1	FY 2	FY 3	FY 4	FY 5	
1	1.3.11	Conduct standardized vernal pool habitat site assessments for San Joaquin Valley vernal pool region	1 year[2]	ALL	113.28		113.28				Cost estimate for 8,792 hectares (21,725 acres)
1	1.3.12	Conduct standardized vernal pool habitat site assessments for Santa Barbara vernal pool region	1 year[2]	ALL	113.28		113.28				Cost estimate for 6,839 hectares (16,898 acres)
1	1.3.13	Conduct standardized vernal pool habitat site assessments for Solano-Colusa vernal pool region	4 years 6 months[2]	USFWS, CDFG, LOC, OWN, CNPS, UNIV, TNC	505.51		113.28	113.28	113.28	113.28	Cost estimate for 46,047 hectares (113,781 acres)
1	1.3.14	Conduct standardized vernal pool habitat site assessments for Southeastern Sacramento Valley vernal pool region	5 years[2]	ALL	566.4		113.28	113.28	113.28	113.28	Cost estimate for 71,894 hectares (177,648 acres)
1	1.3.15	Conduct standardized vernal pool habitat site assessments for Southern Sierra Foothills vernal pool region	10 years[2]	ALL	1,132.8		113.28	113.28	113.28	113.28	Cost estimate for 100,124 hectares (247,404 acres)
1	1.3.16	Conduct standardized vernal pool habitat site assessments for Western Riverside County vernal pool region	1 year 2 months[2]	ALL	148.68		113.28	35.4			Cost estimate for 11,019 hectares (27,227 acres)
1	1.4.1.1	Ensure Federal agencies use their authority to protect species occurrences and their vernal pool habitat in Priority 1 core areas.	Until recovery goals obtained	USFWS, BLM, DOD, USBR, BLM,	36,098.84	622.4	622.4	622.4	622.4	622.4	To implement 7(a)(1), 7(a)(2) and other obligations
1	1.4.2.1	Ensure State and local agencies use their authority to protect species occurrences and their vernal pool habitat in Priority 1 core areas.	Until recovery goals obtained	CDFG, CPR, SLC, LOC	59,133.58	1,019.19	1,019.19	1,019.19	1,019.19	1,019.19	To implement section 10 and other obligations

[1] Suggested primary participants listed.
[2] Action duration based on size of vernal pool region and the amount of time it might take one biologist to conduct a windshield survey of that area.

Implementation Schedule for Draft Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon											
					Cost Estimate (in $1,000 units)						
Action Priority	Action Number	Action Description	Action Duration	Responsible Parties[1]	Total Costs	FY 1	FY 2	FY 3	FY 4	FY 5	Comments/Notes
1	1.4.3.1	Ensure existing conservation areas on private lands are managed to protect vernal pool species and habitat in Priority 1 core areas.	Until recovery goals obtained	OWN, CONS, TNC,	14,356.16	247.52	247.52	247.52	247.52	247.52	To implement section 10 and other obligations
1	1.4.4.1	Protect remaining species occurrences and habitat, not currently protected on private land in Priority 1 core areas.	Ongoing	ALL	597,890						Maximum cost based on fee title acquisition for approximately 234,256 hectares (578,838 acres)
1	2.1.1.1	Ensure Federal agencies conduct interim habitat management on lands in Priority 1 core areas.	5 years	USFWS, BLM, DOD, NRCS, USBR	3,111.88	622.4	622.4	622.4	622.4	622.4	Assumes long term management plan is developed and implemented in 5 years
1	2.1.2.1	Ensure State and local agencies conduct interim habitat management on lands in Priority 1 core areas.	5 years	CDFG, CPR, SLC, LOC	5,095.95	1,019.19	1,019.19	1,019.19	1,019.19	1,019.19	Assumes long term management plan is developed and implemented in 5 years
1	2.1.3.1	Ensure private land owners with conservation agreements conduct interim habitat management on lands in Priority 1 core areas	5 years	OWN, CONS, TNC	4,973.92	994.78	994.78	994.78	994.78	994.78	Assumes long term management plan is developed and implemented in 5 years
1	2.3.2.1	Ensure Federal agencies develop or improve existing management and monitoring plans.	5 years	USFWS, BLM, DOD, USBR, NRCS, USFS, BIA	8,201.68	1640.34	1640.34	1640.34	1640.34	1640.34	Concurrent with interim management

[1] Suggested primary participants listed.
[2] Action duration based on size of vernal pool region and the amount of time it might take one biologist to conduct a windshield survey of that area.

Implementation Schedule for Draft Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon											
					Cost Estimate (in $1,000 units)						
Action Priority	Action Number	Action Description	Action Duration	Responsible Parties[1]	Total Costs	FY 1	FY 2	FY 3	FY 4	FY 5	Comments/Notes
1	2.3.2.2	Ensure State and local agencies develop or improve existing management and monitoring plans.	5 years	CDFG, LOC, DWR, DPR, UNIV, UFID	5,039.58	1007.92	1007.92	1007.92	1007.92	1007.92	Concurrent with interim management
1	2.3.2.3	Ensure private land owners with existing conservation agreements develop or improve existing management and monitoring plans.	5 years	OWN, TNC, CONS	1,856.40	371.28	371.28	371.28	371.28	371.28	Concurrent with interim management
1	2.3.2.4	Ensure responsible parties of newly protected lands develop or improve existing management and monitoring plans.	TBD	ALL							
1	2.3.3.1.1	Ensure Federal agencies implement long-term, comprehensive habitat management and monitoring plans on lands in Priority 1 core areas.	Every year until delisting or downlisting	USFWS, BLM, DOD, NRCS, USBR	9,024.42	155.59	155.59	155.59	155.59	155.59	Based on assumed time in field to conduct habitat management each field season
1	2.3.3.2.1	Ensure State and local agencies implement long-term, comprehensive habitat management and monitoring plans on lands in Priority 1 core areas.	Every year until delisting or downlisting	CDFG, CPR, SLC, LOC	13,142.22	226.59	226.59	226.59	226.59	226.59	Based on assumed time in field to conduct habitat management each field season
1	2.3.3.3.1	Ensure private land owners with existing conservation agreements implement long-term, comprehensive habitat management and monitoring plans on lands in Priority 1 core areas.	Every year until delisting or downlisting	OWN, TNC, CONS	3,589.04	61.88	61.88	61.88	61.88	61.88	Based on assumed time in field to conduct habitat management each field season
1	2.3.3.4.1	Ensure responsible parties of newly protected lands implement long-term, comprehensive habitat management and monitoring plans on lands in Priority 1 core areas.	Every year until delisting or downlisting	ALL		TBD					This action will be additive to Actions 2.1.1.1 through 2.3.3.3.5.

[1] Suggested primary participants listed.
[2] Action duration based on size of vernal pool region and the amount of time it might take one biologist to conduct a windshield survey of that area.

Implementation Schedule for Draft Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon											
					Cost Estimate (in $1,000 units)						
Action Priority	**Action Number**	**Action Description**	**Action Duration**	**Responsible Parties[1]**	**Total Costs**	**FY 1**	**FY 2**	**FY 3**	**FY 4**	**FY 5**	**Comments/Notes**
1	2.5.1.1	Review existing seed bank collections, as needed, to determine need to collect seeds and the number of seeds necessary.	3 months	USFWS, CDFG, STO , UNIV	32.21	32.21					
1	2.5.1.2	Conduct Priority 1 seed collection and banking as identified in **Table IV-2**, if necessary.	3 months	STO, UNIV	255.00		255.00				Assumes $15,000 for collection in each region
1	2.5.2.1	Review existing shrimp cyst collections, as needed, to determine need to collect cysts and the number of cysts necessary.	3 months	USFWS, UNIV	32.21	32.21					
1	2.5.2.2	Conduct Priority 1 cyst collection as identified in **Table IV-4**, if necessary.	3 months	UNIV	TBD depends on method						
1	2.5.3.1	Prepare a controlled propagation plan for Priority 1 reintroductions and introductions indicated in **Table IV-5** and **Table IV-6**, respectively.	6 months	USFWS, CDFG	32.21		32.21				Assumes 1/4 of year to develop first controlled propagation plan.
1	2.5.3.5	Propagate plants for Priority 1 reintroductions and introductions indicated in **Table IV-5** and **Table IV-6**, respectively.	6 months	USFWS, STO	4.00			4.00			Assumes $2,000 x 2 species
1	2.5.4.1	Conduct Priority 1 reintroductions and introductions of plants as indicated in **Table IV-5** and **Table IV-6**, respectively.	6 months (site preparation)	USFWS	50.00				50.00		Assumes $25,000 x at least 2 sites
1	2.5.4.4	Monitor Priority 1 reintroductions and/or introductions of plants.	Minimum 5 years per site	USFWS, ALL	169.9	33.98	33.98	33.98	33.98	33.98	Assumes 24 days of monitoring per year per site
1	2.5.5.1	Determine appropriate locations for reintroduction/introduction of shrimp.		USFWS, ALL	TBD						Sites identified by recovery team

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Implementation Schedule for Draft Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon											
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Action Priority	**Action Number**	**Action Description**	**Action Duration**	**Responsible Parties[1]**	**Total Costs**	**FY 1**	**FY 2**	**FY 3**	**FY 4**	**FY 5**	**Comments/Notes**
1	2.5.5.2	Conduct Priority 1 reintroductions and introductions of shrimp as indicated in **Table IV- 4.**		USFWS, UNIV	TBD						Cost will vary depending on no. of sites
1	2.5.5.5	Monitor Priority 1 reintroductions and introductions of shrimp.	Minimum 5 years per site		TBD						Cost will vary depending on no. of sites; may be added to 2.5.4.4
1	3.1.1	Review existing species survey guidance to determine whether such guidance is adequate	3 months	USFWS	32.21	32.21					Assumes cost of one biologist for 1/4 time
1	3.1.2	If necessary, revise existing guidance or develop new standardized, scientifically based, and species-specific survey guidance.	3 months	USFWS	32.21	32.21					Assumes cost of one biologist for 1/4 time
1	3.2.1	Identify and prioritize areas within each vernal pool region, starting with core areas, to conduct standardized status surveys.	6 months	ALL	64.43		64.43				Assumes cost of one biologist for ½ time
1	3.2.2	Conduct standardized status surveys within each vernal pool region, starting with core areas.	10 years	ALL	3,742.41	374.24	374.24	374.24	374.24	374.24	See 1.3.1-1.3.17 above
1	4.1.3.2.3.1	Implement research on dispersal mechanisms of vernal pool fairy shrimp.	1 year	UNIV, PVT	TBD	TBD					
1	4.1.3.2.4	Implement research on dispersal mechanisms of delta green ground beetle.	1 year	UNIV, PVT	TBD	TBD					
1	4.3.2.2	Investigate methods for remediating contamination by herbicides, salt, and industrial chemicals at Davis Communications Annex.	3 years	DOD	800	266.67	266.67	266.67			CERCLA & BRAC responsibility

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					Cost Estimate (in $1,000 units)						
Action Priority	**Action Number**	**Action Description**	**Action Duration**	**Responsible Parties[1]**	**Total Costs**	**FY 1**	**FY 2**	**FY 3**	**FY 4**	**FY 5**	**Comments/Notes**
1	4.3.7.1	Investigate methods to control the following invasive plants: *Crypsis schoenoides*, *Glyceria declinata*, *Lepidium latifolium*, *Phyla nodiflora*, *Salsola* spp.	5 years	PVT, UNIV	375	75	75	75	75	75	Assumes $ 15,000 per species per year
1	5.1	Form a single vernal pool recovery implementation team.	3 months	USFWS, TEAM	32.21	32.21					Assumes staff time cost to organize an implementation team
1	5.2.1	Form individual working groups for each vernal pool region.	1 year	TEAM	32.21	16.11	16.11				Assumes compensation to team members to establish working groups
1	5.2.5.1.1	Develop tools such as Candidate Conservation Agreements, Memoranda of Understanding, or other appropriate documents for Priority 1 conservation of taxa of concern on public lands.	3 months	USFWS	32.21		10.74	10.74	10.74		Cost assumes 1 month of work over the course of one year to complete each agreement.
2	1.4.1.2	Ensure Federal agencies use their authority to protect species occurrences and their vernal pool habitat in Priority 2 core areas.	Until recovery goals obtained	USFWS, USBR, USFS, DOD, NRCS, BLM, BIA	144,245.87	2,486.99	2,486.99	2,486.99	2,486.99	2,486.99	To implement 7(a)(1), 7(a)(2) and other obligations
2	1.4.2.2	Ensure State and local agencies use their authority to protect species occurrences and their vernal pool habitat in Priority 2 core areas.	Until recovery goals obtained	CDFG, SLC, UNIV, OR	36,924.9	636.64	636.64	636.64	636.64	636.64	To implement section 10 and other obligations
2	1.4.3.2	Ensure existing conservation areas on private lands are managed to protect vernal pool species and habitat in Priority 2 core areas.	Until recovery goals obtained	OWN, CONS, TNC,	21,534.24	371.28	371.28	371.28	371.28	371.28	To implement section 10 and other obligations

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Implementation Schedule for Draft Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon											
					Cost Estimate (in $1,000 units)						
Action Priority	Action Number	Action Description	Action Duration	Responsible Parties[1]	Total Costs	FY 1	FY 2	FY 3	FY 4	FY 5	Comments/Notes
2	1.4.4.2	Protect remaining species occurrences and habitat, not currently protected on private land in Priority 2 core areas.	Ongoing	ALL	804,795						Maximum cost based on fee title acquisition for approximately 259,434 hectares (641,052 acres)
2	2.1.1.2	Ensure Federal agencies conduct interim habitat management on lands in Priority 2 core areas.	5 years	USFWS, USBR, USFS, DOD, NRCS, BLM, BIA	12,434.95	2,486.99	2,486.99	2,486.99	2,486.99	2,486.99	Assumes long term management plan is developed and implemented in 5 years
2	2.1.2.2	Ensure State and local agencies conduct interim habitat management on lands in Priority 2 core areas.	5 years	CDFG, SLC, UNIV, OR	3,183.2	636.64	636.64	636.64	636.64	636.64	Assumes long term management plan is developed and implemented in 5 years
2	2.1.3.2	Ensure private land owners with conservation agreements conduct interim habitat management on lands in Priority 2 core areas.	5 years	OWN, CONS, TNC	5,752.85	1,150.57	1,150.57	1,150.57	1,150.57	1,150.57	Assumes long term management plan is developed and implemented in 5 years
2	2.2.1	Develop standardized monitoring techniques to evaluate ecosystem function and response, species response, and threat response to interim management activities.	3 months	USFWS, CDFG	32.21	32.21					
2	2.2.2	Implement standardized monitoring to document ecosystem and species responses to interim habitat management activities.	5 years	ALL	TBD	TBD					

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Implementation Schedule for Draft Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon											
					Cost Estimate (in $1,000 units)						
Action Priority	**Action Number**	**Action Description**	**Action Duration**	**Responsible Parties[1]**	**Total Costs**	**FY 1**	**FY 2**	**FY 3**	**FY 4**	**FY 5**	**Comments/Notes**
2	2.3.1	Compile, review, and analyze existing long-term, comprehensive habitat management and monitoring plans, or pertinent information from those plans, as necessary.	5 years	USFWS, OWN	161.05	32.21	32.21	32.21	32.21	32.21	Concurrent with interim management
2	2.3.3.1.2	Ensure Federal agencies implement long-term, comprehensive habitat management and monitoring plans on lands in Priority 2 core areas.	Every year until delisting or downlisting	USFWS, USBR, USFS, DOD, BLM, DOD	36,060.35	621.73	621.73	621.73	621.73	621.73	Based on assumed time in field to conduct habitat management each field season
2	2.3.3.2.2	Ensure State and local agencies implement long-term, comprehensive habitat management and monitoring plans on lands in Priority 2 core areas.	Every year until delisting or downlisting	CDFG, SLC, UNIV, OR	7,647.82	131.86	131.86	131.86	131.86	131.86	Based on assumed time in field to conduct habitat management each field season
2	2.3.3.3.2	Ensure private land owners with existing conservation agreements implement long-term, comprehensive habitat management and monitoring plans on lands in Priority 2 core areas.	Every year until delisting or downlisting	OWN, TNC, CONS	5,383.56	92.82	92.82	92.82	92.82	92.82	Based on assumed time in field to conduct habitat management each field season
2	2.3.3.4.2	Ensure responsible parties of newly protected lands implement long-term, comprehensive habitat management and monitoring plans on lands in Priority 2 core areas.	Every year until delisting or downlisting	ALL		TBD					This action will be additive to Actions 2.1.1.1 through 2.3.3.3.5.
2	2.5.1.3	Conduct Priority 2 seed collection and banking as identified in **Table IV-2**, if necessary.	3 months	STO, UNIV	255.00		255.00				Assumes $15,000 for collection in each region
2	2.5.2.3	Conduct Priority 2 cyst collection as identified in **Table IV-4**, if necessary.	3 months	UNIV	TBD depends on method						

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Action Priority	**Action Number**	**Action Description**	**Action Duration**	**Responsible Parties[1]**	**Total Costs**	**FY 1**	**FY 2**	**FY 3**	**FY 4**	**FY 5**	**Comments/Notes**
2	2.5.3.2	Prepare a controlled propagation plan for Priority 2 reintroductions and introductions of plants indicated in **Table IV-5** and **Table IV-6**, respectively.	6 months	USFWS, CDFG	64.42		64.42				Assumes ½ of year to develop controlled propagation plan for the collective priority 2 plants
2	2.5.3.6	Propagate plants for Priority 2 reintroductions and introductions indicated in **Table IV-5** and **Table IV-6**, respectively.	6 months	USFWS, STO	8.00			8.00			Assumes $2,000 x 4 species
2	2.5.4.2	Conduct Priority 2 reintroductions and introductions of plants as indicated in **Table IV-5** and **Table IV-6**, respectively.	6 months (site preparation)	USFWS	150.00				150.00		Assumes $25,000 x at least 6 sites
2	2.5.4.5	Monitor Priority 2 reintroductions and/or introductions of plants.	Minimum 5 years per site	USFWS, ALL	509.76	101.95	101.95	101.95	101.95	101.95	Assumes 24 days of monitoring per year per site
2	2.5.5.3	Conduct Priority 2 reintroductions and introductions of shrimp as indicated in **Table IV- 4**		USFWS, UNIV	TBD						Cost will vary depending on no. of sites
2	2.5.5.6	Monitor Priority 2 reintroductions and introductions of shrimp	Minimum 5 years per site		TBD						Cost will vary depending on no. of sites; may be added to 2.5.4.5
2	2.5.6.1	Reintroduce delta green ground beetle at appropriate sites.	1 year	USFWS, CDFG, CONS, UNIV	30.6	30.6					Assumes labor cost to locate beetles for translocation
2	2.5.6.2	Monitor delta green ground beetle reintroductions.	Minimum of 5 years	CONS, UNIV	44.2		8.84	8.84	8.84	8.84	Assumes monitoring of one site during survey season

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Action Priority	**Action Number**	**Action Description**	**Action Duration**	**Responsible Parties[1]**	**Total Costs**	**FY 1**	**FY 2**	**FY 3**	**FY 4**	**FY 5**	**Comments/Notes**
2	3.3.1	Compile most recent status reviews, or comparable evaluations, for each species and develop a prioritized list for status reviews of the species addressed in this draft recovery plan.	Every 5 years until recovery	ALL	354.31			32.21			Assumes data compilation can be completed for all species can be completed in 3 months
2	3.3.2	Conduct status reviews of listed species by vernal pool region.	Every 5 years until recovery	USFWS	14,947.3			1288.56			Assumes 6 months review based on cost per species
2	4.1.1.1	Conduct genetics analysis on species slated for reintroductions and introductions, as listed in **Tables IV-3** and **IV-4** (*i.e.*, species requiring seed or cyst banking).	5 years	USFWS, UNIV, PVT	8,000	1600	1600	1600	1600	1600	Assumes $ 100,000 per year per species
2	4.1.1.3	Conduct genetic research on remaining vernal pool species, as necessary.	1 year	UNIV, PVT	TBD	TBD					
2	4.1.2.1	Conduct biosystematics research on *Limnanthes floccosa* ssp. *californica*.	1 year	UNIV, PVT	100	100					Assumes combined cost for researcher, equipment, *etc.*
2	4.1.3.1	In conjunction with the priorities listed below for specific plant categories or species, develop a prioritized list, by species, of additional research needs on dispersal mechanisms.	3 months	USFWS, UNIV, PVT	48.32	48.32					Based on collaboration between agency staff and researchers
2	4.1.3.2.1.1	Implement research on dispersal mechanisms of *Astragalus tener* var. *ferrisiae* and *Navarretia myersii* ssp. *deminuta*.	1 year	UNIV, PVT	TBD	TBD					
2	4.1.3.2.1.2	Implement research on dispersal mechanisms of *Tuctoria mucronata*.	1 year	UNIV, PVT	TBD	TBD					

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Implementation Schedule for Draft Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon											
Action Priority	Action Number	Action Description	Action Duration	Responsible Parties[1]	Cost Estimate (in $1,000 units)						Comments/Notes
					Total Costs	FY 1	FY 2	FY 3	FY 4	FY 5	
2	4.1.3.2.2	Implement research on dispersal mechanisms of perennial plants.	1 year	UNIV, PVT	TBD	TBD					
2	4.1.3.2.5	Implement research on dispersal mechanisms of western spadefoot toad.	1 year	UNIV, PVT	TBD	TBD					
2	4.1.4.1	Determine and prioritize basic biology and ecology research needed to inform management and habitat protection decisions.	3 months	USFWS, ALL	32.21		32.21				Assumes staff time costs to review and prioritize
2	4.1.4.2	Conduct basic biology and ecology research, based on priorities.	TBD	ALL	TBD			TBD			
2	4.1.5.1	Determine and prioritize research on effects of environmental factors needed to inform management and habitat protection decisions.	3 months	ALL	32.21			32.21			Assumes staff time costs to review and prioritize
2	4.1.5.2	Conduct research on the effects of environmental factors, based on priorities.	TBD	ALL	TBD			TBD			
2	4.1.6.1	Develop a prioritized list of species that would benefit the most from conducting a population viability analysis.	3 months	USFWS, UNIV	32.21	32.21					Assumes staff time costs to review and prioritize
2	4.1.6.2	Conduct population viability analyses as sufficient data is accumulated and apply results to refine recovery actions and criteria, habitat management, and threat reduction actions.	6 months	UNIV	825		825				Assumes cost of $25,000 per species
2	4.3.1	Research the effects of environmental contaminants on vernal pools, ecosystem function, and individual species.	3 years	USFWS, UNIV	800	266.67	266.67	266.67			Based on comprehensive contaminants research

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Action Priority	**Action Number**	**Action Description**	**Action Duration**	**Responsible Parties[1]**	**Total Costs**	**FY 1**	**FY 2**	**FY 3**	**FY 4**	**FY 5**	**Comments/Notes**
2	4.3.2.1	Investigate methods for remediating contamination by lead at the former Castle Air Force Base.	3 years	DOD	800	266.67	266.67	266.67			CERCLA responsibility
2	4.3.2.3	Investigate methods for remediating contamination by poultry manure at Arena Plains Unit of Merced National Wildlife Refuge.	3 years	USFWS, OWN	800	266.67	266.67	266.67			Based on comprehensive contaminants research
2	4.3.2.4	Investigate methods for remediating contamination at other vernal pool sites identified through threats monitoring activities.	2 years	ALL	TBD	TBD	TBD				
2	4.3.5	Determine pollinators and their habitat requirements of vernal pool plants. Incorporate results into reserve design and habitat protection and management strategies.	5 years	PVT, UNIV	500	100	100	100	100	100	Assumes combined cost for researcher, equipment, *etc.*
2	4.3.6.1	Determine degree of threat from, and identify factors contributing to, excessive grasshopper foraging on *Neostapfia colusana* and develop remedies.	1 year	PVT, UNIV	100	100					Assumes combined cost for researcher, equipment, *etc.*
2	4.3.6.2	Determine degree of threat from, and identify factors contributing to, excessive grasshopper foraging on *Orcuttia inaequalis* and develop remedies.	1 year	PVT, UNIV	100	100					Assumes combined cost for researcher, equipment, *etc.*
2	4.3.6.3	Determine degree of threat from, and identify factors contributing to, excessive grasshopper foraging on *Tuctoria mucronata* and develop remedies.	1 year	PVT, UNIV	100	100					Assumes combined cost for researcher, equipment, *etc.*

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Action Priority	**Action Number**	**Action Description**	**Action Duration**	**Responsible Parties[1]**	**Total Costs**	**FY 1**	**FY 2**	**FY 3**	**FY 4**	**FY 5**	**Comments/Notes**
2	4.3.7.2	Investigate methods to control the following invasive plants: *Centaurea solstitialis*, *Convolvulus arvensis*, *Eleocharis macrostachya*, *Hordeum* spp., *Lolium multiflorum*, *Medicago polymorpha*, *Taeniatherum caput-medusae*, *Xanthium strumarium*, and other invasive plants.	5 years	PVT, UNIV	600	120	120	120	120	120	Assumes $ 15,000 per species per year
2	5.2.5.1.2	Develop tools such as Candidate Conservation Agreements, Memoranda of Understanding, or other appropriate documents for Priority 2 conservation of taxa of concern on public lands.	3 months	USFWS	32.21		10.74	10.74	10.74		Cost assumes 1 month of work over the course of one year to complete each agreement.
3	1.4.1.3	Ensure Federal agencies use their authority to protect species occurrences and their vernal pool habitat in Priority 3 core areas.	Until recovery goals obtained	BLM, DOD	9,715.29	167.51	167.51	167.51	167.51	167.51	To implement 7(a)(1), 7(a)(2) and other obligations
3	1.4.1.4	Ensure Federal agencies use their authority to protect species occurrences and their vernal pool habitat that do not occur within a core area, but do occur within a vernal pool region.	Until recovery goals obtained	USFWS, USBR, USFS, DOD, NRCS, BLM, BIA	TBA						To implement 7(a)(1), 7(a)(2) and other obligations
3	1.4.1.5	Ensure Federal agencies use their authority to protect all other species occurrences and their vernal pool habitat that do not occur within a vernal pool region, but do contribute to recovery and long-term conservation of species addressed in this draft recovery plan.	Until recovery goals obtained	USFWS, USBR, USFS, DOD, NRCS, BLM, BIA	TBA						To implement 7(a)(1), 7(a)(2) and other obligations

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Action Priority	Action Number	Action Description	Action Duration	Responsible Parties[1]	Cost Estimate (in $1,000 units)						Comments/Notes
					Total Costs	FY 1	FY 2	FY 3	FY 4	FY 5	
3	1.4.2.3	Ensure State and local agencies use their authority to protect species occurrences and their vernal pool habitat in Priority 3 core areas.	Until recovery goals obtained	CDF, CPR, LOC, SLC	27,445.58	473.20	473.20	473.20	473.20	473.20	To implement section 10 and other obligations
3	1.4.2.4	Ensure State and local agencies use their authority to protect species occurrences and their vernal pool habitat that do not occur within a core area, but do occur within a vernal pool region.	Until recovery goals obtained	CDFG, CPR, DWR, UNIV, UFID, LOC, SLC, OR	TBD						To implement section 10 and other obligations
3	1.4.2.5	Ensure State and local agencies use their authority to protect all other species occurrences and their vernal pool habitat that does not occur within a vernal pool region, but do contribute to recovery and long-term conservation of species addressed in this draft recovery plan.	Until recovery goals obtained	CDFG, CPR, DWR, UNIV, UFID, LOC, SLC, OR	TBD						To implement section 10 and other obligations
3	1.4.3.3	Ensure existing conservation areas on private lands are managed to protect vernal pool species and habitat in Priority 3 core areas.	Until recovery goals obtained	OWN, TNC	7,178.08	123.76	123.76	123.76	123.76	123.76	To implement section 10 and other obligations
3	1.4.3.4	Ensure existing conservation areas on private lands are managed to protect vernal pool species and habitat that do not occur within a core area, but do occur within a vernal pool region.	Until recovery goals obtained	OWN, CONS, TNC,	TBD						To implement section 10 and other obligations

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Action Priority	Action Number	Action Description	Action Duration	Responsible Parties[1]	Total Costs	FY 1	FY 2	FY 3	FY 4	FY 5	Comments/Notes
3	1.4.3.5	Ensure existing conservation areas on private lands are managed to protect vernal pool species and habitat that does not occur within a vernal pool region, but do contribute to recovery and long-term conservation of species addressed in this draft recovery plan.	Until recovery goals obtained	OWN, CONS, TNC,	TBD						To implement section 10 and other obligations
3	1.4.4.3	Protect remaining species occurrences and habitat, not currently protected on private land in Priority 3 core areas.	Ongoing (breakdown given for completion in 5 years)	ALL	123,710						Maximum cost- based on fee title acquisition for approximately 15,256 hectares (37,698 acres)
3	1.4.4.4	Protect species occurrences and their vernal pool habitat that do not occur within a core area, but do occur within a vernal pool region.	As needed	ALL	TBD						
3	1.4.4.5	Protect all other species occurrences and their vernal pool habitat that does not occur within a vernal pool region, but do contribute to recovery and long-term conservation of species addressed in this draft recovery plan.	As needed	ALL	TBD						
3	2.1.1.3	Ensure Federal agencies conduct interim habitat management on lands in Priority 3 core areas.	5 years	DOD, BLM	837.55	167.51	167.51	167.51	167.51	167.51	Assumes long term management plan is developed and implemented in 5 years

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Implementation Schedule for Draft Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon											
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Action Priority	Action Number	Action Description	Action Duration	Responsible Parties[1]	Total Costs	FY 1	FY 2	FY 3	FY 4	FY 5	Comments/Notes
3	2.1.1.4	Ensure Federal agencies conduct interim habitat management on lands that do not occur within a core area, but do occur within a vernal pool region.	5 years	USFWS, USBR, USFS, DOD, NRCS, BLM, BIA	TBD						Assumes long term management plan is developed and implemented in 5 years
3	2.1.1.5	Ensure Federal agencies conduct interim habitat management on lands that do not occur within a vernal pool region, but do contribute to recovery and long-term conservation of species addressed in this draft recovery plan.	5 years	USFWS, USBR, USFS, DOD, BOR, NRCS, BLM, BIA	TBD						Assumes long term management plan is developed and implemented in 5 years
3	2.1.2.3	Ensure State and local agencies conduct interim habitat management on lands in Priority 3 core areas.	5 years	CDF, CPR, LOC, SLC	2,366	473.20	473.20	473.20	473.20	473.20	Assumes long term management plan is developed and implemented in 5 years
3	2.1.2.4	Ensure State and local agencies conduct interim habitat management on lands that do not occur within a core area, but do occur within a vernal pool region.	5 years	CDFG, CPR, DWR, UNIV, UFID, LOC, SLC, OR	TBD						Assumes long term management plan is developed and implemented in 5 years
3	2.1.2.5	Ensure State and local agencies conduct interim habitat management on lands that do not occur within a vernal pool region, but do contribute to recovery and long-term conservation of species addressed in this draft recovery plan.	5 years	CDFG, CPR, DWR, UNIV, UFID, LOC, SLC, OR	TBD						Assumes long term management plan is developed and implemented in 5 years

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[2] Action duration based on size of vernal pool region and the amount of time it might take one biologist to conduct a windshield survey of that area.

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					Cost Estimate (in $1,000 units)						
Action Priority	Action Number	Action Description	Action Duration	Responsible Parties[1]	Total Costs	FY 1	FY 2	FY 3	FY 4	FY 5	Comments/Notes
3	2.1.3.3	Ensure private land owners with conservation agreements conduct interim habitat management on lands in Priority 3 core areas.	5 years	OWN, CONS, TNC,	669.52	133.9	133.9	133.9	133.9	133.9	Assumes long term management plan is developed and implemented in 5 years
3	2.1.3.4	Ensure private land owners with conservation agreements conduct interim habitat management on lands that do not occur within a core area, but do occur within a vernal pool region.	5 years	OWN, CONS, TNC,	TBD	TBD					Assumes long term management plan is developed and implemented in 5 years
3	2.1.3.5	Ensure private land owners with conservation agreements conduct interim habitat management on lands that do not occur within a vernal pool region, but do contribute to recovery and long-term conservation of species addressed in this draft recovery plan.	5 years	OWN, CONS, TNC,	TBD	TBD					Assumes long term management plan is developed and implemented in 5 years
3	2.3.3.1.3	Ensure Federal agencies implement long-term, comprehensive habitat management and monitoring plans on lands in Priority 3 core areas.	Every year until delisting or downlisting	USFWS, USBR, USFS, DOD, BLM, DOD	2,491.22	42.95	42.95	42.95	42.95	42.95	Based on assumed time in field to conduct habitat management each field season
3	2.3.3.1.4	Ensure Federal agencies implement long-term, comprehensive habitat management and monitoring plans on lands that do not occur within a core area, but do occur within a vernal pool region.	Every year until delisting or downlisting	USFWS, USBR, USFS, DOD, BLM, DOD	TBD						

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Action Priority	Action Number	Action Description	Action Duration	Responsible Parties[1]	Total Costs	FY 1	FY 2	FY 3	FY 4	FY 5	Comments/Notes
3	2.3.3.1.5	Ensure Federal agencies implement long-term, comprehensive habitat management and monitoring plans on lands that do not occur within a vernal pool region, but do contribute to recovery and long-term conservation of species addressed in this draft recovery plan.	Every year until delisting or downlisting	USFWS, USBR, USFS, DOD, BLM, DOD	TBD						
3	2.3.3.2.3	Ensure State and local agencies implement long-term, comprehensive habitat management and monitoring plans on lands in Priority 3 core areas.	Every year until delisting or downlisting	CDF, CPR, LOC, SLC	6,861.39	118.30	118.30	118.30	118.30	118.30	Based on assumed time in field to conduct habitat management each field season
3	2.3.3.2.4	Ensure State and local agencies implement long-term, comprehensive habitat management and monitoring plans on lands that do not occur within a core area, but do occur within a vernal pool region.	Every year until delisting or downlisting	CDFG, CPR, DWR, UNIV, UFID, LOC, SLC, OR	TBD						
3	2.3.3.2.5	Ensure State and local agencies implement long-term, comprehensive habitat management and monitoring plans on lands that do not occur within a vernal pool region, but do contribute to recovery and long-term conservation of species addressed in this draft recovery plan.	Every year until delisting or downlisting	CDFG, CPR, DWR, UNIV, UFID, LOC, SLC, OR	TBD						
3	2.3.3.3.3	Ensure private land owners with existing conservation agreements implement long-term, comprehensive habitat management and monitoring plans on lands in Priority 3 core areas.	Every year until delisting or downlisting	OWN, TNC, CONS	1,794.52	30.94	30.94	30.94	30.94	30.94	Based on assumed time in field to conduct habitat management each field season

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					Cost Estimate (in $1,000 units)						
Action Priority	Action Number	Action Description	Action Duration	Responsible Parties[1]	Total Costs	FY 1	FY 2	FY 3	FY 4	FY 5	Comments/Notes
3	2.3.3.3.4	Ensure private land owners with existing conservation agreements implement long-term, comprehensive habitat management and monitoring plans on lands that do not occur within a core area, but do occur within a vernal pool region.	Every year until delisting or downlisting	OWN, TNC, CONS	TBD						
3	2.3.3.3.5	Ensure private land owners with existing conservation agreements implement long-term, comprehensive habitat management and monitoring plans on lands that do not occur within a vernal pool region, but do contribute to recovery and long-term conservation of species addressed in this draft recovery plan.	Every year until delisting or downlisting	OWN, TNC, CONS	TBD						
3	2.3.3.4.3	Ensure responsible parties of newly protected lands implement long-term, comprehensive habitat management and monitoring plans on lands in Priority 3 core areas.	Every year until delisting or downlisting	ALL	TBD						This action will be additive to Actions 2.1.1.1 through 2.3.3.3.5.
3	2.3.3.4.4	Ensure responsible parties of newly protected lands implement long-term, comprehensive habitat management and monitoring plans on lands that do not occur within a core area, but do occur within a vernal pool region.	Every year until delisting or downlisting	ALL	TBD						This action will be additive to Actions 2.1.1.1 through 2.3.3.3.5.

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Action Priority	Action Number	Action Description	Action Duration	Responsible Parties[1]	Total Costs	FY 1	FY 2	FY 3	FY 4	FY 5	Comments/Notes
3	2.3.3.4.5	Ensure responsible parties of newly protected lands implement long-term, comprehensive habitat management and monitoring plans on lands that do not occur within a vernal pool region, but do contribute to recovery and long-term conservation of species addressed in this draft recovery plan.	Every year until delisting or downlisting	ALL	TBD						This action will be additive to Actions 2.1.1.1 through 2.3.3.3.5.
3	2.4.1.1	Review existing enhancement, restoration, and creation mechanisms and success criteria	6 months	USFWS	64.42	64.42					
3	2.4.1.2	As necessary develop scientifically based and site-specific mechanisms and success criteria for enhancement, restoration and creation of vernal pools	3 months	USFWS, ALL	80.21	80.21					In coordination with Sacramento Fish and Wildlife Office
3	2.4.2.1	Review existing shrimp collection, storage, and application mechanisms and success criteria	6 months	USFWS	64.42	64.42					
3	2.4.2.2	As necessary develop scientifically based and site-specific mechanisms and success criteria for shrimp cyst collection, storage, and application	3 months	USFWS, ALL	80.21	80.21					In coordination with Sacramento Fish and Wildlife Office
3	2.4.3.1	Develop a prioritized list of sites from which shrimp cysts need to be collected to further the recovery and long-term conservation of vernal pool species.	3 months	USFWS, ALL	TBD						In coordination with Sacramento Fish and Wildlife Office

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					Cost Estimate (in $1,000 units)						
Action Priority	**Action Number**	**Action Description**	**Action Duration**	**Responsible Parties[1]**	**Total Costs**	**FY 1**	**FY 2**	**FY 3**	**FY 4**	**FY 5**	**Comments/Notes**
3	2.4.3.2	Implement introduction of cysts restored or created habitat	Ongoing	ALL	TBD based on need						Estimates earthwork, soil collection and application, staff time at ~**$25,000** [need to verify] per acre.
3	2.4.3.3	Apply success criteria in a monitoring program to determine success of shrimp cyst introduction effort.	5 years minimum per site		TBD						Post-creation/restoration monitoring
3	2.4.4.1	Develop a prioritized list of sites that need to be enhanced, restored, and/or created to further the recovery and long-term conservation of vernal pool species.	3 months	USFWS, ALL	80.21	80.21					In coordination with the Sacramento Fish and Wildlife Office
3	2.4.4.2	Develop a prioritized list of which aspects of the vernal pool ecosystem function need to be enhanced, restored, and/or created.	3 months	USFWS, ALL	80.21	80.21					In coordination with the Sacramento Fish and Wildlife Office
3	2.4.4.3	Implement vernal pool enhancement, restoration, and creation activities based on scientifically sound and site-specific appropriate mechanisms.	Ongoing	ALL	TBD Based on Need						Estimates soil pits, earthwork, soil disposal, staff time at ~$25,000 per acre.
3	2.4.4.4	Apply success criteria in a monitoring program to determine if species and ecosystem respond positively to the enhancement, restoration, and/or creation effort.	5 years minimum per site	ALL	TBD						Post-creation/restoration monitoring
3	2.5.2.4	Conduct Priority 3 cyst collection as identified in **Table IV-4**, if necessary.	3 months	UNIV	TBD depends on method						

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Action Priority	**Action Number**	**Action Description**	**Action Duration**	**Responsible Parties[1]**	**Total Costs**	**FY 1**	**FY 2**	**FY 3**	**FY 4**	**FY 5**	**Comments/Notes**
3	2.5.3.3	Prepare a controlled propagation plan for Priority 3 reintroductions and introductions of plants indicated in **Table IV-5** and **Table IV-6**, respectively.	6 months	USFWS, CDFG	64.42		64.42				Assumes ½ of year to develop controlled propagation plan for the collective priority 3 plants
3	2.5.3.4	If necessary, conduct germination trials for reintroductions and introductions.	6 months	USFWS, STO	22.00			22.00			Assumes $2,000 x 11 species
3	2.5.3.7	Propagate plants for Priority 3 reintroductions and introductions indicated in **Table IV-5** and **Table IV-6**, respectively.	6 months (growing time)	USFWS, STO	12.00			12.00			Assumes $2,000 x 6 species
3	2.5.4.3	Conduct Priority 3 reintroductions and introductions as indicated in **Table IV-5** and **Table IV-6**, respectively.	6 months (site preparation)	USFWS	650.00				650.00		Assumes $25,000 x at least 26 sites
3	2.5.4.6	Monitor Priority 3 reintroductions and/or introductions of plants.	Minimum 5 years per site	USFWS, ALL	2,208.96	441.80	441.80	441.80	441.80	441.80	Assumes 24 days of monitoring per year per site
3	2.5.4.7	As necessary apply success criteria to reintroductions and/or introductions and modify techniques to achieve recovery and long-term conservation of vernal pool plants.	Ongoing	ALL	TBD						Costs will vary depending on actions necessary to obtain success criteria
3	2.5.5.4	Conduct Priority 3 reintroductions and introductions of shrimp as indicated in **Table IV- 4**		USFWS, UNIV	TBD						Cost will vary depending on no. of sites
3	2.5.5.7	Monitor Priority 3 reintroductions and introductions of shrimp	Minimum 5 years per site		TBD						Cost will vary depending on no. of sites; may be added to 2.5.4.6

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					Cost Estimate (in $1,000 units)						
Action Priority	**Action Number**	**Action Description**	**Action Duration**	**Responsible Parties[1]**	**Total Costs**	**FY 1**	**FY 2**	**FY 3**	**FY 4**	**FY 5**	**Comments/Notes**
3	2.5.5.8	As necessary, apply success criteria to reintroductions and/or introductions and modify techniques to achieve recovery and long-term conservation of vernal pool shrimp species.	TBD		TBD						Costs will vary depending on actions necessary to obtain success criteria
3	3.3.3	Conduct status reviews of species of concern by vernal pool region.	Every 5 years until recovery	USFWS	9,715.7			837.56			Assumes 6 months review based on cost per species
3	3.4	Conduct post-delisting monitoring for recovered species.	5 years	ALL	TBD						Value depends on number of monitoring points for each species
3	4.1.1.2	Compile and review existing information on genetic and population structure of remaining vernal pool species, and develop a prioritized list of species requiring additional genetics studies to assist in making management decisions.	5 months	USFWS, UNIV, PVT	48.32	48.32					Based on collaboration between agency staff and researchers
3	4.1.2.2	Conduct biosystematics research on *Navarretia leucocephala* spp. *plieantha*	1 year	UNIV, PVT	100	100					Assumes combined cost for researcher, equipment, *etc.*
3	4.1.2.3	Conduct biosystematics research on *Astragalus tener* var. *tener* and *A. t.* var. *ferrisiae*	1 year	UNIV, PVT	100	100					Assumes combined cost for researcher, equipment, *etc.*
3	4.1.2.4	Conduct biosystematics research on *Eryngium spinosepalum*	1 year	UNIV, PVT	100	100					Assumes combined cost for researcher, equipment, *etc.*

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Action Priority	**Action Number**	**Action Description**	**Action Duration**	**Responsible Parties[1]**	**Total Costs**	**FY 1**	**FY 2**	**FY 3**	**FY 4**	**FY 5**	**Comments/Notes**
3	4.1.2.5	Conduct biosystematics research on *Myosurus minimus* var. *apus*	1 year	UNIV, PVT	100	100					Assumes combined cost for researcher, equipment, *etc.*
3	4.1.3.2.3.2	Implement research on dispersal mechanisms of California fairy shrimp.	1 year	UNIV, PVT	TBD	TBD					
3	4.2.1	Conduct research to determine minimum reserve size in order to maintain ecosystem function and population viability of vernal pool species.	5 years with monitoring	USFWS, UNIV, PVT	500	100	100	100	100	100	Assumes combined cost for researcher, equipment, *etc.*
3	4.2.2	Determine the role and effects of fire in functioning vernal pool ecosystems in relation to component native species.	2 years	USFWS, TNC, UNIV, PVT, CONS	150	75	75				Estimate based on contemporary research proposal
3	4.2.3	Determine the role and effects of livestock grazing in functioning vernal pool ecosystems in relation to component native species.	2 years	USFWS, UNIV, OWN, CONS	150	75	75				Estimate based on contemporary research proposal
3	4.2.4.1	Compile and review existing literature on vernal pool enhancement, restoration, and creation	3 months	USFWS	32.21						Assumes staff time of 1/4 of year to compile and review information
3	4.2.4.2	Modify ecologically-based success criteria for enhancement, restoration, and creation (Action 2.4) that define functional vernal pool ecosystems, as necessary, as results from research and monitoring become available.	3 months	USFWS	48.32	48.32					Based on collaboration between agency staff and researchers

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Action Priority	**Action Number**	**Action Description**	**Action Duration**	**Responsible Parties[1]**	**Total Costs**	**FY 1**	**FY 2**	**FY 3**	**FY 4**	**FY 5**	**Comments/Notes**
3	4.2.4.3	Develop hydrologic models to predict effects of hydrologic modifications in various situations.	6 months	USFWS, UNIV, PVT, DOD	40		40				Assumes costs for data collection and modeling
3	4.2.4.4.1	Investigate methods for restoring vernal pool ecosystems that have been degraded by alterations in topography or hydrology.	5 years	ALL	500	100	100	100	100	100	Monitoring time not included
3	4.2.4.5	Conduct research on use of human-made vernal pool wetlands by vernal pool species and compare with natural wetlands.	5 years	USFWS, UNIV, PVT, DOD	500	100	100	100	100	100	Monitoring time not included
3	4.3.3	Study impacts of low frequency noises and vibrations on the western spadefoot toad.	5 years	PVT, UNIV	200	100	100				Assumes combined cost for researcher, equipment, *etc.*
3	4.3.4	Determine influence of nonnative aquatic vertebrate predators on population dynamics across full geographic range of vernal pool branchiopods, delta green ground beetle and the western spadefoot toad.	5 years	PVT, UNIV	500	100	100	100	100	100	Assumes combined cost for researcher, equipment, *etc.*
3	5.2.2	Develop a participation plan and submit to recovery implementation team for review.	1 year	TEAM, USFWS	547.64		547.64				Assumes shared staff costs to develop participation plan
3	5.2.3.1	Identify private landowners interested in pursuing recovery and conservation efforts on their lands and prioritize a list of potential participants.	3 months to ongoing	TEAM, USFWS	32.21			32.21			Estimate based on staff time to identify and compile list of known willing participants

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Action Priority	Action Number	Action Description	Action Duration	Responsible Parties[1]	Total Costs	FY 1	FY 2	FY 3	FY 4	FY 5	Comments/Notes
3	5.2.3.2	Work with private landowners to develop Safe Harbor Agreements, Candidate Conservation Agreements, Memoranda of Understanding, or other appropriate tools for conserving listed species or species of concern on their lands.	3 months per agreement	USFWS, PVT, CONS	1,835.97		32.21	32.21	32.21	32.21	Cost assumes 3 months of work over the course of one year to complete each agreement, per year until recovery.
3	5.2.4.1	Initiate cooperative programs with audience organizations.	3 months	USFWS	32.21	32.21					Assumes staff time involved in initiating cooperative programs
3	5.2.4.2	Develop Safe Harbor Agreements, Candidate Conservation Agreements, Memoranda of Understanding, or other appropriate documents for conserving taxa of concern on conservancy lands.	3 months	USFWS	32.21		10.74	10.74	10.74		Cost assumes 1 month of work over the course of one year to complete each agreement.
3	5.2.5.1.3	Develop tools such as Candidate Conservation Agreements, Memoranda of Understanding, or other appropriate documents for Priority 3 conservation of taxa of concern on public lands.	3 months	USFWS	32.21		10.74	10.74	10.74		Cost assumes 1 month of work over the course of one year to complete each agreement.
3	5.2.5.2	Assist lead agencies and districts in incorporating provisions of this draft recovery plan in local decision-making.	3 months	USFWS	32.21	8.05	8.05	8.05	8.05		Ongoing
3	5.3.1	Periodically review progress toward recovery of all listed species and identify those species that require a change in status (downlisting, delisting, uplisting) or emergency actions.	3 months	USFWS	373.64					32.21	Cost assumes review every five years until recovery.

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Action Priority	Action Number	Action Description	Action Duration	Responsible Parties[1]	Cost Estimate (in $1,000 units)						Comments/Notes
					Total Costs	FY 1	FY 2	FY 3	FY 4	FY 5	
3	5.3.2	Periodically review the status of species of concern and identify those species that require a change in status (*e.g.*, listing).	3 months	USFWS	373.64					32.21	Cost assumes review every five years throughout life of recovery plan.
3	5.3.3	Evaluate progress towards completing recovery actions and adjust recovery implementation efforts accordingly.	3 months	USFWS	373.64					32.21	Cost assumes evaluation every five years throughout life of recovery plan.
	Priority 1 actions subtotal: $773,048,400										
	Priority 2 actions subtotal: $1,107,421,300										
	Priority 3 actions subtotal: $202,926,340										
	Total Estimated Cost of Recovery through 2062: $2,083,396,040 + additional costs that cannot be estimated at this time										

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VI. REFERENCES

A. Literature Cited

Abrams, L. 1940. Illustrated flora of the Pacific states: Washington, Oregon, and California. Vol. I. Ophioglossaceae to Aristolochiaceae: ferns to birthworts. Stanford University Press, Stanford, California. 538 pages.

Abrams, L. 1944. Illustrated flora of the Pacific states: Washington, Oregon, and California. Vol. II. Polygonaceae to Krameriaceae: buckwheats to kramerias. Stanford University Press, Stanford, California. 635 pages.

Abrams, L. 1951. Illustrated flora of the Pacific states: Washington, Oregon, and California. Vol. III. Geraniaceae to Scrophulariaceae: geraniums to figworts. Stanford University Press, Stanford, California. 866 pages.

Abrams, L., and R. S. Ferris. 1960. Illustrated flora of the Pacific states: Washington, Oregon, and California. Vol. IV. Bignoniaceae to Compositae: bignonias to sunflowers. Stanford University Press, Stanford, California. 732 pages.

Ahl, J. S. B. 1991. Factors affecting contributions of the tadpole shrimp, *Lepidurus packardi*, to its oversummering egg reserves. Hydrobiologia 212:137-143.

Alexander, D. G., and R. A. Schlising. 1997. Vernal pool ecology and vernal pool landscape management as illustrated by rare macroinvertebrates and vascular plants at Vina Plains Preserve, Tehama County, California. Unpublished report to the California Department of Fish and Game, Redding. 139 pages.

Anderson, P. R. 1968. The reproductive and developmental history of the California tiger salamander. Master of Science Thesis. Fresno State College, Fresno, California.

Andrews, F. 1978. *Elaphrus viridis* Horn, 1878. Unpublished manuscript.

Arnold, R. A. 1983. Biological studies of the delta green ground beetle, *Elaphrus viridis* Horn (Coleoptera: Carabidae), at Jepson Prairie Preserve in 1983. Unpublished report produced for The Nature Conservancy.

Arnold, R. A. 1989. Evaluation for habitat quality for the threatened delta green ground beetle in the vicinity of Jepson Prairie Preserve for PGT and PG&E's gasline expansion project. Unpublished report, submitted to: Pacific Gas & Electric Co., San Ramon, California.

Arnold, R. A. 1990. Vaca Valley Raceway invertebrates report. Unpublished report to Vaca Valley Raceway. 6 pages + appendices.

Arroyo, M. T. K. 1973. A taximetric study of infraspecific variation in autogamous *Limnanthes floccosa*. Brittonia 25:177-191.

Arroyo, M. T. K. 1975. Electrophoretic studies of genetic variation in natural populations of allogamous *Limnanthes alba* and autogamous *Limnanthes floccosa* (Limnanthaceae). Heredity 35:153-164.

Atsatt, P. R. 1970. The population biology of annual grassland hemiparasites. II. Reproductive patterns in *Orthocarpus*. Evolution 24:598-612.

Atsatt, P. R, and D. R. Strong. 1970. The population biology of annual grassland hemiparasites. I. The host environment. Evolution 24:278-291.

Baldwin, P., and S. Baldwin. 1989*a*. Annual monitoring of rare plants at The Nature Conservancy's Boggs Lake Preserve for 1988. Unpublished report to The Nature Conservancy, San Francisco, California. 22 pages.

Baldwin, P., and S. Baldwin. 1989*b*. Annual monitoring of rare plants at The Nature Conservancy's Boggs Lake Preserve for 1989. Unpublished report to The Nature Conservancy, San Francisco, California.

Baldwin, P., and S. Baldwin. 1990. Monitoring report [*Navarretia plieantha* at Boggs Lake Preserve], 1990. Pages 173-182.

Baldwin, P., and S. Baldwin. 1991. Report on annual monitoring of rare plants at The Nature Conservancy's Boggs Lake Preserve for 1991. Unpublished report to The Nature Conservancy, San Francisco, California. 19 pages.

Barclay, W. R. and A. W. Knight. 1984. Physiochemical processes affecting production in a turbid vernal pond. Pages 126-142 *in*: S. Jain and P. Moyle, editors Vernal pools and intermittent streams. Institute of Ecology Publication No. 28, University of California, Davis.

Barneby, R. C. 1950. Pugillus Astragalorum XII: some problems in California. El Aliso 2:203-215.

Barneby, R. C. 1964. Atlas of North American *Astragalus*. Memoirs of the New York Botanical Garden 13:1-1188. As cited in Liston (1990*b*)

Barry, S. J. 1995. Vernal Pools on California's Annual Grasslands. Rangelands 17(5):173–175.

Barry, S. J. 1998. Managing the Sacramento Vernal Pool Landscape to Sustain Native Flora. Pp. 236–240 *in*: C. W. Witham, E. T. Bauder, D. Belk, W. R. Ferren, Jr., and R. Ornduff (eds.). Ecology, Conservation, and Management of Vernal Pool Ecosystems. Proceedings from a 1996 Conference. California Native Plant Society; Sacramento, California.

Bates, L. A. 1977. Soil survey of Solano County, California. U.S. Department of Agriculture, Soil Conservation Service and University of California, Agriculture Experiment Station.

Bauder, E.T. 1987. Threats to San Diego Vernal Pools and a Case Study in Altered Pool Hydrology. In: Elias, T.S. (ed.). Conservation and Management of Rare and Endangered Plants. Proceedings of a California Conference on the Conservation and Management of Rare and Endangered Plants. California Native Plant Society. 1987:209–213.

Bauder, E. T., and S. McMillan. 1998. Current distribution and historical extent of vernal pools in Southern California and Northern Baja California, Mexico. Pages 56-70 *in*: C. W. Witham, E. T. Bauder, D. Belk, W. R. Ferren Jr., and R. Ornduff, editors. Ecology, conservation, and management of vernal pool ecosystems. California Native Plant Society, Sacramento, California.

Belk, D. 1975. Key to the Anostraca (fairy shrimps) of North America. The Southwestern Naturalist 20:91-103.

Belk, D. 1998. Global status and trends in ephemeral pool invertebrate conservation: implications for California fairy shrimp. Pages 147-150 *in*: C. W. Witham, E.T. Bauder, D. Belk, W.R. Ferren, Jr., and R. Ornduff (editors) Ecology, Conservation, and Management of Vernal Pool Ecosystems. California Native Plant Society, Sacramento, California.

Belk, D., and J. Brtek. 1995. Checklist of the Anostraca. Hydrobiologia 298:315-353.

Belk, D., and M. Fugate. 2000. Two new *Branchinecta* (Crustacea: Anostraca) from the Southwestern United States. The Southwestern Naturalist 45:111-117.

BioSystems Analysis, Inc. 1993. Floristic inventory Butte 149 project. Unpublished report to the California Department of Transportation, Marysville. 69 pages + appendices.

BioSystems Analysis, Inc. 1994. Rare plant preconstruction report, PGT-PG&E pipeline expansion project, California. Unpublished report, Santa Cruz, California.

Bittman, R. 1989. Report to the Fish and Game Commission on the status of few-flowered navarretia *(Navarretia pauciflora*). California Department of Fish and Game, Natural Heritage Division, Sacramento, Status Report 89-17. 22 pages.

Bliss, S. A., and P. H. Zedler. 1998. The germination process in vernal pools: sensitivity to environmental conditions and effects on community structure. Oecologia 113:67-73.

Boileau, M. G., and P. D. N. Hebert. 1991. Genetic consequences of passive dispersal in pond dwelling copepods. Evolution 45:721-733.

Borgias, D., and C. Patterson. 1999. Assessment and map of the Agate Desert vernal pool ecosystem in Jackson County, Oregon: March 1998 imagery revision. Report to the U.S. Fish and Wildlife Service, Oregon State Office, Portland, Oregon. 15 pages + figures.

Bragg, A. N. 1962. Predation on arthropods by spadefoot tadpoles. Herpetologica 18:144.

Bragg, A. N. 1964. Further study of predation and cannibalism in spadefoot tadpoles. Herpetologica 20(1):17-24.

Brown, C. R., and S. K. Jain. 1979. Reproductive system and pattern of genetic variation in two *Limnanthes* species. Theoretical and Applied Genetics 54:181-190.

Brown, H. A. 1966. Temperature adaptation and evolutionary divergence in allopatric populations of the spadefoot toad, *Scaphiopus hammondii*. Doctor of Philosophy Dissertation, University of California, Riverside, California.

Brown, H. A. 1967. Embryonic temperature adaptations and genetic compatibility of two allopatric populations of the spadefoot toad, *Scaphiopus hammondii*. Evolution 21(4):742-761.

Brown, H. A. 1976. The status of California and Arizona populations of the western spadefoot toads (genus *Scaphiopus*). Contributions in Science of the Natural History Museum of Los Angeles County 286:1-15.

Broyles, P. 1983. A flora of The Nature Conservancy's Vina Plains Preserve, Tehama County, California. M.A. thesis, California State University, Chico, California.

Broyles, P. 1987. A flora of the Vina Plains Preserve, Tehama County, California. Madroño 34:209-227.

Brtek, J. 1964. Eine neue Gattung und Familie der Ordnung Anostraca. Annotationes Zoologicae et Botanicae, Bratislava 7:1-7.

Burgess, R. C., Jr. 1950. Development of spade-foot toad larvae under laboratory conditions. Copeia 1950(1):49-51.

California Department of Fish and Game. 1985. California native plant status report: *Eryngium constancei.* California Department of Fish and Game Endangered Plant Program, California Natural Diversity Data Base, and California Native Plant Society, Sacramento, California. 4 pages.

California Department of Fish and Game. 1986. California native plant status report: *Orthocarpus campestris* var. *succulentus*. California Department of Fish and Game Endangered Plant Program, California Natural Diversity Data Base, and California Native Plant Society, Sacramento, California. 4 pages.

California Department of Fish and Game. 1987*a*. California native plant status report: *Limnanthes floccosa* ssp. *californica*. California Department of Fish and Game Endangered Plant Project, California Natural Diversity Data Base, and California Native Plant Society, Sacramento, California. 4 pages.

California Department of Fish and Game. 1987*b*. California native plant status report: *Navarretia plieantha*. California Department of Fish and Game Endangered Plant Project, California Natural Diversity Data Base, and California Native Plant Society, Sacramento, California. 4 pages.

California Department of Fish and Game. 1987*c*. Report to the Fish and Game Commission on the status of sticky Orcutt grass (*Orcuttia viscida*), Sacramento, California. 5 pages.

California Department of Fish and Game. 1987*d*. California native plant status report: *Gratiola heterosepala*. California Department of Fish and Game Endangered Plant Project, California Natural Diversity Data Base, and California Native Plant Society, Sacramento, California. 4 pages.

California Department of Fish and Game. 1990a. Annual Report on the Status of California's State Listed Threatened and Endangered Plants and Animals. Sacramento, California. California Department of Fish and Game.

California Department of Fish and Game. 1990b. California native plant status report: *Parvisedum leiocarpum*. California Department of Fish and Game Endangered Plant Program, California Natural Diversity Data Base, Sacramento, California.

California Department of Fish and Game. 1991. Annual report on the status of California State listed threatened and endangered animals and plants. California Department of Fish and Game, Sacramento, California. 192 pages.

California Department of Fish and Game. 1994. Draft management plan for Loch Lomond Vernal Pool Ecological Reserve. California Department of Fish and Game, Sacramento, California. 75 pages.

California Department of Fish and Game. 1998. Special animal list. California Natural Heritage Division, Sacramento, California. 66 pages.

California Department of Fish and Game. 1999. Special plants list. California Department of Fish and Game, Natural Diversity Database, Sacramento, California. 119 pages.

California Native Plant Society. 2001. Inventory of rare and endangered plants of California (6th edition). Rare Plant Scientific Advisory Committee,

David P. Tibor, Convening Editor. California Native Plant Society. Sacramento, California. x + 388 pages.

California Natural Diversity Data Base. 1997. Natural Heritage Division. California Department of Fish and Game, State of California.

California Natural Diversity Data Base. 2000. Natural Heritage Division. California Department of Fish and Game, State of California.

California Natural Diversity Data Base. 2001. Natural Heritage Division. California Department of Fish and Game, State of California.

California Natural Diversity Data Base. 2003. Natural Heritage Division. California Department of Fish and Game, State of California.

Campbell, G. R. 1952. The genus *Myosurus* L. (Ranunculaceae) in North America. El Aliso 2:389-403.

Cannatella, D. C. 1985. A phylogeny of primitive frogs (Archaeobatrachians). Doctor of Philosophy dissertation, University of Kansas, Lawrence, Kansas.

Center for Natural Lands Management. 1997. Draft land management plan for the Foothill Park Preserve. Unpublished report to the City of Chico, California. Center for Natural Lands Management, Fallbrook, California. 70 pages + appendices.

Center for Plant Conservation. 1991. Appendix. Genetic sampling guidelines for conservation collections of endangered plants. Pages 225-238 *in*: Genetics and conservation of rare plants. D. A Falk and K. E. Holsinger, editors. Oxford University Press, New York.

Chester, T. 2000. Threats to the Main Vernal Pools of the Mesa de Colorado. http://tchester.org/srp/vp/threat.html. 2 pages.

Childs, H. E., Jr. 1953. Selection by predation on albino and normal spadefoot toads. Evolution 7(3):228-233.

Chuang, T. I., and L. R. Heckard. 1991. Generic realignment and synopsis of subtribe Castillejinae (Scrophulariaceae - Tribe Pedicularieae). Systematic Botany 16:644-666.

Chuang, T. I., and L. R. Heckard. 1993. *Castilleja*. Pages 1016-1024 *in*: J.C. Hickman, editor. The Jepson manual: higher plants of California. University of California Press, Berkeley, California. 1400 pages.

City of Chico. 1989. Alternate mitigation program. Addendum to a draft plan for the conservation of Butte County meadowfoam in the City of Chico. Unpublished report by the City of Chico Community Services Department, Chico, California. 6 pages.

Clark, G. M., T. J. Roscoe, M. J. van Ess, and N. Wymer. 1998. Management considerations for small vernal pool preserves: the Phoenix vernal pools. Pages 250-254 *in*: C.W. Witham, E.T. Bauder, D. Belk, W.R. Ferren, Jr., and R. Ornduff, editors. Ecology, conservation, and management of vernal pool ecosystems: proceedings from a 1996 conference. California Native Plant Society, Sacramento, California. 285 pages.

Clausen, R. T. 1946. Nomenclatural changes and innovations in the Crassulaceae. Cactus and Succulent Journal 18:58-61.

Clausen, R. T. 1975. *Sedum* of North America north of the Mexican plateau. Cornell University Press, Ithaca, NY. 742 pages.

Collie, N. and E. W. Lathrop. 1976. Chemical characteristics of the standing water of a vernal pool on Santa Rosa Plateau, Riverside County, California. Pages 27-31 *in* S. Jain, ed. Vernal pools: their ecology and conservation. Institute of Ecology Publication No. 9, University of California, Davis.

Constance, L. 1993. Apiaceae [Umbelliferae]. Pages 136-166 *in*: J.C. Hickman, editor. The Jepson manual: higher plants of California. University of California Press, Berkeley, California. 1400 pages.

Corbin, B., and G. Schoolcraft. 1989. *Orcuttia tenuis* species management guide. Unpublished report to Lassen National Forest and Susanville District Bureau of Land Management. 31 pages.

Corbin, B., G. Schoolcraft, A. Sanger, and J. Molter. 1994. *Gratiola heterosepala* conservation strategy. Unpublished report to Lassen National Forest, Modoc National Forest, Alturas Resource Area BLM, and Redding Resource Area BLM. 68 pages.

Crampton, B. 1954. Morphological and ecological considerations in the classification of *Navarretia* (Polemoniaceae). Madroño 12:225-238.

Crampton, B. 1959. The grass genera *Orcuttia* and *Neostapfia*: a study in habitat and morphological specialization. Madroño 15:97-110.

Crampton, B. 1976. Rare grasses in a vanishing habitat. Fremontia 4(3):22-23.

Crawford, D. J., and R. Ornduff. 1989. Enzyme electrophoresis and evolutionary relationships among three species of *Lasthenia* (Asteraceae: Heliantheae). American Journal of Botany 76:289-296.

Crompton, K. 1993. Population survey of Butte County meadowfoam (*Limnanthes floccosa* ssp. *californica*), Simmons Ranch, Bruce Road and Humboldt Road, Chico, Butte County, California. Unpublished report from Kelley and Associates Environmental Sciences, Inc. to Drake Homes, Chico, California. 13 pages.

Csiki, E. 1928. Carabidae: Mormolycinae, Harpalinae I. *In*: W. Junk and S. Schenkling, editors. Coleiopterorum Catalogus. Berlin: W. Junk. 2(97):1-226.

Davies, C.P., M.A. Simovich and S.A. Hathaway. 1997. Population genetics of a California endemic branchiopod, *Branchinecta sandiegonensis*. Hydrobiologia 359: 149-158.

Davis, H. G., 1998. Allee effects in *Blennosperma bakeri*. A thesis submitted to the faculty of San Francisco State University in partial fulfillment of the requirements for the degree Master of Arts in Biology: Conservation Biology. San Francisco, California

Davy, J. B. 1898. *Stapfia*, a new genus of Meliceae, and other noteworthy grasses. Erythea 6(11):109-113.

Davy, J. B. 1899. Concerning *Stapfia*, Davy. Erythea 7:43.

Day, A.G. 1993*a*. New taxa and nomenclatural changes in *Allophyllum*, *Gilia*, and *Navarretia* (Polemoniaceae). Novon 3:331-340.

Day, A.G. 1993*b*. *Navarretia*. Pages 844-849 *in*: J.C. Hickman, editor. The Jepson manual: higher plants of California. University of California Press, Berkeley, California. 1400 pages.

Day, A.G. 1995. Sessile-flowered species in the *Navarretia leucocephala* group (Polemoniaceae). Madroño 42:34-39.

Dempster, L.T. 1993. Convolvulaceae. Pages 516-522 *in*: J.C. Hickman, editor. The Jepson manual: higher plants of California. University of California Press, Berkeley, California. 1400 pages.

Den Boer, P. J. 1971. Stabilization of animal numbers and the heterogeneity of the environment: the problem of the persistence of sparse populations. Pages 77-97 *in* P. J. Boer and G. R. Gradwells (editors), Dynamics of Populations. Pudoc, Wadeningen

Denton, M.F. 1993. *Parvisedum*. Page 531 *in*: J.C. Hickman, editor. The Jepson manual: higher plants of California. University of California Press, Berkeley, California. 1400 pages.

Dimmitt, M. A., and R. Ruibal. 1980. Environmental correlates of emergence in spadefoot toads (*Scaphiopus*). Journal of Herpetology 14(1):21-29.

Driver, E. A. 1981. Calorific values of pond invertebrates eaten by ducks. Freshwater Biology 11:579-581.

Dodds, G. S. 1923. A new species of Phyllopod. Occasional Papers of the Museum of Zoology 141:1-3.

Dole, J. A. 1988. Results of a field survey for the Butte County meadowfoam in the vicinity of the City of Chico, California. Unpublished report to the City of Chico, Community Services Department. 36 pages.

Dole, J. A., and M. Sun. 1992. Field and genetic survey of the endangered Butte County meadowfoam--*Limnanthes floccosa* subsp. *californica* (Limnanthaceae). Conservation Biology 6:549-558.

Driver, E. A. 1981. Calorific values of pond invertebrates eaten by ducks: Freshwater Biology. 11:579–581.

Duncan & Jones Urban and Environmental Planning Consultants. 1996. Final supplemental environmental impact report. Unpublished report to the City of Fremont, California.

Durgarian, A. B. 1995. Natural and created vernal pools in Madera County, California: a comparative study. M.A. thesis, California State University, Fresno, California. 130 pages.

EIP Associates. 1994. University of California San Joaquin campus site selection draft environmental impact report. Volume 2: Project description/environmental analysis. Unpublished report to the University of California Office of the President, [no city given]. 451 pages.

EIP Associates. 1999. UC Merced/UC community planning area 1999 special-status plant survey report. Unpublished report to the University of California and Merced County, Sacramento, California. 66 pages.

Eng, L., D. Belk, and C. H. Eriksen. 1990. Californian Anostraca: distribution, habitat, and status. Journal of Crustacean Biology 10:247-277.

Eriksen, C. H. and D. Belk. 1999. Fairy shrimps of California's puddles, pools, and playas. Mad River Press, Eureka, California.

Erickson, C. H. and R. J. Brown. 1980. Comparative respiratory physiology and ecology of phyllopod crustacea. I. Conchostraca. Crustaceana 39(1):1-10.

Ertter, B. 1986. The *Juncus triformis* complex. Memoirs of the New York Botanical Garden 39:1-90.

Evans, D. 2000. Agate Desert Vernal Pool surveys. Draft report prepared for the Rogue Valley Council of Governments. 17 pages + appendices.

Feaver, P. E. 1971. Breeding pool selection and larval mortality of three California amphibians: *Ambystoma tigrinum californiense* Gray, *Hyla regilla* Baird and Girard, and *Scaphiopus hammondii* Girard. Master of Arts Thesis, Fresno State College, Fresno, California.

Ferren, W. R., Jr. and D. A. Pritchett. 1988. Enhancement, Restoration, and Creation of Vernal Pools at Del Sol Open Space and Vernal Pool Reserve, Santa Barbara County, California. Environmental Research Team, The Herbarium, Department of Biological Sciences, University of California, Santa Barbara. Environmental Report No. 13. 160 p.

Ferris, R. S. 1958. Taxonomic notes on western plants. Contributions from the Dudley Herbarium 5:99-108.

Finn, M. 2000. Natural environment study for State Route 99/149/70. California Department of Transportation, Marysville.

Fisher, R. N., and H. B. Shaffer. 1996. The decline of amphibians in California's Great Central Valley. Conservation Biology 10(5):1387-1397.

Frayer, W. E., D. D. Peters, and H. R. Pywell. 1989. Wetlands of the California central valley: status and trends. U.S. Fish and Wildlife Service. Portland, OR. 28 pages.

Fugate, M. L. 1992. Speciation in the fairy shrimp genus *Branchinecta* (Crustacea: Anostraca) from North America. University of California, Riverside. Riverside, California. Page 88.

Fugate, M. 1998. *Branchinecta* of North America: Population structure and its implications for conservation practice. Pages 140-146 *in*: C. W. Witham, E. T. Bauder, D. Belk, W. R. Ferren Jr., and R. Ornduff, editors. Ecology, conservation, and management of vernal pool ecosystems - Proceedings from a 1996 conference. California Native Plant Society, Sacramento, California.

Gallagher, S. P. 1996. Seasonal occurrence and habitat characteristics of some vernal pool branchiopoda in northern California, U.S.A. Journal of Crustacean Biology 16:323-329.

Gonzalez, R. J., J. Drazen, S. Hathaway, B. Bauer, and M. Simovich. 1996. Physiological correlates of water chemistry requirements in fairy shrimps (Anostraca) from Southern California. Journal of Crustacean Biology 16:286-293.

Goudey, C. B., and D.W. Smith (Eds). 1994. Ecological Units of California: Subsections.(map) San Francisco, California. U.S. Department of Agriculture, Forest Service. Scale 1,000,000; colored.

Goulet, H. 1983. The genera of Holarctic Elaphrini and species of *Elaphrus* (Fabricius) (Coleoptera: Carabidae): Classification, phylogeny and zoogeography. Quaestiones Entomologicae 19:219-482.

Goulet, H., and A. Smetana. 1997. Additions to the knowledge of the genus *Elaphrus* Fabricius, 1775 (Coleoptera: Carabidae). Elytra 25:201-220.

Grant, V., and K. A. Grant. 1965. Flower pollination in the phlox family. Columbia University Press, New York, 180 pages.

Gray, A. 1864. A revision and arrangement (mainly by the fruit) of the North American species of *Astragalus* and *Oxytropis*. Proceedings of the American Academy of Arts and Sciences 6:188-236.

Greene, E. L. 1885. Studies in the botany of California and parts adjacent. III. 1. A revision of *Myosurus*. Bulletin of the California Academy of Sciences 1:276-282.

Greene, E. L. 1888. New or noteworthy species. III. Pittonia 1:215-225.

Greene, E. L. 1890. New or noteworthy species. VII. Pittonia 2:69-81.

Geier & Geier Consulting, Inc. 1994. Draft environmental impact report, Campbell Ranch. Unpublished report prepared for Solano County.

Griggs, F. T. 1974. Systematics and ecology of the genus *Orcuttia* (Gramineae). M.A. thesis, California State University, Chico, California. 69 pages. As cited in Stone *et al.* (1988).

Griggs, F. T. 1977*a*. Rare plant status report: *Orcuttia californica* Vasey var. *inaequalis* (Hoover) Hoover. California Native Plant Society, Sacramento, 3 pages.

Griggs, F. T. 1977*b*. Rare plant status report: *Orcuttia greenei* Vasey. California Native Plant Society, Sacramento, California. 4 pages.

Griggs, F. T. 1980. Population studies in the genus *Orcuttia* (Poaceae). Ph.D. dissertation, University of California, Davis, California. 98 pages.

Griggs, F. T. 1981. Life histories of vernal pool annual grasses. Fremontia 9(1):14-17.

Griggs, F. T., and S. K. Jain. 1983. Conservation of vernal pool plants in California. II. Population biology of a rare and unique grass genus *Orcuttia*. Biological Conservation 27:171-193.

Grubb, J. C. 1972. Differential predation by *Gambusia affinis* on the eggs of seven species of anuran amphibians. American Midland Naturalist 88:102-108.

Gurney, R. 1924. Some notes on the genus *Apus* (Crustacea, Branchiopoda). Annals and Magazine of Natural History, 14(9):559-568.

Hall, H. M. 1914. Baeria. North American Flora 34(1):76-80.

Hanes, T. and L. Stromberg. 1998. Hydrology of vernal pools on non-volcanic soils in the Sacramento Valley. Pages 38-49 *in*: C.W. Witham, E.T. Bauder, D. Belk, W.R. Ferren, Jr., and R. Ornduff, editors. Ecology, conservation, and management of vernal pool ecosystems. California Native Plant Society, Sacramento, California.

Hanes, W. T., B. Hecht, and L. P. Stromberg. 1990. Water relationships of vernal pools in the Sacramento region, California. Pages 49-60 *in*: D.H. Ikeda and R.A. Schlising, editors. Vernal pool plants, their habitats and biology. Studies from the Herbarium Number 8, California State University. Chico, California.

Hathaway, S.H., D. P. Sheehan, M.A. Simovich. 1996. Vulnerability of branchiopod cysts to crushing. Journal of Crustacean Biology 16(3): 448-452.

Hauptli, H., B.D. Wester, and S. Jain. 1978. Variation in nutlet morphology of *Limnanthes*. American Journal of Botany 65:615-624.

Havel, J. E., P. D. N. Hebert and L. D. Delorme. 1990. Genetics of sexual Ostracoda from a low Arctic site. Journal of Evolutionary Biology 3:65-84.

Hayes, M. P., and J. Warner. 1985. *Rana catesbeiana* (bullfrog) food. Herpetological Review 16(4):109.

Hayes, M. P., and M. R. Jennings. 1986. Decline of ranid frog species in western North America: are bullfrogs (*Rana catesbeiana*) responsible? Journal of Herpetology 20:490-509.

Hebert, P. D. N. 1974. Enzyme variability in natural populations of *Daphnia magna*, 1. Population structure in East Anglia. Evolution 28:546-556.

Heckard, L. R. 1977. Rare plant status report: *Orthocarpus succulentus* (Hoover) Hoover. California Native Plant Society, Sacramento, California. 3 pages.

Heine, G. 1987. Einfache Meß- und Rechenmethode zur Ermittlung der Überlebenschance wandernder Amphibien beim Überqueren von Straßen. Beihefte zu den Veröffentlichungen Naturschutz und Landschaftspflege Baden-Württemberg **41**:473-479. As cited in Reh and Seitz (1990).

Helm, B. P. 1998. Biogeography of eight large branchiopods endemic to California. Pages 124-139 *in*: C. W. Witham, E. T. Bauder, D. Belk, W. R. Ferren Jr. and R. Ornduff, editors. Ecology, conservation, and management of vernal pool ecosystems--Proceedings from a 1996 Conference. California Native Plant Society, Sacramento, California.

Helm, B. P. and W. Fields. 1998. Aquatic macro-invertebrate assemblages occurring in selected vernal pools on the Agate Desert and nearby sites in Jackson County, Oregon. Oregon Natural Heritage Program, Portland, Oregon .

Heywood, V. H., editor. 1978. Flowering plants of the world. Mayflower Books, Inc., New York. 335 pages. As cited in Stone *et al.* (1988).

Hickman, J. C, editor. 1993. The Jepson Manual. University of California Press, Berkeley, California. 1,400 pages.

Hill, S. R. 1993. Malvaceae. Pages 746-762 *in*: J. C. Hickman, editor. The Jepson manual: higher plants of California. University of California Press, Berkeley, California, 1400 pages.

Hitchcock, A. S. 1934. New species, and changes in nomenclature, of grasses of the United States. American Journal of Botany 21:127-139.

Hitchcock, A. S., and A. Chase. 1971. Manual of the grasses of the United States. Volume I. Dover Publications, Inc., New York. 569 pages.

Hogle, I. 2002. Status survey and habitat requirements of *Neostapfia colusana*. Report to the U.S. Fish and Wildlife Service. Sacramento, California. 12 pages + tables and figures.

Holland, R. F. 1978. The geographic and edaphic distribution of vernal pools in the Great Central Valley, California. California Native Plant Society, special publication number 4.

Holland, R. F. 1984. Endangerment status of *Legenere limosa* (Greene) McVaugh in California. Unpublished report, Orangevale, California. 46 pages.

Holland, R. F. 1987. What constitutes a good year for an annual plant? Two examples from the Orcuttieae. Pages 329-333 *in*: T.S. Elias, editor. Conservation and management of rare and endangered plants. California Native Plant Society, Sacramento, California. 630 pages.

Holland, R. F. 1998. Great Valley vernal pool distribution, photorevised 1996. Pages 71-75 *in*: C. W. Witham, E. T. Bauder, D. Belk, W. R. Ferren Jr. and R. Ornduff, editors. Ecology, conservation, and management of vernal pool ecosystems--Proceedings from a 1996 Conference. California Native Plant Society, Sacramento, California.

Holland, R. F. and V. I. Dains. 1990. The edaphic factor in vernal pool vegetation. Pages 273-297 *in*: D. H. Ikeda, R. A. Schlising, F. J. Fuller, L. P. Janeway, and P. Woods, eds. Vernal pool plants: their habitat and biology. Study No. 8 from the Herbarium, California State University, Chico, California.

Holland, R. F. and F. T. Griggs. 1976. A unique habitat - California's vernal pools. Fremontia 4(3):3-6.

Holland, R. F. 2003. Distribution of vernal pool habitats in five counties of California's southern coast ranges. Report to U.S. Fish and Wildlife Service. Ventura, California. 23 pages.

Holland, R. F. and S. Jain. 1988. Vernal pools. Pages 515-533 *in*: M. G. Barbour and J. Major (eds.), Terrestrial vegetation of California. Wiley-Interscience, New York, New York.

Hoover, R. F. 1936*a*. New Californian plants. Leaflets of Western Botany 1:225-230.

Hoover, R. F. 1936*b*. Notes on California grasses. Madroño 3:227-230.

Hoover, R. F. 1937. Endemism in the flora of the Great Valley of California. Ph.D. dissertation, University of California, Berkeley, California. 76 pages.

Hoover, R. F. 1940. Observations on Californian plants-I. Leaflets of Western Botany 2:273-274.

Hoover, R. F. 1941. The genus *Orcuttia*. Bulletin of the Torrey Botanical Club 68:149-156.

Hoover, R. F. 1968. Two *Orthocarpus* species from the San Joaquin Valley. Four Seasons 2(4):14-15.

Hrusa, G. F., and A. Buckmann. 2000. Noteworthy collections - California. *Eryngium constancei* Y. Sheikh (Apiaceae). Madroño 47:139.

International Union for the Conservation of Nature. 1983. Red Data Book.

Jain, S. 1976*a*. Evolutionary studies in the meadowfoam genus *Limnanthes*: an overview. Pages 50-57 *in*: S.K. Jain, editor. Vernal pools: their ecology and conservation. Institute of Ecology Publication No. 9, Davis, California. 93 pages.

Jain, S. 1976*b*. Meadowfoams–mermaids of our vernal pools. Fremontia 4(3):19-21.

Jain, S. K. 1978. Local dispersal of *Limnanthes* nutlets: an experiment with artificial vernal pools. Canadian Journal of Botany 56:1995-1997.

Jain, S. K, I. A. Boussy, and H. Hauptli. 1978. Male sterility in meadowfoam. Journal of Heredity 69:61-63.

Jennings, M. R. 1988. Natural history and decline of native ranids in California. Pages 61-72 *in*: H. F. DeLisle, P. R. Brown, B. Kaufman, and B. M. McGurty, editors. Proceedings of the conference on California Herpetology, Southwestern Herpetologists Society.

Jennings, M. R. 1998. California Natural Diversity Data Base field notes. Unpublished data.

Jennings, M. R., and M. P. Hayes. 1994. Amphibian and reptile species of special concern in California. California Department of Fish and Game, Sacramento, California.

Jepson Prairie Preserve Docent Program. 1998. Jepson Prairie Preserve Handbook.

Jepson, W.L. 1922. A revision of Californian Umbelliferae. Madroño 1:101-114, 117-30, 133-146, 149-162, 281-285.

Jepson, W.L. 1925. A manual of the flowering plants of California. Associated Students Store, University of California, Berkeley, California. 1170 pages.

Johnston, I. M. 1923. II. Studies in the Boraginaceae. 4. A synopsis and redefinition of *Plagiobothrys*. Contributions from the Gray Herbarium of Harvard University 68:57-80.

Johnston, I. M. 1932. The Allocarya section of the genus *Plagiobothrys* in the western United States. Contributions of the Arnold Arboretum 3:1-82. As cited in Abrams (1951).

Jokerst, J. D. 1983. The vascular plant flora of Table Mountain, Butte County, California. Madroño 30(4) Supplement:1-18.

Jokerst, J. D. 1989. A draft plan for the conservation of Butte County meadowfoam in the City of Chico. *Limnanthes floccosa* ssp. *californica*. Unpublished report to the City of Chico, California, 128 pages.

Jokerst, J. D. 1990. Floristic analysis of volcanic mudflow vernal pools. Pages 1-30 *in*: D.H. Ikeda and R.A. Schlising, editors. Vernal pool plants – their habitat and biology. California State University, Chico, California.

Jones and Stokes Associates. 1997. Final Conservation and Development Areas Plan for the Habitat Conservation and Management Plan for Beale Air Force Base. Prepared for Beale Air Force Base. July 1997.

Jones and Stokes Associates. 2003. Proposed Conservation Strategy for the UC Merced Project. J & S 01-549, Prepared for the University of California, Merced, California, and Merced County UC Development Office, Atwater, California. December 29, 2003.

Kalin, M. T. 1971. The evolution of autogamy in *Limnanthes* section *Inflexae* (Limnanthaceae). Ph.D. dissertation, University of California, Berkeley. As cited in Arroyo (1973).

Kaye, T., W. Messinger, S. Massey, and R. Meinke. 1990. *Gratiola heterosepala*: inventory and breeding system evaluation. Unpublished

report to the U.S. Bureau of Land Management, Lakeview, Oregon. 22 pages.

Keeler-Wolf, T., D. R. Elam, and S. A. Flint. 1995. California vernal pool assessment--preliminary report. California Department of Fish and Game, Sacramento, California.

Keeler-Wolf, T., D. R. Elam, K. Lewis, and S. A. Flint. 1998. California vernal pool assessment preliminary report. California Department of Fish and Game, Sacramento, California. 159 pages.

Keeley, J. E. 1984. Photosynthetic characteristics of certain vernal pool species. Pages 218-222 *in*: S. Jain and P. Moyle, editors. Vernal pools and intermittent streams. Institute of Ecology Publication No. 28, University of California, Davis, California.

Keeley, J. E. 1988. Anaerobiosis as a stimulus to germination in two vernal pool grasses (*Tuctoria greenei* and *Orcuttia californica*). American Journal of Botany 75:1086-1089.

Keeley, J. E. 1990. Photosynthesis in vernal pool macrophytes: relation of structure and function. Pages 61-87 *in*: D. H. Ikeda and R. A. Schlising, editors. Vernal pool plants–their habitat and biology. California State University, Chico, California.

Keeley, J. E. 1998*a*. C_4 photosynthetic modifications in the evolutionary transition from land to water in aquatic grasses. Oecologia 116:85-97.

Keeley, J. E. and P. H. Zedler. 1998. Characterization and global distribution of vernal pools. Pages 1-14 *in*: C. W. Witham, E. T. Bauder, D. Belk, W. R. Ferren Jr. and R. Ornduff, editors. Ecology, conservation, and management of vernal pool ecosystems - proceedings from a 1996 Conference, California Native Plant Society, Sacramento, California. 285 pages.

Kelley and Associates Environmental Sciences, Inc. 1992*a*. Biological report on Butte County meadowfoam (*Limnanthes floccosa* ssp. *californica*) for Simmons Ranch Project, Bruce and Warfield Roads, Bruce and Stilson Canyon Roads, Chico, Butte County, California. Unpublished report, Davis, California. 11 pages.

Kelley and Associates Environmental Sciences, Inc. 1992*b*. Biological report on Butte County meadowfoam (*Limnanthes floccosa* ssp. *californica*) for Farm Credit Project, Bruce and Warfield Roads, Chico, Butte County, California. Revised version with 1992 data. Unpublished report, Davis, California. 11 pages + maps.

Kelley and Associates Environmental Sciences, Inc. 1992*c*. Memorandum [re: mitigation agreement on preservation plan, B.R.U.S.A. project, Butte County meadowfoam (*Limnanthes floccosa* ssp. *californica*)] to Tom Lando, City of Chico, California, and California Department of Fish and Game, Sacramento, California. 5 pages + attachments.

Kelley and Associates Environmental Sciences, Inc. 1993*a*. Draft biological report on Butte County meadowfoam (*Limnanthes floccosa* ssp. *californica*) for Stonegate Project, southeast corner, Bruce and Warfield Roads, Chico, Butte County, California. Unpublished report, Davis, California. 8 pages.

Kelley and Associates Environmental Sciences, Inc. 1993*b*. Population survey of Butte County meadowfoam (*Limnanthes floccosa* ssp. *californica*), Stonegate Project, Bruce Road and Warfield Road, Chico, Butte County, California (1993). Unpublished report, Davis, California. 5 pages.

Kelley and Associates Environmental Sciences, Inc. 1994. Population survey of Butte County meadowfoam (*Limnanthes floccosa* ssp. *californica*), Stonegate Project–1994, Bruce Road and Warfield Road, Chico, Butte County, California. Unpublished report, Davis, California. 5 pages.

Kelley, D. B., L. R. Stallings, K. Crompton, R. L. McDonald, and B. L. Parker. 1994. 1994 mitigation monitoring results for Farm Credit Project, Chico, California. Unpublished report, Kelley and Associates Environmental Sciences, Inc., Davis, California. 24 pages.

Kesseli, R., and S. K. Jain. 1984. An ecological genetic study on gynodioecy in *Limnanthes douglasii* (Limnanthaceae). American Journal of Botany 71:775-786.

King, J. L. 1996. The evolution of diversity in ephemeral pools crustaceans: from genes to communities. Ph D Dissertation, Department of Zoology, University of California, Davis, California. 207 pages.

King, J. L., and R. Hanner. 1998. Cryptic species in a "living fossil" lineage: Taxonomic and phylogenetic relationships within the genus *Lepidurus* (Crustacea: Notostraca) in North America. Molecular Phylogenetics and Evolution 10:23-36.

King, J. L., M. A. Simovich and R. C. Brusca. 1996. Species richness, endemism and ecology of crustacean assemblages in northern California vernal pools. Hydrobiologia 328: 85-116.

Knuth, P.E. 1908. Handbook of flower pollination. II. Observations on flower pollination made in Europe and the Arctic regions on species belonging to the natural orders Ranunculaceae to Stylidieae. Translated by J.R. Ainsworth Davis. Clarendon Press, Oxford, England. 703 pages.

Koutnik, D. L. 1985. New combinations in California *Chamaesyce* (Euphorbiaceae). Madroño 32:187-189.

Koutnik D. L. 1993. *Chamaesyce*. Pages 568-572 *in*: J.C. Hickman, editor. The Jepson manual: higher plants of California. University of California Press, Berkeley, California. 1400 pages.

Krapu, G. L. 1974. Foods of breeding pintails in North Dakota. Journal of Wildlife Management. 38(3):408-417.

Kreissman, B. 1991. California: An Environmental Atlas and Guide. Bear Klaw Press, Davis, California..

Kuenster, G., J. Lacey, and E. Hubert. 1994. Botanical studies: Delta Field Division (California Aqueduct and South Bay Aqueduct). Unpublished report to the California Department of Water Resources, Sacramento, California. 47 pages + maps.

Kuhn, J. 1987. Strassentod der Erdkröte (*Bufo bufo* L.): Verlusquoten und Verkehrsaufkommen. Verhalten auf der Strasse. Beith. Veröff. Naturshutz und Landschaftspflege Baden-Württemberg 41:175-186. As cited in Reh and Seitz (1990).

Leong, J. M. 1994. Pollination of a patchily-distributed plant, *Blennosperma nanum*, in natural and artificially created vernal pool habitats. Ph.D. Dissertation, University of California, Davis, California.

Linder, F. 1941. Morphology and taxonomy of the Branchiopoda Anostraca. Zoologiska bidrag fran Uppsala 20:103-303.

Linder, F. 1952. Contributions to the morphology and taxonomy of the Branchiopoda Notostraca, with special reference to the North American species. Proceedings of the United States National Museum 102:1-69.

Lindroth, C.H. 1961-1969. The ground-beetles (Carabidae, excl. Cicindelinae) of Canada and Alaska, part 2. Opuscula Entomologica Supplementum 20: University of Lund, Sweden. 200 pages.

Liston, A. 1989. The conservation biology of *Astragalus* sect. *Leptocarpi* subsect. *Californici*. Unpublished report, Rancho Santa Ana Botanic Garden, Claremont, California. 13 pages.

Liston, A. 1990*a*. An evolutionary study of *Astragalus* sect. *Leptocarpi* subsect. *Californici* (Fabaceae). Ph.D. dissertation, Claremont Graduate School, Claremont, California.

Liston, A. 1990*b*. Taxonomic notes on *Astragalus* section *Leptocarpi* subsection *Californici* (Fabaceae). Brittonia 42:100-104.

Liston, A. 1992. Isozyme systematics of *Astragalus* sect. *Leptocarpi* subsect. *Californici* (Fabaceae). Systematic Botany 17:367-379.

Longhurst, A. R. 1955. Evolution in the Notostraca. Evolution 9:84-86.

LSA Associates, Inc. 1994. Wetland mitigation and monitoring plan for the Stonegate property, Chico, Butte County, California. Unpublished report to Northstate Business Center, Chico, California. 29 pages.

Lynch, J. E. 1966. *Lepidurus lemmoni* Holmes: a redescription with notes on variation and distribution. Transaction of the American Microscopical Society 85(2):181-192.

Lynch, J. A. 1972. *Lepidurus couesii* Packard (Notostraca) redescribed with a discussion of specific characters in the genus. Crustaceana 23:43-49.

Maeda-Martinez, A. M., D. Belk, H. Obreón-Barboza, and H. J. Dumont. 1997. Large branchiopod assemblages common to Mexico and the United States. Hydrobiologica 359(1-3):45-62.

Marty, J. 2004. Managing for diversity in California vernal pool grasslands. Presentation Abstracts. Ecology and Management of California Grasslands. April 2–3, 2004, University of California at Berkeley.

Mason, C. T., Jr. 1952. A systematic study of the genus *Limnanthes* R. Br. University of California Publications in Botany 25(6):455-512.

Mason, H. L. 1946. Five new species of *Navarretia*. Madroño 8:196-200.

Mason, H. L. 1957. A flora of the marshes of California. University of California Press, Berkeley. 878 pages.

Mason, H. L., and R. Bacigalupi. 1954. A new *Gratiola* from Boggs Lake, Lake County, California. Madroño 12:150-152.

Mathias, M. E. 1936. Studies in the Umbelliferae. V. Brittonia 2:239-245.

Mathias, M. E., and L. Constance. 1941. A synopsis of the North American species of *Eryngium*. American Midland Naturalist 25:361-387.

Mattoni, R., G. F. Pratt, T. R. Longcore, J. F. Emmel, and J. N. George. 1997. The endangered quino checkerspot butterfly, *Euphydryas editha quino* (Lepidoptera: Nymphalidae). Journal of Research on the Lepidoptera 34:99-118.

Mattoni, R., and T. R. Longcore. 1998. The Los Angeles coastal prairie, a vanished community. Crossosoma 23(2):71-102.

McGriff, D. 1987. Field survey form for *Elaphrus viridis* submitted to the California Department of Fish and Game Natural Diversity Data Base.

McNeill, C., and C. Brown. 1979. Rare plant status report: *Limnanthes floccosa* Howell ssp. *californica* Arroyo. California Native Plant Society, Sacramento. 3 pages.

McVaugh, R. 1943. Campanulaceae (Lobelioideae). North American Flora 32A:1-134.

Medeiros, J. L. 1976. The future of the Great Valley pools. Fremontia 4(3):24-27.

Menges, E. S. 1991. The application of minimum viable population theory to plants. Pages 45-61 *in*: D. A. Falk and K. E. Holsinger, editors. Genetics and conservation of rare plants. Oxford University Press, New York, 283 pages.

Medeiros, J. L. 1976. The Future of the Great Valley Pools. Fremontia 4(3):24-27.

Messick, T. C. 1993. *Plagiobothrys*. Pages 386-390 *in*: J. C. Hickman, editor. The Jepson manual: higher plants of California. University of California Press, Berkeley, California, 1400 pages.

Moran, R. 1997. The genus *Sedella* Britton & Rose (Crassulaceae). Haseltonia 5:53-60.

Morey, S. R. 1988. Western spadefoot *Scaphiopus hammondi*. Pages 56-57 *in*: D. C. Zeiner, W. F. Laudenslayer, Jr., and K. E. Mayer, editors. California's wildlife. Volume 1. Amphibians and reptiles. California Statewide Wildlife Habitat Relationships System, California Department of Fish and Game, Sacramento, California.

Morey, S. R. 1998. Pool duration influences age and body mass at metamorphosis in the western spadefoot toad: implications for vernal pool conservation. Pages 86-91 *in*: C. W. Witham, E. T. Bauder, D. Belk, W. R. Ferren Jr., and R. Ornduff, editors. Ecology, conservation, and management of vernal pool ecosystems: Proceedings from a 1996 conference. California Native Plant Society, Sacramento, California.

Morey, S. R., and D. A. Guinn. 1992. Activity patterns, food habits, and changing abundance in a community of vernal pool amphibians. Pages 149-158 *in*: D. Williams, S. Byrne, and T. A. Rado, editors. Endangered and sensitive species of the San Joaquin Valley, California. The California Energy Commission, Sacramento, California.

Morin, N. 1993. Campanulaceae. Pages 459-468 *in* J.C. Hickman, editor. The Jepson manual: higher plants of California. University of California Press, Berkeley, California. 1400 pages.

Morin, N., and T. Niehaus. 1977. Rare plant status report: *Legenere limosa* (Greene) McVaugh. California Native Plant Society, Sacramento, California. 3 pages.

Moyle, P. B. 1973. Effects of introduced bullfrogs, *Rana catesbeiana*, on the native frogs of the San Joaquin Valley, California. Copeia 1973:18-22.

Munz, P. A., and D. D. Keck. 1959. A California flora. University of California Press, Berkeley, California. 1681 pages.

Munz, P. A., and D. D. Keck. 1968. A California flora and supplement. University of California Press, Berkeley, California. 1905 pages.

Niehaus, T., and D. Fruchter. 1977. Rare plant status report: *Navarretia pauciflora* Mason. California Native Plant Society, Sacramento, California, 3 pages.

Oakeshott, G. B. 1978. California's Changing Landscapes. McGraw-Hill Publishing Co.

Oberbauer, T. A. 1990. Areas of vegetation communities in San Diego County, Department of Planning and Land Use, County of San Diego, California.

Oregon Natural Heritage Program. 1997. Agate Desert vernal pool habitat: Preliminary mapping and Assessment. Report to Oregon Division of State Lands, Contract No. 10738-369. 23+ pages.

Ornduff, R. 1966. A biosystematic survey of the goldfield genus *Lasthenia*. University of California Publications in Botany 40:1-92.

Ornduff, R. 1969. The origin and relationships of *Lasthenia burkei* (Compositae). American Journal of Botany 56:1042-1047.

Ornduff, R. 1976. Speciation and oligogenic differentiation in *Lasthenia* (Compositae). Systematic Botany 1:91-96.

Ornduff, R. 1979. Rare plant status report: *Lasthenia conjugens* Greene. California Native Plant Society, Sacramento. 3 pages.

Ornduff, R. 1993*a*. *Blennosperma*. Page 214 *in*: J.C. Hickman, editor. The Jepson manual: higher plants of California. University of California Press, Berkeley, California, 1400 pages.

Ornduff, R. 1993*b*. *Lasthenia*. Pages 298-300 *in*: J.C. Hickman, editor. The Jepson manual: higher plants of California. University of California Press, Berkeley, California, 1400 pages.

Ornduff, R. 1993*c*. Limnanthaceae. Pages 736-738 *in*: J.C. Hickman, editor. The Jepson manual: higher plants of California. University of California Press, Berkeley, California, 1400 pages.

Oswald, V. H., and J. G. Silveira. 1995. A flora of the Sacramento National Wildlife Refuge. U.S. Fish and Wildlife Service, Willows, California. 34 pages.

Pardieck, B. 2003. Contra Costa Goldfields Management Plan: April, May, June 2003. Unpublished report. Muir Heritage Land Trust.

Patterson, C. A. 1986. Special status report: *Parvisedum leiocarpum*, Lake County, California. Unpublished report to the California Department of Fish and Game, Sacramento. 24 pages + map.

Patterson, C. A. 1988. A petition to the State of California Fish and Game Commission to list Lake County stonecrop (*Parvisedum leiocarpum*). Unpublished report to the California Fish and Game Commission, Sacramento, California. 15 pages.

Patterson, C. A., B. Guggolz, and M. Waaland. 1994. Seasonal wetland baseline report for the Santa Rosa Plain, Sonoma County. Unpublished report to the California Department of Fish and Game, Yountville, 65 pages + 31 pages appendices.

Pavlik, B. M. 1994. Demographic monitoring and the recovery of endangered plants. Pages 322-350 *in*: M.L. Bowles and C.J. Whelan, editors. Restoration of endangered species: conceptual issues, planning and implementation. Cambridge University Press, Cambridge, England. 394 pages.

Pennak, R. 1953. Fresh Water Invertebrates. The Ronald Press Company, New York.

Petrovich, A.M. 1990. The Fate of Nitrogenous Fertilizers Applied to Turfgrass. Journal of Environmental Quality. Vol. 19, No. 1.

Pfennig, D. W. 1992. Polyphenism in spadefoot toad tadpoles: a locally adjusted evolutionary stable strategy. Evolution 46:1408-1420.

Pierce, R. O., and S. K. Jain. 1977. Variation in some plant and seed oil characteristics of meadowfoam. Crop Science 17:521-526.

Piper, C. V. 1920. A study of *Allocarya*. Contributions of the U.S. National Herbarium 22:79-113.

Platenkamp, G. A. 1998. Patterns of vernal pool biodiversity at Beale Air Force Base. Pages 151-160 *in*: C. W. Witham, E. T. Bauder, D. Belk, W. R. Ferren, Jr., and R. Ornduff, editors. Ecology, conservation, and management of vernal pool ecosystems - proceedings from a 1996 conference. California Native Plant Society, Sacramento, California. 285 pages.

Powell, W. R. 1974. Inventory of rare and endangered vascular plants of California. Special Publication No. 1, California Native Plant Society, Sacramento, California. 56 pages.

Proctor, V. W. 1964. Viability of crustacean eggs recovered from ducks. Ecology 45:656-658.

Proctor, V. W., C. R. Malone, V. L. DeVlaming. 1967. Dispersal of aquatic organisms: viability of disseminules recovered from the intestinal tract of captive killdeer. Ecology 48:672-676.

Reeder, J. R. 1965. The tribe Orcuttieae and the subtribes of the Pappophoreae (Gramineae). Madroño 18:18-28.

Reeder, J. R. 1980. Nomenclatural changes in *Orcuttia* (Gramineae). Phytologia 47:221.

Reeder, J. R. 1982. Systematics of the tribe Orcuttieae (Gramineae) and the description of a new segregate genus, *Tuctoria*. American Journal of Botany 69:1082-1095.

Reeder, J. R. 1993. *Orcuttia*. Pages 1276-1277 *in* J. C. Hickman, editor. The Jepson manual: higher plants of California. University of California Press, Berkeley, California. 1400 pages.

Reh, W., and A. Seitz. 1990. The influence of land use on the genetic structure of populations of the common frog *Rana temporaria*. Biological Conservation 54:239-249.

Ripley, Bonnie J., Kirsten C. Davis, B.J. Carter and Marie A. Simovich. 2004. Toxicity of malathion and Roundup to the San Diego fairy shrimp. 2002-

2003 Transactions of the Western Section of the Wildlife Society 38/39: 13-21.

Ritland, K., and S. Jain. 1984. The comparative life histories of two annual *Limnanthes* species in a temporally variable environment. American Naturalist 124:656-679.

Rogers, D. C. 1998. Aquatic macroinvertebrate occurrences and population trends in constructed and natural vernal pools in Folsom, California. Pages 224-235 in: C. W. Witham, E. T. Bauder, D. Belk, W. R. Ferren, Jr., and R. Ornduff, editors. Ecology, conservation, and management of vernal pool ecosystems. California Native Plant Society, Sacramento, California.

Rogers, D. C. 2001. Revision of the Nearctic *Lepidurus* (Notostraca). Journal of Crustacean Biology 21:991-1006.

Rubtzoff, P., and L.R. Heckard. 1975. New distributional records for California flowering plants of aquatic and moist habitats. Wasmann Journal of Biology 33:89-106.

Ruibal, R., L. Tevis, Jr., and V. Roig. 1969. The terrestrial ecology of the spadefoot toad *Scaphiopus hammondii*. Copeia 1969:571-584.

Sassaman, C. 1991. Sex ratio variation in female-biased populations of Notostracans. Hydrobiologia 212:169-179.

Sattler, P. W. 1980. Genetic relationships among selected species of North American *Scaphiopus*. Copeia 1980:605-610.

Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento, California. 471 pages.

Scholnick, D. A. 1995. Sensitivity of metabolic rate, growth, and fecundity of tadpole shrimp *Triops longicaudatus* to environmental variation. Biological Bulletin 189(1):22-28.

Scribner, F. L. 1899. American grasses-II. U.S.D.A. Division of Agrostology, Bulletin No. 17, page 221.

Semlitsch, R. D. and J. R. Brodie. 2003. Biological criteria for buffer zones around wetlands and riparian habitats for amphibians and reptiles. Conservation Biology 17(5):1219-1228.

Serpa, L. 1985. Element stewardship abstract for the Delta green ground beetle, *Elaphrus viridis*. The Nature Conservancy, 8 pages.

Serpa, L. 1993. Monitoring report [*Gratiola heterosepala* at Boggs Lake Preserve], 1992. Pages 67-69.

Seymour, R. S. 1973. Energy metabolism of dormant spadefoot toads (*Scaphiopus*). Copeia 1973:435-445.

Shaffer, M. L. 1981. Minimum population sizes for species conservation. BioScience 31:131-134.

Sharsmith, H. K. 1940. Further notes on the genus *Sedella*. Madroño 5:192-196.

Sheikh, M. Y. 1978. A systematic study of west North American *Eryngium* (Umbelliferae-Apiaceae). Ph.D. dissertation, University of California, Berkeley, California..

Sheikh, M.Y. 1983. New taxa of western American *Eryngium* (Umbelliferae). Madroño 30:93-101.

Shoemaker, V. H., L. McClanahan, Jr., and R. Ruibal. 1969. Seasonal changes in body fluids in a field population of spadefoot toads. Copeia 1969:585-591.

Silveira, J. 1996. Arena Plains National Wildlife Refuge and Sunrise Ranch annotated plant list. Draft manuscript, 11 pages.

Silveira, J. G. 1998. Avian uses of vernal pools and implications for conservation practice. Pages 92-106 *in*: C.W. Witham, E.T. Bauder, D. Belk, W.R. Ferren, Jr., and R. Ornduff, editors. Ecology, conservation, and management of vernal pool ecosystems. California Native Plant Society, Sacramento, California.

Simon, E. 1886. Etude sur les crustacées du sous-ordre des Phyllopodes. Annales de la Société Entomologique de France VI:343-460.

Simovich, M.A. 1998. Crustacean biodiversity and endemism in California's ephemeral wetlands. Pages 107-118 in: C.W. Witham, E.T. Bauder, D. Belk, W.R. Ferren, Jr., and R. Ornduff, editors. Ecology, conservation, and management of vernal pool ecosystems. California Native Plant Society, Sacramento, California.

Simovich, M.A, Sassaman and A. Chovnick. 1991. Post-mating selection of hybrid toads (*Scaphiopus multiplicatus* and *Scaphiopus bombifrons*). Proceedings of the San Diego Natural Society of Natural History 5:1-6.

Simovich, M., J. King, and R. Brusca. 1992. Invertebrate survey 1991-1993 PGT-PGE/Bechtel Pipeline Expansion Project. University of San Diego, California.

Skinner, M. W., and B. M. Pavlik. 1994. Inventory of rare and endangered vascular plants of California. Fifth edition. Special Publication No. 1, California Native Plant Society, Sacramento, California. 338 pages.

Skinner, M. W., D. P. Tibor, R. L. Bittman, B. Ertter, T. S. Ross, S. Boyd, A. C. Sanders, J. R. Shevock, and D. W. Taylor. 1995. Research needs for conserving California's rare plants. Madroño 42:211-241.

Smith, D. W., and W. L. Verrill. 1998. Vernal pool-soil-landform relationships in the Central Valley, California. Pages 15-23 *in* C.W. Witham, E.T. Bauder, D. Belk, W.R. Ferren, Jr., and R. Ornduff, editors. Ecology, conservation, and management of vernal pool ecosystems. California Native Plant Society, Sacramento, California. 285 pages.

Smith, J.P., Jr. 1977. Vascular plant families. Mad River Press, Eureka, California. 320 pages.

Smith, J. P., Jr., R. J. Cole, and J. O. Sawyer, Jr. 1980. Inventory of rare and endangered vascular plants of California. Second edition. Special Publication No. 1. California Native Plant Society, Sacramento, California. 115 pages.

Spellenberg, R. 1993. *Astragalus*. Pages 583-605 *in*: J. C. Hickman, editor. The Jepson manual: higher plants of California. University of California Press, Berkeley, California, 1400 pages.

Spencer, S. C. 1993. The evolution of vernal pool adaptation and restriction in *Navarretia* (Polemoniaceae) as inferred from anatomical, morphological,

and palynological studies. American Journal of Botany 80(6) Supplement:177.

Spencer, S. C. and L. H. Rieseberg. 1998. Evolution of amphibious vernal pool specialist annuals: putative vernal pool adaptive traits in *Navarretia* (Polemoniaceae). Pages 76-85 in: C. W. Witham, E. T. Bauder, D. Belk, W. R. Ferren, Jr., and R. Ornduff, editors. Ecology, conservation, and management of vernal pool ecosystems. California Native Plant Society, Sacramento, California.

Stebbins, R. C. 1951. A field guide to western reptiles and amphibians. Houghton Mifflin Company, Boston, Massachusetts.

Stebbins, R. C. 1966. A field guide to western reptiles and amphibians. Houghton Mifflin Company, Boston, Massachusetts.

Stebbins, R. C. 1985. A field guide to western reptiles and amphibians. Second Edition, revised. Houghton Mifflin Company, Boston, Massachusetts.

Stebbins, J. C., W. O. Trayler, and T. E. Mallory. 1993. Botanical resources report: California Aqueduct - San Luis Field Division, Department of Water Resources. Unpublished report, California State University, Fresno, 34 pages. + appendices.

Stebbins, J. C., W. O. Trayler, and R. Kokx. 1995. Habitat characterization study of San Joaquin Valley vernal pools. Unpublished report to the California Department of Fish and Game and the U.S. Fish and Wildlife Service, Sacramento, California. 35 pages. + appendices.

Stebbins, J. C., J. R. Brownell, and W. Trayler. 1996. Effective mitigation techniques for Central Valley vernal pools. Unpublished report to the California Department of Transportation, Fresno, California, 23 pages + appendices.

Stern, K.R. 1992. Habitat delineation, harvesting, and redistribution of seeds of *Limnanthes floccosa* ssp. *californica* (Butte County meadowfoam) on the Simmons Ranch Property east of Bruce Road in the vicinity of Stilson Canyon Road, Chico, Butte County, California. Unpublished report to John D. Drake, Chico, California. 4 pages.

Stine, S. 1994. Extreme and persistent drought in California and Patagonia during medieval time. Nature 369:546-549.

Stone, D. E. 1957. Studies in population differentiation and variation in *Myosurus* of the Ranunculaceae. Ph.D. dissertation, University of California, Berkeley.

Stone, D. E. 1959. A unique balanced breeding system in the vernal pool mouse-tails. Evolution 13:151-174.

Stone, R.D. 1990. California's endemic vernal pool plants: some factors influencing their rarity and endangerment. Pages 89-107 *in*: D.H. Ikeda and R.A. Schlising, editors. Vernal pool plants–their habitat and biology. California State University, Chico, California.

Stone, R. D., W. B. Davilla, D. W. Taylor, G. L. Clifton, and J. C. Stebbins. 1988. Status survey of the grass tribe Orcuttieae and *Chamaesyce hooveri* (Euphorbiaceae) in the Central Valley of California. 2 volumes. U.S. Fish and Wildlife Service Technical Report, Sacramento, California. 124 pages.

Storer, T. L. 1925. A synopsis of the amphibia of California. University of California Publications in Zoology 27:1-342.

Stroud, G. 1990. Monitoring report [*Tuctoria greenei* at Vina Plains Preserve], 1990. Pages 265-268.

Stutz, H. C., and G. L. Chu. 1993. *Atriplex persistens* (Chenopodiaceae), a new species from California. Madroño 40:209-213.

Sugnet, P. 1993. Preliminary compilation of documented distribution, fairy shrimp and tadpole shrimp proposed for listing. Sugnet and Associates, Sacramento, California. 10 pages.

Swab, J.C. 1993. Juncaceae. Pages 1157-1166 *in*: J.C. Hickman, editor. The Jepson manual: higher plants of California. University of California Press, Berkeley, California, 1400 pages.

Swanson, G. A., M. I. Meyer, and J. R. Serie. 1974. Feeding ecology of breeding blue-winged teals. Journal of Wildlife Management 38(3):396-407.

Syrdahl, R. L. 1993. Distribution patterns of some key macro-invertebrates in a series of vernal pools at Vina Plains Preserve in Tehama County, California. Biological Sciences. University of California, Chicom California.

Taylor, D., and D.H. Wilken. 1993. *Atriplex*. Pages 501-505 *in* J.C. Hickman, editor. The Jepson manual: higher plants of California. University of California Press, Berkeley, California, 1400 pages.

The Nature Conservancy. 1991. Removal of *Lippia nodiflora* (mat-grass) from vernal pools, Jepson Prairie Preserve (Solano County). Unpublished report to the California Department of Fish and Game, Sacramento, California. 5 pages.

Thiele, H.-U. 1977. Carabid beetles in their environment: a study on habitat selection by adaptation in physiology and behavior. Springer-Verlag, New York. 369 pages.

Thiery, A., and Fugate, M. 1994. A new American fairy shrimp, *Linderiella santarosae* (Crustacea: Anostraca: Linderiellidae), from vernal pools of California, USA. Proceedings of the Biological Society of Washington 107(4):641-656.

Thorp, R.W. 1976. Insect pollination of vernal pool flowers. Pages 36-40 *in*: S.K. Jain, editor. Vernal pools: their ecology and conservation. Institute of Ecology Publication No. 9, Davis, California. 93 pages.

Thorp, R. W. and J. M. Leong. 1995. Native bee pollinators of vernal pool plants. Fremontia 23(2):3-7.

Thorp, R. W., and J. M. Leong. 1998. Specialist bee pollinators of showy vernal pool flowers. Pages 169-179 *in*: Ecology, conservation, and management of vernal pool ecosystems: proceedings from a 1996 conference. C. W. Witham, E. T. Bauder, D. Belk, W. R. Ferren, Jr., and R. Ornduff, editors. California Native Plant Society, Sacramento, California. 285 pages.

Thorson, T.D., S.A. Bryce, D.A. Lammers, A.J. Woods, J. M. Omernik, J. S. Kagan, D. E. Pater, and J. A. Comstock. 2003. Ecoregions of Oregon (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,500,000).

Twisselmann, E.C. 1967. A Flora of Kern County, California. The Wasmann Journal of Biology 25(1&2):1-395.

U.S. Army Corps of Engineers. 1996. Biological data report: Kaweah River Basin investigation, California. Unpublished report, Environmental Resources Branch, Sacramento District, Sacramento, California.

U.S. Census Bureau. 1996. Populations Projections for States by Age, Sex, Race, and Hispanic Origin. http://www.census.gov/population/www/projections/ppl47.html#tableb. Accessed November 4, 2004.

U.S. Department of Agriculture. 2000. Summary Report: 1997 National Resources Inventory (revised December 2000). Natural Resources Conservation Service, Washington, DC, and Statistical Laboratory, Iowa State University, Ames, Iowa. 89 pages.

U.S. Fish and Wildlife Service. 1978*a*. Endangered and threatened wildlife and plants; determination of five plants as endangered species. Federal Register 43:44810-44812.

U.S. Fish and Wildlife Service. 1978*b*. Endangered and threatened wildlife and plants; proposed endangered or threatened status and critical habitat for 10 beetles. Federal Register 43:35636-35643.

U.S. Fish and Wildlife Service. 1979. Endangered and threatened wildlife and plants; withdrawal of proposed critical habitat for the delta green ground beetle. Federal Register 44:12383-12384.

U.S. Fish and Wildlife Service. 1980*a*. Endangered and threatened wildlife and plants; promulgation of rules for designation of critical habitat. Federal Register 45:13021.

U.S. Fish and Wildlife Service. 1980*b*. Endangered and threatened wildlife and plants; reproposal of critical habitat for the delta green ground beetle. Federal Register 45:29371-29373.

U.S. Fish and Wildlife Service. 1980*c*. Endangered and threatened wildlife and plants; listing the delta green ground beetle as a threatened species with critical habitat. Federal Register 45:52807-52810.

U.S. Fish and Wildlife Service. 1983*a*. Endangered and threatened species; listing and recovery priority guidelines. Federal Register 48:43098-43105.

U.S. Fish and Wildlife Service. 1983*b*. Endangered and threatened wildlife and plants; supplement to review of plant taxa for listing as endangered or threatened species. Federal Register 48:53640-53670.

U.S. Fish and Wildlife Service. 1985*a*. Delta green ground beetle and Solano grass recovery plan. U.S. Fish and Wildlife Service, Portland, OR, 68 pages.

U.S. Fish and Wildlife Service. 1985*b*. Endangered and threatened wildlife and plants; emergency determination of endangered status for Loch Lomond coyote-thistle (*Eryngium constancei*). Federal Register 50:31187-31190.

U.S. Fish and Wildlife Service. 1985*c*. Endangered and threatened wildlife and plants; review of plant taxa for listing as endangered or threatened species; notice of review. Federal Register 50:39526-39527 + 57 page appendix.

U.S. Fish and Wildlife Service. 1986. Endangered and threatened wildlife and plants; determination of endangered status for *Eryngium constancei* (Loch Lomond coyote-thistle). Federal Register 51:45904-45907.

U.S. Fish and Wildlife Service. 1992. Endangered and threatened wildlife and plants; determination of endangered status for the plant *Limnanthes floccosa* ssp. *californica* (Butte County meadowfoam). Federal Register 57:24192-24199.

U.S. Fish and Wildlife Service. 1993. Endangered and threatened wildlife and plants; proposed reclassification of the plant *Eryngium constancei* (Loch Lomond Coyote-thistle) from endangered to threatened status. Federal Register 58:62629-62633.

U.S. Fish and Wildlife Service. 1994*a*. Endangered and threatened wildlife and plants; determination of endangered status for the Conservancy fairy shrimp, longhorn fairy shrimp, and the vernal pool tadpole shrimp; and threatened status for the vernal pool fairy shrimp. Federal Register 59:48136-48153.

U. S. Fish and Wildlife Service. 1994*b*. Endangered and threatened wildlife and plants; animal candidate review for listing as endangered or threatened species; proposed rule. Federal Register 59(219):58982-59028.

U.S. Fish and Wildlife Service. 1996*a*. Endangered and threatened wildlife and plants; review of plant and animal taxa that are candidates for listing as endangered or threatened species. Federal Register 61:7596-7613.

U.S. Fish and Wildlife Service. 1996*b*. Endangered and threatened species; notice of reclassification of 96 candidate taxa. Federal Register 61:7457-7463.

U.S. Fish and Wildlife Service. 1996*c*. Endangered and threatened wildlife and plants; Notice of final decision on identification of candidates for listing as endangered or threatened. Federal Register 61:64481-64485.

U.S. Fish and Wildlife Service. 1997*a*. Endangered and threatened wildlife and plants; determination of endangered status for three plants and threatened status for five plants from vernal pools in the Central Valley of California. Federal Register 62:14338-14352.

U.S. Fish and Wildlife Service. 1997*b*. Endangered and threatened wildlife and plants; endangered status for four plants from vernal pools and mesic areas in northern California. Federal Register 62:34029-34038.

U.S. Fish and Wildlife Service. 1998*a*. Recovery plan for upland species of the San Joaquin Valley, California. Region 1, Portland, Oregon. 319 pages.

U.S. Fish and Wildlife Service. 1998*b*. Vernal pools of southern California recovery plan. U.S. Fish and Wildlife Service, Portland, OR, 113 pages.

U.S. Fish and Wildlife Service. 2000. Policy regarding controlled propagation of species listed under the Endangered Species Act; notice of policy. Federal Register 65:56916-56922.

U.S. Fish and Wildlife Service. 2002. Endangered and threatened wildlife and plants; critical habitat designation for four vernal pool crustaceans and eleven vernal pool plants in California and southern Oregon; proposed rule. Federal Register 67:59884-60039.

U.S. Fish and Wildlife Service. 2003. Endangered and threatened wildlife and plants; final designation of critical habitat for four vernal pool crustaceans and eleven vernal pool plants in California and Southern Oregon. Federal Register 68:46683-46867.

U.S. Fish and Wildlife Service. 2004. Finding of No Significant Impact and Environmental Assessment and for Seasonal Grazing, Prescribed Burning, Mowing, and Herbicide Application on the Warm Springs Seasonal Wetland Unit of the Don Edwards San Francisco Bay National Wildlife Refuge. January 2004.

U.S. Fish and Wildlife Service and National Marine Fisheries Service. 1998. Endangered species consultation handbook.

Vasey, G. 1891. New grasses. Botanical Gazette 16:145-147.

Vollmar, J. E. (editor). 2002. Wildlife and rare plant ecology of eastern Merced County's vernal pool grasslands. Merced, California: Merced County UC Development Office.

Waaland, M.., and J. Vilms. 1989. Santa Rosa Plains Endangered Plant Protection Program report. Unpublished report to the Sonoma County Planning Department and the California Department of Fish and Game Endangered Plant Project, Sacramento, California. 99 pages.

Webster, G. L. 1975. Conspectus of a new classification of the Euphorbiaceae. Taxon 24:593-601.

Weins, J. J., and T. A. Titus. 1991. A phylogenetic analysis of *Spea* (Anura: Pelobatidae). Herpetologica 47:21-28.

Weintraub, J. D. 1979. Selection of daytime retreats by recently metamorphosed *Scaphiopus multiplicatus*. Journal of Herpetology 14(1):83-84.

Wetherwax, M. 1993. *Gratiola*. Pages 1032-1033 *in*: J.C. Hickman, editor. The Jepson manual: higher plants of California. University of California Press, Berkeley, California. 1400 pages.

Wheeler, L.C. 1940. Dichapetalacea et Euphorbiaceae novae. Proceedings of the Biological Society of Washington 53:7-12.

Wheeler, L.C. 1941. *Euphorbia* subgenus *Chamaesyce* in Canada and the United States exclusive of southern Florida. Rhodora 43:97-154, 168-205, 223-286.

Wiggins, G. B. 1995. Larvae of North American Caddisfly Genera (Trichoptera), 2nd edition. University of Toronto Press. Toronto.

Wilken, D.H. 1993. Ranunculaceae. Pages 910-930 *in*: J.C. Hickman, editor. The Jepson manual: higher plants of California. University of California Press, Berkeley, California. 1400 pages.

Winegar, H. H. 1977. Camp Creek channel fencing - plant, wildlife, soil, and water response. Rangeman's Journal 4(1):10-12.

Zedler, P. H. 1987. The ecology of southern California vernal pools: a community profile. U.S. Fish and Wildlife Service Biology Report 85(7.11). 136 pages.

Zedler, P. H. 1990. Life histories of vernal pool vascular plants. Pages 123-146 *in*: D. H. Ikeda and R. A. Schlising, editors. Vernal pool plants–their habitat and biology. California State University, Chico, California.

B. Personal Communications

Alexander, Doug. 1997. Professor, California State University, Chico, California.

Arnold, Dick. Entomological Associates, Pleasant Hill, California.

Buckmann, A. 2001. Associate Wildlife Biologist, California Department of Fish and Game, Yountville, California.

Day, Alva. 1997. Research Associate, California Academy of Sciences, San Francisco, California.

Diaz-Haworth, Jenny. 2001. Friends of Mt. Cobb, Middletown, California.

Eng, Larry. California Department of Fish and Game, Sacramento, California.

Esposito, Linda. 1997. Graduate Student, Sonoma State University, Rohnert Park, California.

Flynn, B. 2001. Private landowner, Middletown, California.

Fuller, Kenneth. 1997. Botanist, U.S. Fish and Wildlife Service, Sacramento, California.

Goulet, Henri. Entomology Biosystematics Research Institute, Agriculture Canada, Central Experiment Farm, Ottawa, Ontario, Canada.

Kavanaugh, Dave. California Academy of Sciences, San Francisco, California.

Knight, Jan. 1997. Sacramento Valley Branch Chief, U.S. Fish and Wildlife Service, Sacramento, California.

McGriff, Darlene. California Department of Fish and Game, Sacramento, California.

Meisler, Julian. Solano County Farmlands and Open Space Foundation, Vacaville, California.

Muick, Pam. Solano County Farmlands and Open Space Foundation, Vacaville, California.

Patterson, Charles. Plant Ecologist, Lafayette, California.

Reiner, Rich. The Nature Conservancy, San Francisco, California.

Scoonover, Roger. California Department of Fish and Game, Sacramento, California.

Serpa, Larry. The Nature Conservancy, San Francisco, California.

Silveira, Joseph. 1997, 2004. Wildlife Biologist, Sacramento National Wildlife Refuge Complex, Willows, California.

Tarp, Kirsten. 1997. Botanist, U.S. Fish and Wildlife Service, Sacramento, California.

Taylor, Dean. 1997. Research Associate, Jepson Herbarium, University of California, Berkeley, California.

Thorpe, Robbin. Department of Entomology, UC Davis, Davis, California.

Tuss, Craig. 2004. U.S. Fish and Wildlife Service, Roseburg, Oregon.

Warne, Elizabeth. 2001. Botanist, U.S. Fish and Wildlife Service, Sacramento, California.

Williams, Kevin. University of California Natural Reserve System, Davis, California.

Witham, Carol. California Native Plant Society, Davis, California.

Woolington, Dennis. 1997. Supervisory Wildlife Biologist, San Luis National Wildlife Refuge Complex, Los Banos, California.

York, Dana. 1996. Biologist, California Department of Transportation, Fresno, California.

C. *In Litt.* References

Aasen, K. 1995. Memorandum to Ron Pape, California Department of Forestry and Fire Protection, Santa Rosa, California. 6 pages.

Ahart, L. 1986. Letter to California Natural Diversity Data Base, Sacramento, California. 7 pages.

Alexander, D. 1998. Electronic mail to Ellen Cypher, Endangered Species Recovery Program, Bakersfield, California. 1 page + 6 pages attachments. Attachment entitled: Week 2: Vina Plains Preserve (handout developed for Ecology classes).

Baye, P. 2000*a*. Electronic mail to Ellen Cypher, Endangered Species Recovery Program, Bakersfield, California. 2 pages.

Baye, P. 2000*b*. Electronic mail to Ellen Cypher, Endangered Species Recovery Program, Bakersfield, California. 1 page.

Boykin, L. 2000. Letter to Ellen Cypher, Endangered Species Recovery Program, Bakersfield, California. 1 page + 7 pages attachments. Attachment entitled: Evolutionary relationships of Orcuttieae (Poaceae) revealed: transition from land to water? (grant proposal).

Buckmann, A. 1998. Letter to Bonny Rice and Ed Escudero, Middletown, California. 1 page.

Cochrane, S. A. 1995*a*. Recovery workshop summary: Sacramento Orcutt grass (*Orcuttia viscida*) and slender Orcutt grass (*Orcuttia tenuis*) in

Sacramento County. Letter of 2 June 1995 to workshop participants. 10 pages.

Cochrane, S. A. 1995*b*. Summary of 2/7/95 Recovery Workshop information and 1995 field survey information on the extant occurrences of slender Orcutt grass (*Orcuttia tenuis*) in Sacramento County and all extant occurrences of Sacramento Orcutt grass (*Orcuttia viscida*). Letter of 22 November 1995 to workshop participants. 4 pages.

Cole, R. 1983. Letter to Sanford Wilbur regarding research and teaching affiliation between the University of California at Davis and The Nature Conservancy. 1 pg.

Corbin, B. 1999. List sent to Ken Fuller, U.S. Fish and Wildlife Service, Sacramento, California. 1 page.

Corbin, B. 2000. Letter to Ellen Cypher, Endangered Species Recovery Program, Bakersfield, California. 3 pages + 4 pages attachments.

Day, A. G. 1993. Letter to Ken Fuller, U.S. Fish and Wildlife Service, Sacramento, California. 4 pages.

Day, A. G. 1997. Letter to Ellen Cypher, Endangered Species Recovery Program, Bakersfield, California. 2 pages + 4 pages attachments.

Esposito, L. 2000. Electronic mail to Ellen Cypher, Endangered Species Recovery Program, Bakersfield, California. 3 pages.

Faubion, R. 2000. Electronic mail to Patrick Kelly, Endangered Species Recovery Program, Fresno, California. 1 pages.

Franklin, A. 1993. California native species field survey form for *Castilleja campestris succulenta*. Submitted to California Natural Diversity Data Base, Sacramento, California. 3 pages.

Fuller, K. 1999. Memorandum to Ellen Cypher, Endangered Species Recovery Program, Bakersfield, California. 1 page.

Fuller, K. 2000. Electronic mail to Ellen Cypher, Endangered Species Recovery Program, Bakersfield, California. 1 page + 5 pages attachments.

Griggs, M. A. 2000. Electronic mail to Ellen Cypher, Endangered Species Recovery Program, Bakersfield, California. 3 pages.

Holland, R. F. 1986. Memorandum of 8 July 1986 to Bill Bailey, Scott Clemons, and Susan Cochrane, California Department of Fish and Game, Sacramento, California. 2 pages.

Howald, A. M. 1995. Letter to Genny Diaz-Hayworth [sic], Middletown, California. 1 page.

Hunter, B. 1996. Letter to Ron Pape, California Department of Forestry and Fire Protection, Santa Rosa, California. 2 pages.

Keeler-Wolf, T. 2000. Electronic mail to Ellen Cypher, Endangered Species Recovery Program, Bakersfield, California. 1 page.

Leitner, B. 1984. Memo to Jepson Prairie file regarding conversation with Richard Arnold and Dave Kavanaugh regarding the delta green ground beetle and prescribed burning. 1 page.

Liston, A. 1988. Letter to Rick York, California Natural Diversity Data Base, Sacramento, California. 8 pages.

Liston, A. 1993. Letter to Carol Witham, Davis, California. 1 page.

Liston, A. 2000. Electronic mail to Ellen Cypher, Endangered Species Recovery Program, Bakersfield, California. 1 page.

Marr, J. C. 1996. Letter to Heather Bell, U.S. Fish and Wildlife Service, Sacramento, California. 1 page.

Morey, S. 1996. Letter of 27 November 1996 to workshop participants, California Department of Fish and Game, Sacramento, California. 3 pages.

Patterson, C. A. 2000. Letter to Ellen Cypher, Endangered Species Recovery Program, Bakersfield, California. 1 page + 22 pages attachments.

Rocco, C. 1993. Letter to Ken Fuller, U.S. Fish and Wildlife Service, Sacramento, California. 5 pages.

Rogers, C. 2001. Draft species account for the vernal pool tadpole shrimp. Prepared for Sacramento County Habitat Conservation Plan by Jones and Stokes, Associates, Sacramento, California. 12 pages.

Schonholtz, R. 1995. Letter to Jan Knight, Mark Littlefield, and Steve Morey, U.S. Fish and Wildlife Service, Sacramento, California. 10 pages + attachments.

Schoolcraft, G. D. 2000. Letter to Ellen Cypher, Endangered Species Recovery Program, Bakersfield, California. 2 pages.

Sellers, C. 2001. Electronic mail to Ellen Cypher, Endangered Species Recovery Program, Bakersfield, California. 2 pages + 4 pages attachments.

Serpa, L. 1997. Letter to Bradley Goettle, U.S. Fish and Wildlife Service, Sacramento, California., regarding updated information on element abstract for delta green ground beetle originally done in 1985 for The Nature Conservancy. 1 page.

Silveira, J. 1997. Memorandum to Ken Fuller, U.S. Fish and Wildlife Service, Sacramento, California. 3 pages.

Silveira, J. 2000. Letter to Ellen Cypher, Endangered Species Recovery Program, Bakersfield, California. 1 page + 35 pages attachments.

Single, J. 2003. Email to Glen Tarr, U.S. Fish and Wildlife Service. California Department of Fish and Game. Fresno, California. September 8, 2003. (Includes attached file: Merced Easements summary.xls).

Snover, S. A. 1994. Letter to Liz Molacek, U.S. Fish and Wildlife Service, Sacramento, California. 2 pages.

Stebbins, J. 2000*a*. Letter to Ellen Cypher, Endangered Species Recovery Program, Bakersfield, California. 1 page + 17 pages attachments.

Stebbins, J. 2000*b*. Electronic mail to Ellen Cypher, Endangered Species Recovery Program, Bakersfield, California. 1 page.

Stern, K. R. 1994. Simmons Ranch meadowfoam survey. Letter to Tony Symmes, Drake Homes, Chico, California. 2 pages.

Stone, R. D. 1992. Letter to Melinda Trask, Dames and Moore, Goleta, California. 11 pages.

Taylor, D. 1997. Electronic mail to Ellen Cypher, Endangered Species Recovery Program, Bakersfield, California. 1 page + 2 pages attachments.

Trask, M. 1993. California native species field survey form for *Orthocarpus (=Castilleja) campestris succulentus.* Submitted to California Natural Diversity Data Base, Sacramento, California. 1 page.

Whittemore, A. 1993. Letter to Roxanne Bittman, California Natural Diversity Data Base, Sacramento, California. 3 pages.

Witham, C. W. 1990. Focused field survey, *Astragalus tener* var. *tener*, Solano and Yolo Counties, California, April 1990. Submitted to California Natural Diversity Data Base, Sacramento, California. 5 pages.

Witham, C. W. 1992. Letter to Greg Elliot, Cosumnes River Preserve, Galt, California. 4 pages.

Witham, C. W. 1993. Letter to Aaron Liston, Oregon State University, Corvallis, Oregon. 1 page.

Witham, C. W. 1998. Electronic mail to Ellen Cypher, Endangered Species Recovery Program, Bakersfield, California. 1 page.

Witham, C. W. 2000*a*. Letter to Ellen Cypher, Endangered Species Recovery Program, Bakersfield, California. 1 page + 18 pages attachments.

Witham, C. W. 2000*b*. California native species field survey form for *Gratiola heterosepala*. 1 page.

VII. APPENDICES

APPENDIX A. LIST OF SCIENTIFIC AND COMMON NAMES OF PLANTS AND ANIMALS

Common name	Scientific name
adobe popcorn flower	*Plagiobothrys acanthocarpus*
Ahart's dwarf rush	*Juncus leiospermus* var. *ahartii*
Ahart's rush	*Juncus leiospermus* var. *ahartii*
alkali bulrush	*Scirpus maritimus*
alkali heath	*Frankenia salina*
alkali mallow	*Malvella leprosa* (= *Sida hederacea*)
alkali milk-vetch	*Astragalus tener* var. *tener*
alkali weed	*Cressa truxillensis*
awnless Orcutt grass	*Tuctoria greenei*
Baker's navarretia	*Navarretia leucocephala* ssp. *bakeri*
ball saltbush	*Atriplex fruticulosa*
bearded allocarya	*Plagiobothrys hystriculus*
bearded popcorn flower	*Plagiobothrys hystriculus*
bellflower family	Campanulaceae
bindweed	*Convolvulus arvensis*
black oak	*Quercus kelloggii*
blunt spikerush	*Eleocharis obtusa*
bog bulrush	*Scirpus mucronatus*
Boggs Lake dodder	*Cuscuta howelliana*
Boggs Lake hedge-hyssop	*Gratiola heterosepala*
borage family	Boraginaceae
bractless hedge-hyssop	*Gratiola ebracteata*
brass buttons	*Cotula coronopifolia*
broad-leaved pepper-weed	*Lepidium latifolium*
brome	*Bromus* spp.
Burke's goldfields	*Lasthenia burkei*
Butte County meadowfoam	*Limnanthes floccosa* ssp. *californica*
buttercup family	Ranunculaceae
California buckeye	*Aesculus californica*
California goldfields	*Lasthenia californica*
California lilac	*Ceanothus* species
California Orcutt grass	*Orcuttia californica*
California semaphore grass	*Pleuropogon californicus*
carrot family	Apiaceae (= Umbelliferae)
cattail	*Typha* species
chamise	*Adenostoma fasciculatum*
Chico grass	*Tuctoria greenei*
Clara Hunt's milk-vetch	*Astragalus clarianus*
coastal dunes milk-vetch	*Astragalus tener* var. *titi*
cocklebur	*Xanthium strumarium*
Colusa grass	*Neostapfia colusana*
common American hedge-hyssop	*Gratiola neglecta*
common coyote-thistle	*Eryngium castrense*
common mousetail	*Myosurus minimus*
common spikeweed	*Hemizonia pungens*
Constance's coyote-thistle	*Eryngium constancei*
Contra Costa goldfields	*Lasthenia conjugens*
coyote-thistle	*Eryngium* species
Crampton's Orcutt grass	*Tuctoria mucronata*
Crampton's tuctoria	*Tuctoria mucronata*

Common name	Scientific name
dense-flowered owl's-clover	*Castilleja densiflora*
Douglas fir	*Pseudotsuga menziesii*
Douglas' meadowfoam	*Limnanthes douglasii*
Douglas' pogogyne	*Pogogyne douglasii*
downingia	*Downingia* species
dwarf downingia	*Downingia pusilla*
dwarf peppergrass	*Lepidium latipes* var. *latipes*
dwarf woolly-heads	*Psilocarphus brevissimus*
false mermaid family	Limnanthaceae
Ferris's milk-vetch	*Astragalus tener* var. *ferrisiae*
few-flowered navarretia	*Navarretia leucocephala* ssp. *pauciflora*
field bindweed	*Convolvulus arvensis*
field owl's-clover	*Castilleja campestris* ssp. *campestris*
figwort family	Scrophulariaceae
filaree	*Erodium* species
fleshy owl's-clover	*Castilleja campestris* ssp. *succulenta*
foxtail	*Alopecurus saccatus*
foxtail mousetail	*Myosurus minimus* ssp. *alopecuroides*
frankenia	*Frankenia salina*
Fremont's goldfields	*Lasthenia fremontii*
Fremont's tidy-tips	*Layia fremontii*
fringed downingia	*Downingia concolor*
Gairdner's yampah	*Perideridia gairdneri* ssp. *gairdneri*
goldfields	*Lasthenia* species
goosefoot family	Chenopodiaceae
grass family	Poaceae
Great Valley gumplant	*Grindelia camporum*
Greene's legenere	*Legenere limosa*
Greene's Orcutt grass	*Tuctoria greenei*
Greene's orcuttia	*Tuctoria greenei*
Greene's popcorn flower	*Plagiobothrys greenei*
Greene's tuctoria	*Tuctoria greenei*
hairy checker-mallow	*Sidalcea hirsuta*
hairy Orcutt grass	*Orcuttia pilosa*
hairy orcuttia	*Orcuttia pilosa*
hard-stemmed tule	*Scirpus acutus* var. *occidentalis*
Hoover's spurge	*Chamaesyce hooveri*
Howell's quillwort	*Isoetes howelli*
hyssop-leaved bassia	*Bassia hyssopifolia*
inch-high dwarf rush	*Juncus uncialis*
Italian ryegrass	*Lolium multiflorum*
Jepson's button-celery	*Eryngium aristulatum*
Jepson's milk-vetch	*Astragalus rattanii* var. *jepsonianus*
juniper	*Juniperus* species
Kaweah brodiaea	*Brodiaea insignis*
Lake County stonecrop	*Parvisedum leiocarpum*
leafy common madia	*Madia elegans* ssp. *densifolia*
legenere	*Legenere limosa*
Lemmon's canary grass	*Phalaris lemmonii*
lippia	*Phyla nodiflora* (= *Lippia nodiflora*)
little mousetail	*Myosurus minimus* ssp. *apus*
Loch Lomond button-celery	*Eryngium constancei*
Loch Lomond coyote-thistle	*Eryngium constancei*
madrone	*Arbutus menziesii*
mannagrass	*Glyceria* species
many-flowered navarretia	*Navarretia leucocephala* ssp. *plieantha*

Common name	Scientific name
manzanita	*Arctostaphylos* species
mayweed	*Anthemis cotula*
meadowfoam family	Limnanthaceae
meadowfoams	*Limnanthes* species
Mediterranean barley	*Hordeum marinum* ssp. *gussoneanum*
medusahead	*Taeniatherum caput-medusae*
moss	class Musci
Mt. Hamilton stonecrop	*Parvisedum pentandrum*
mucronate tuctoria	*Tuctoria mucronata*
navarretias	*Navarretia* species
oak	*Quercus* species
Oregon oak	*Quercus garryana*
Oregon woolly-heads	*Psilocarphus oregonus*
Orcutt grasses	*Orcuttia* species
Otay Mesa mint	*Pogogyne nudiuscula*
owl's-clover	*Castilleja* species or *Triphysaria* species
pale spikerush	*Eleocharis macrostachya*
Parish's brittlescale	*Atriplex parishii*
pea family	Fabaceae
pennyroyal	*Mentha pulegium*
persistent-fruited saltscale	*Atriplex persistens*
phlox family	Polemoniaceae
pilose Orcutt grass	*Orcuttia pilosa*
pincushion navarretia	*Navarretia myersii* ssp. *myersii*
pink meadowfoam	*Limnanthes douglasii* ssp. *rosea*
plantain	*Plantago* species
pointed rush	*Juncus oxymeris*
ponderosa pine	*Pinus ponderosa*
popcorn flower	*Plagiobothrys* species
prostrate navarretia	*Navarretia prostrata*
pygmy stonecrop	*Crassula connata* (= *Tillaea erecta*)
Red Bluff dwarf rush	*Juncus leiospermus* var. *leiospermus*
rough-fruited popcorn flower	*Plagiobothrys trachycarpus*
rush family	Juncaceae
rushes	*Juncus* species
Russian thistle	*Salsola tragus*
ryegrass	*Lolium* species
Sacramento Orcutt grass	*Orcuttia viscida*
Sacramento orcuttia	*Orcuttia viscida*
Sacramento Valley milk-vetch	*Astragalus tener* var. *ferrisiae*
saltgrass	*Distichlis spicata*
San Diego button-celery	*Eryngium aristulatum* var. *parishii*
San Diego mesa mint	*Pogogyne abramsii*
San Joaquin Orcutt grass	*Orcuttia inaequalis*
San Joaquin Valley Orcutt grass	*Orcuttia inaequalis*
San Joaquin Valley orcuttia	*Orcuttia inaequalis*
semaphore grass	*Pleuropogon* species
sessile mousetail	*Myosurus sessilis*
Shippee meadowfoam	*Limnanthes floccosa* ssp. *californica*
silver sagebrush	*Artemisia cana*
slender Orcutt grass	*Orcuttia tenuis*
slender orcuttia	*Orcuttia tenuis*
slender popcorn flower	*Plagiobothrys tener*
slender rattle-weed	*Astragalus tener* var. *tener*
small pincushion navarretia	*Navarretia myersii* ssp. *deminuta*
smooth goldfields	*Lasthenia glaberrima*

Common name	Scientific name
snapdragon family	Scrophulariaceae
Solano grass	*Tuctoria mucronata*
Sonoma sunshine	*Blennosperma bakeri*
spikerush	*Eleocharis* species
spiny-sepaled button-celery	*Eryngium spinosepalum*
spreading navarretia	*Navarretia fossalis*
spurge family	Euphorbiaceae
sticky Orcutt grass	*Orcuttia viscida*
stonecrop family	Crassulaceae
Stony Creek spurge	*Chamaesyce ocellata* ssp. *rattanii*
succulent owl's-clover	*Castilleja campestris* ssp. *succulenta*
swamp grass	*Crypsis schoenoides*
sweet clover	*Melilotus indica*
thistle	*Cirsium* species
thread-like mousetail	*Myosurus minimus* ssp. *filiformis*
three-colored monkey flower	*Mimulus tricolor*
thyme-leaved spurge	*Chamaesyce serpyllifolia*
toad rush	*Juncus bufonius*
turkey mullein	*Eremocarpus setigerus*
two-horned downingia	*Downingia bicornuta*
valley downingia	*Downingia pulchella*
valley oak	*Quercus lobata*
Vasey's coyote-thistle	*Eryngium vaseyi*
vernal pool layia	*Layia chrysanthemoides*
vernal pool popcorn flower	*Plagiobothrys stipitatus* (= *Allocarya stipitata*)
vernal pool saltbush	*Atriplex persistens*
vernal pool smallscale	*Atriplex persistens*
vinegar weed	*Trichostema lanceolatum*
water shamrock	*Marsilea vestita*
whiteflower navarretia	*Navarretia leucocephala*
white meadowfoam	*Limnanthes alba*
white tumbleweed	*Amaranthus albus*
wild barley	*Hordeum* species
winecup clarkia	*Clarkia purpurea*
woolly meadowfoam	*Limnanthes floccosa* ssp. *floccosa*
yampah	*Perideridia* species
yellow carpet	*Blennosperma nanum*
yellow pine	*Pinus ponderosa*
yellow star-thistle	*Centaurea solstitialis*
yerba golondrina	*Chamaesyce ocellata* ssp. *ocellata*
ANIMALS	
alkali fairy shrimp	*Branchinecta mackini*
backswimmers	order Hemiptera; family Notonectidae
bee flies	order Diptera; family Bombyliidae
bees	order Hymenoptera, superfamily Apoidea
beetles	order Coleoptera
black-tailed deer	*Odocoileus hemionus*
Blennosperma-specialist bee	*Andrena blennospermatis*
bullfrog	*Rana catesbeiana*
burrowing bee	*Andrena* and *Panurginus* species
burrowing owl	*Athene cunicularia*
butterflies	order Lepidoptera
California fairy shrimp	*Linderiella*
California ground squirrel	*Spermophilus beecheyi*

Common name	Scientific name
California tiger salamander	*Ambystoma californiense*
cliff swallow	*Petrochelidon pyrrhonata*
Colorado fairy shrimp	*Branchinecta coloradensis*
Conservancy fairy shrimp	*Branchinecta conservatio*
crab spiders	order Araneae; family Thomisidae
crane flies	order Diptera; family Tipulidae
cryptic tadpole shrimp	*Lepidurus cryptis*
delta green ground beetle	*Elaphrus viridis*
dragonflies and damselflies	order Odonata
elk	*Cervus elaphus*
flies	order Diptera
golden-haired dung fly	*Scatophaga stercoraria*
ground squirrel	*Spermophilus* species
honeybee	*Apis mellifera*
horned lark	*Eremophila alpestris*
lesser nighthawk	*Chordeiles acutipennis*
Limnanthes-specialist bees	*Andrena limnanthis* and *Panurginus occidentalis*
longhorn fairy shrimp	*Branchinecta longiantenna*
mayflies	order Ephemeroptera
midges	order Diptera; family Chironomidae
midvalley fairy shrimp	*Branchinecta mesovallensis*
mosquitoes	order Diptera; family Culicidae
moths	order Lepidoptera
pocket gopher	*Thomomys* species
pronghorn	*Antilocapra americana*
saldid bugs	order Hemiptera; family Saldidae
solitary bees	order Hymenoptera; family Andrenidae
springtails	order Collembola
true bugs	order Hemiptera
tule elk	*Cervus elaphus nannoides*
vernal pool fairy shrimp	*Branchinecta lynchi*
vernal pool tadpole shrimp	*Lepidurus packardi*
wasps	order Hymenoptera
water boatmen	order Hemiptera; family Corixidae
waterfowl	family Anatidae
water striders	order Hemiptera; family Gerridae
western spadefoot toad	*Spea hammondii*

APPENDIX B. GLOSSARY OF TECHNICAL TERMS

Term	Definition
achene	a dry, single-seeded *fruit* that does not split open; the fruit wall is thinner than that of a *nutlet*
adaptive management	a long-term repeated process of gradually modifying management techniques based upon the results of modeling and research
allele	a form of a gene
alluvial fan	the fan-shaped area of sediment deposited where a mountain stream first enters a valley or plain
alluvium	sediment deposited by flowing water
anaerobic	lacking oxygen
annual	a plant that lives less than 1 year; the entire life cycle from seed germination to *seed set* is completed in a single growing season
anther	the pollen-producing portion of a *stamen*
axil	the angle between the base of a leaf and the stem
banner	the outermost petal in flowers of the pea family; it often curves upward away from the other petals
beak	a narrow projection
biennial	a plant that lives for 2 years, flowering only in the second year
bisexual	flowers containing functional male and female reproductive structures
blade	the flattened portion of a leaf
bottleneck	a situation occurring when a population is reduced to only a few individuals, which then reproduce to create a larger population over time; although the population may continue to increase in size, its genetic diversity remains low
bract	a leaf-like structure located in the *inflorescence*
bractlet	a tiny *bract* occurring below an individual flower
breeding system	a plant's strategy for reproduction; examples are outcrossing and inbreeding
calyx	the set of *sepals* in a single flower
capsule	a type of dry *fruit* that splits open at maturity
caryopsis	the *fruit* of a grass; also known as a grain
Category 1 candidate	a species for which sufficient information is on file with the Fish and Wildlife Service to list it as endangered or threatened, but which is awaiting publication of a formal listing proposal
Category 2 candidate	a species for which listing possibly may be appropriate, but for which insufficient information is available to make a determination; this category is no longer used by the Fish and Wildlife Service
compatible use	activities and practices that contribute to population stability
competition	the simultaneous demand by two or more organisms or species for an essential common resource that is actually or potentially in limited supply

Term	Definition
colony	a group of plants separated by a short distance from other groups of the same species, but not far enough apart to qualify as separate *occurrences*
compound leaf	a leaf composed of several to many separate segments (*leaflets*), which share a common *petiole*
conservation easement	a contract or deed restriction that specifies the type of land uses that may occur in the designated area
corolla	the set of petals in a single flower
cyathium	the complex flowering structure found in spurges, which resembles a single flower
decumbent	a stem laying on the ground, with the tip turned upward
deflexed	pointing downward
demographic monitoring	a process for determining population trends and identifying and evaluating the factors responsible for lack of population stability; consists of *trend analysis* and *factor resolution* (see Pavlik 1994)
demography	the study of populations with reference to birth and death rates, size and density, distribution, migration, and other vital statistics
diploid	the number of chromosomes found in the non-reproductive cells of an organism; designated by 2*n*
disk flowers	the tiny, tubular flowers at the center of a flower head in some members of the Asteraceae
distichous	arranged in two opposing rows
ecomorph	A group of individuals of a species that have a unique appearance because of where they live, rather than due to genetic differences.
element occurrence	the unique number assigned to an *occurrence* by the California Natural Diversity Data Base
elytra	first pair of wings which, in beetles, are hardened and act as a protective covering
endemic	restricted to a particular area
enhancement	manipulating a species or its habitat to increase population size above current levels or improve habitat conditions; one example is adding seed to an existing population
entire	not divided (referring to a leaf margin or flower part)
entomologists	people who study insects
enzyme system	a group of related proteins; analysis of these proteins provides clues as to the genetic relatedness of individuals because the genetic code for each protein is carried on a different gene
extant	still in existence
extirpated	eliminated from a particular area
extrinsic	due to external factors; for example, habitat loss due to urban development is an extrinsic threat
exudate	aromatic, sticky fluid
factor resolution	identifying and evaluating the factors responsible for lack of population stability

Term	Definition
fecundity	the number of offspring produced by an animal or the number of seeds produced by a plant
filament	the stalk that supports an *anther*
final rule	the document published in the Federal Register in which a species is officially designated as threatened or endangered
floret	a single flower of a grass plant, including the *stamens*, *pistil*, *lemma* and *palea*
frequency	the proportion of samples in which a given species occurs
fruit	the plant structure that bears seeds; may be fleshy or dry
genera	plural of genus
generalist (pollinator)	an animal, usually an insect, that pollinates flowers of a wide variety of plant species from many families
germination	sprouting (of a seed)
glume	the scale-like structures at the base of a grass *spikelet*
grain	the *fruit* of a grass; also known as a *caryopsis*
hemiparasite	a plant that obtains water and nutrients from the roots of other plants but manufactures its own food through photosynthesis
herbivore	an animal (invertebrate or vertebrate) that eats plants
host	the source of water and nutrients for a *hemiparasite*
hydrology	patterns of water movement
in litt.	abbreviation for the Latin phrase *in litteris*, meaning "in a letter"; also applies to unpublished references, such as internal agency reports
incompatible uses	activities or practices that contribute to the decline of a population
indeterminate	growth pattern in which the stem continues elongating as long as the plant is alive
inflorescence	the entire flowering structure of a plant, often consisting of many separate flowers, their associated *bracts*, and the *rachis*
intergrades	plants intermediate in *morphology* between two recognized *taxa*
intrinsic	not due to external factors; for example, low levels of genetic diversity within a species is an intrinsic threat
introduce/introduction	to seed or transplant into a site that is not known to have been occupied by a particular species but is within a vernal pool region, pool type, and set of ecological conditions from which the species was known to occur
juvenile leaves	the cylindrical leaves of Orcuttieae that form underwater
keel	the innermost, boat-shaped pair of fused petals in flowers of the pea family
lacustrine	originating in lakes
leaflet	one of the distinct segments of a *compound leaf*

Term	Definition
lemma	a scale-like structure that encloses the *palea*, *stamens*, and *pistil* in a grass flower
ligule	the flattened, strap-shaped portion of the *corolla* in *ray flowers* of the aster family; also the appendage commonly found at the junction of the *sheath* and *blade* in grasses
lips	two or more groups of fused petals that occur within a single *corolla* but differ in appearance
List 1B	plants considered by the California Native Plant Society to be "rare, threatened, or endangered in California and elsewhere" (California Native Plant Society 2001)
lobes	free tips of fused plant parts that are partially fused, such as petals, *sepals*, or leaf tissue
male-sterile	flowers that lack functional anthers
marginal	a population believed to be too small for long-term persistence without *enhancement*
median	in a set of data, the value for which half of the observations are smaller and half are greater
metapopulation	separate colonies that function as a single population by exchanging of genetic material at least once a year
microhabitat	localized areas with unique conditions due to small-scale variations in physical features of the landscape
mitigation	actions undertaken to compensate for impacts to endangered species populations or wetlands
mitigation bank	an area important for conservation in which developers of unrelated projects may buy a share to compensate for their impacts to a similar suite of endangered species or wetlands that will be destroyed due to project development in another area
molecular taxonomy	studying similarities among *taxa* by comparing proteins, DNA, and other molecules
morphology	external form and structure
node	the point where a leaf or branch attaches to the stem
nomenclature	a system of naming rules in the biological sciences, thus plant species are named according to the rules of botanical nomenclature
nutlet	one of several small, dry, single-seeded *fruits* with a hard covering that are produced within a single flower; nutlets have thicker walls than do *achenes*
obsidian	volcanic glass
occurrence	an occupied area at least 0.4 kilometers (¼ mile) away from the next occupied area; see also *element occurrence*, *population*
order	a taxonomic rank below class and above family
order of magnitude	a factor of 10; for example 1,000 is three orders of magnitude greater than 1
outcrossing	fertilization of an ovary by pollen from a different plant

Term	Definition
oviposition	egg-laying
palea	a papery scale that encloses the stamens and *pistil* in a grass flower
pappus	the hair-like or scale-like structures attached to an *achene*, which assist in dispersal (e.g., the tufts visible on dandelions gone to seed)
perennial	a plant that lives for many years
petiole	leaf stalk
phenology	the timing of various stages in the life cycle of a plant
phyllary	one of the *bracts* below the flower head in members of the Asteraceae
pilose	covered with long, soft hairs
pinnately compound	divided into distinct segments, which are arranged feather-like on either side of a *rachis* (see also *compound leaf*)
pinnately lobed	a leaf that has projections (*lobes*) arranged in a feather-like pattern but is not completely divided into distinct segments
pistil	the female reproductive structure of a flower
pistillate	a flower containing only female reproductive parts
pith	the tissue at the core of a plant stem
population	a group of individuals of the same species that occupy an area small enough to permit interbreeding regularly (herein used interchangeably with *occurrence* or to represent a group of individuals that is not included in the California Natural Diversity Data Base)
pubescent	covered with short hairs
pupation	a nonmobile stage in which larvae transform to adults
race	a group of plant populations that share distinct genetic or morphological traits
rachis	the central stalk of an *inflorescence* or *compound leaf*
ray flowers	tiny flowers with flattened, fused petals that occur near the margin of a flower head in some members of the aster family (e.g., the “petals” of a common daisy)
reintroduce/reintroduction	to seed or transplant a species into a specific site from which it has been extirpated
root graft	a connection between the water-conducting tissues in root systems of two plants
rosette	a cluster of leaves near the ground
scape	a leafless flowering stem
seasonal wetlands	areas that hold or carry water for only a portion of the year; herein refers to *vernal pools* and *swales*
section 6	the section of the Federal Endangered Species Act through that allows for states to receive Federal funding for programs to conserve listed species

Term	Definition
seed bank	stored seeds; may be dormant seeds in the soil (see *soil seed bank*) or those stored in a facility for conservation purposes
seed set	production of mature seeds
self-compatible	capable of setting seed when pollen reaches *pistils* on the same plant
self-incompatible	requiring fertilization by pollen from a different plant in order to set seed
sepal	one of several leaf-like structures beneath the petals of a flower
sheath	the narrow, tubular portion of a grass leaf that surrounds the stem
sites necessary for conservation	specific sites necessary to prevent the extinction of species that are not formally listed as endangered or threatened; equivalent to *important habitat* for listed species
soil seed bank	viable seeds that remain dormant in the soil
solitary	a structure or organism that occurs individually, rather than in groups or clusters (e.g., solitary flowers, solitary bees)
specialist pollinator	an animal (usually an insect) that pollinates only flowers of a single genus or species
spikelet	in grasses, the structure consisting of one or more *florets*, the tiny stems that connect the florets, and the *glumes*
spur	a tubular projection from a sepal or petal
stable	remaining at the current level; (for *annual* plants, this takes into account not only above-ground plants but also seeds present in the soil; see Pavlik 1994, p. 329)
stamen	the male reproductive structure of a flower, consisting of an *anther* and a *filament*
status survey	identifying all historical localities of a species, predicting additional likely sites where the species may occur, visiting all of the historical and likely sites, and evaluating population size and threats at those sites
stigma	the part of the *pistil* that receives pollen
stocking rate	the number of livestock per acre
stomates	pores in the surface of a leaf that facilitate gas exchange
stratification	exposure to cold, submersion, or other treatment that is necessary for certain seeds to germinate
swale	a shallow drainage that carries water seasonally; differs from a vernal pool in that it has an outlet
tarsus	terminal leg segments
taxa	plural of *taxon*
taxon	a term used to denote a taxonomic entity of any rank; often used to refer to an assorted group consisting of species, subspecies, and varieties
terrace	a flat-topped soil formation bordering a river or stream

Term	Definition
terrestrial	growing on dry land as opposed to water
terrestrial leaves	the flat-bladed leaves of Orcuttieae that develop after water has evaporated from the pools (as opposed to *juvenile leaves*)
thatch	a matted layer of dead vegetation on the soil surface
translocation	moving a species from one site to another; may involve *enhancement, introduction,* or *reintroduction*
trend analysis	the process of determining whether a population is increasing, declining, or remaining stable
tribe	a taxonomic rank below family and above genus
tube	the fused portion of a *calyx* or *corolla*
tubercle	a wart-like projection
tuffaceous	porous, such as rock formed from cemented volcanic ash
type locality	the site from which the *type specimen* was collected
type specimen	the individual, preserved plant or animal that the original author designated to represent a new species
vernal pool	a depression that retains water seasonally due to a shallow, impermeable soil layer beneath the surface and the absence of a drainage outlet
viscid	sticky
wings	the pair of petals inside the *banner* of a flower in the pea family; these petals are very narrow at their bases
> is the symbol for ‘greater than’; < is the symbol for ‘less than’	

APPENDIX C. RECOVERY PRIORITY AND FEDERAL REGISTER NOTICE REFERENCE AND DATES

Species Name	Recovery Priority[1]	Federal Register Notice, Date Listed
Castilleja campestris ssp. *succulenta* (Fleshy owl's clover)	9	62:14338-14352, March 26, 1997
Chamaesyce hooveri (Hoover's spurge)	2c	62:14338-14352, March 26, 1997
Eryngium constancei (Loch Lomond button-celery)	14	51:45904-45907, December 23, 1986
Lasthenia conjugens (Contra Costa goldfields)	5c	62:34029-34038, June 18, 1997
Limnanthes floccosa ssp. *californica* (Butte County meadowfoam)	2c	57:24192-24199, June 8, 1992
Navarretia leucocephala ssp. *pauciflora* (few-flowered navarettia)	3	62:34029-34038, June 18, 1997
Navarretia leucocephala ssp. *plieantha* (many-flowered navarettia)	3	62:34029-34038, June 18, 1997
Neostapfia colusana (Colusa grass)	2c	62:14338-14352, March 26, 1997
Orcuttia inaequalis (San Joaquin Valley Orcutt grass)	8	62:14338-14352, March 26, 1997
Orcuttia pilosa (hairy Orcutt grass)	2c	62:14338-14352, March 26, 1997
Orcuttia tenuis (slender Orcutt grass)	8	62:14338-14352, March 26, 1997
Orcuttia viscida (Sacramento Orcutt grass)	5c	62:14338-14352, March 26, 1997
Parvisedum leiocarpum (Lake County stonecrop)	2c	62:34029-34038, June 18, 1997
Tuctoria greenei (Greene's tuctoria)	2c	62:14338-14352, March 26, 1997
Tuctoria mucronata (Solano grass)	2	43:44810-44812, September 28, 1978
Conservancy fairy shrimp (*Branchinecta conservatio*)	8	59(180):48136-48152, September 19, 1994
Longhorn fairy shrimp (*Branchinecta longiantenna*)	8	59(180):48136-48152, September 19, 1994
Vernal pool fairy shrimp (*Branchinecta lynchi*)	2c	59(180):48136-48152, September 19, 1994
Delta green ground beetle (*Elaphrus viridis*)	8	45:52807-52810, August 8, 1980
Vernal pool tadpole shrimp (*Lepidurus packardi*)	2c	59(180):48136-48152, September 19, 1994

[1] Appendix D describes how we determine recovery priority for each species.

APPENDIX D. PRIORITIES FOR RECOVERY OF THREATENED AND ENDANGERED SPECIES

Degree of Threat	Recovery Potential	Taxonomy	Priority	Conflict
High	High	Monotypic Genus	1	1C 1
	High	Species	2	2C 2
	High	Subspecies	3	3C 3
	Low	Monotypic Genus	4	4C 4
	Low	Species	5	5C 5
	Low	Subspecies	6	6C 6
Moderate	High	Monotypic Genus	7	7C 7
	High	Species	8	8C 8
	High	Subspecies	9	9C 9
	Low	Monotypic Genus	10	10C 10
	Low	Species	11	11C 11
	Low	Subspecies	12	12C 12
Low	High	Monotypic Genus	13	13C 13
	High	Species	14	14C 14
	High	Subspecies	15	15C 15
	Low	Monotypic Genus	16	16C 16
	Low	Species	17	17C 17
	Low	Subspecies	18	18C 18

APPENDIX E. POTENTIAL CONTAMINANTS ASSOCIATED WITH WESTERN SPADEFOOT TOAD HABITAT

The chemicals of greatest concern for which data on amphibians, fish, or their food supply could be found are:

acephate
azinphos-methyl
carbaryl
chlorpyrifos
diazinon
dicofol
disulfoton
endosulfan
esfenvalerate
fenamiphos
glyphosate
malathion
mancozeb
methamidophos
methoprene
naled
paraquat
permethrin
phosmet
polycyclic aromatic hydrocarbons
pyrethrins
rotenone
strychnine
triclopyr
trifluralin

Glossary of Terminology and Units for Contaminants

LC50-lethal concentration to 50 percent of test organisms
mg/kg-milligrams per kilogram
mg/L-milligrams per liter
ng/L-nanograms per liter
:g/L-micrograms per liter
PAH-Polycyclic Aromatic Hydrocarbons

APPENDIX F. CONSERVATION TOOLS AND STRATEGIES

Rights and Interests in Land that Can be Acquired

Right or Interest	Explanation	Advantages	Disadvantages
Fee simple ownership	Full title to land and all rights associated with land.	Owner has full control of land. Allows for permanent protection and public access.	Most costly. Ownership responsibility includes liability and maintenance.
Conservation easement / development rights (Access to monitor species populations should be added to conservation easement)	A partial interest in property transferred to an appropriate nonprofit or governmental entity either by gift or purchase. As ownership changes, the land remains subject to the easement restrictions.	Less expensive than fee simple. Landowner retains ownership and property is taxed at a lower rate. Easement may allow for some development. Potential income and estate tax benefits from donation.	Public access may not be guaranteed. Easement must be enforced. Restricted use may lower resale value. If the easement has a "sunset" then permanent protection is not guaranteed.
Fee simple / leaseback	Purchase of full title and leaseback to previous owner or other lessee. May impose land use restrictions.	Allows for comprehensive preservation program of land banking. Income through leaseback. Liability and management responsibilities assigned to lessee.	Public access is not guaranteed. Land must be appropriate for leaseback (e.g., agricultural).
Lease	Short or long-term rental of land.	Low cost for use of land. Landowner receives income and retains control of property.	Does not provide equity and affords only limited control of property. Temporary.
Undivided Interest	Ownership is split between different owners, with each fractional interest extending over the whole parcel. Each owner has equal rights to entire property.	Prevents one owner from acting without the consent of the others.	Several landowners can complicate property management issues, especially payment of taxes, future sale, land uses, and access.
Deed Restriction	Voluntary or imposed restriction on land use placed on title by landowner.	Can prevent impacts to or protect habitat and/or open space values as long as landowner retains the restriction.	Is easily removed from property title by property owner without government. knowledge. Does not guarantee even short-term protection.

Ways that Title Can Be Acquired

Technique	Explanation	Advantages	Disadvantages
Fair market value sale*	Land is sold at its highest and best use value.	Highest income (cash inflow) to seller.	Most expensive. Greatest capital gains.
Bargain Sale*	Part donation/part sale - property is sold at less than fair market value.*	Tax benefits to seller since difference between fair market value and sale price is considered a charitable contribution. Smaller capital gains tax.	Seller must be willing to sell at less than fair market value.
Charitable Gift	A donation by landowner of all interest in property.*	Allows for permanent protection without direct public expenditure. Tax benefits to seller since property's fair market value is considered a charitable contribution.	Seller must be willing to donate.
Bequest	Landowner retains ownership until death.*	Management respon-sibility usually deferred until donor's death.	Date of acquisition is uncertain. Donor does not benefit from income tax deductions. Landowner can change will, will may contain land use conditions unfavorable to open space/ habitat use.
Donation with reserved life estate	Landowner donates during lifetime but has lifetime use.	Landowner retains use but receives tax benefits from donation.	Date of acquisition is uncertain.
Land exchange	Exchange of developable high habitat/open space land for land with equal development potential but less habitat/open space value.	Low-cost technique if trade parcel is donated. Reduces capital gains tax for original owner of protected land.	Properties must be of comparable value. Complicated and time consuming.
Eminent domain (government)	The constitutional police power of government to take private property for public purpose upon payment of just compensation.	Provides government with a tool to acquire desired properties if other acquisition techniques are not workable.	Can be expensive. Can have negative political consequences. Can result in expensive and time consuming litigation.
Tax foreclosure (government)	Government acquires land by tax payment default.	Limited expenditure. If land is not appropriate for public open space, it can be sold or exchanged.	Competitive sealed bidding risk.
Purchase of a Deed of Trust (1st)	Government acquires land by defaulted loan (private institution) payment and subsequent foreclosure.	Land can be acquired at a distressed sale price.	Can be complicated and result in conflict with local Tax Collector/Assessor
Agency transfer (government)	Certain government agencies may have surplus property inappropriate for their needs that could be transferred to a parks agency for park use.	Limited expenditure.	Time consuming with possible conflicts with local government.

Technique	Explanation	Advantages	Disadvantages
Restricted auction (nonprofit)	Government restricts the future use of property to open space, then sells.	Property sold to highest bidder but restriction lowers price and competition.	It may be difficult for a nonprofit to convince government that a restriction will serve to benefit the general public. Can be expensive.

* There are different ways of financing, i.e.: cash, mortgaged, owner financed, lease/option, etc. with some means having greater tax benefits than others for the seller and some means more easily financed by government than others. Conservation easements also can be acquired by these means.

Management and Ownership Options Following Purchase by Nonprofit Organization

Technique	Explanation	Advantages	Disadvantages
Conveyance to public agency	Nonprofit organiza-tion acquires and holds land until public agency is able to purchase.	A nonprofit organization can enter the real estate market more easily than government, and can often facilitate a sale when the government agency would be unable.	Must have a public agency willing and able to buy within a reasonable time frame. Private fund raising can be difficult.
Conveyance to another nonprofit organization	Nonprofit organization acquires and holds land until another nonprofit organization has been established or is able to finance acquisition.	Allows immediate acquisition even though acquiring group cannot or is not willing to hold property.	Requires existence or establishment of ultimate land holder that has solid support, funding and the ability to manage land.
Management by nonprofit organization	Nonprofit organization retains ownership and assumes management responsibilities.	Ownership remains within the community; local citizens can provide responsible care and management.	Land must fit criteria of acquiring organization. Organization must assume long-term management responsibilities and costs.
Saleback or leaseback	Nonprofit organization purchases property, limits future development through restrictive easements or covenants, and resells or leases back part or all of property. May involve subdivision of property.	Acquisition is financed by resale or leaseback. Resale at less than fair market value (because of restrictions) makes land affordable for buyer. Sale can finance preservation of part of site.	Complex negotiations. A leaseback means the nonprofit organization retains responsibility for the land.

Financing Options for Government

Financing Option	Explanation	Advantages	Disadvantages
General fund appropriation	Appropriation from primary government funds.	Avoids interest and debt service cost.	Budget allocations unpredictable. Might not provide sufficient funds, and competes with other programs.
Bond act	Borrowing money through insurance of bonds. Usually approved through local or statewide referendum.	Distributes cost of acquisition. Does not impact general funds.	Requires approval of general public. Can be expensive - interest charges are tacked on to cost of project.
Land and Water Conservation Fund	Federal funds provided to local governments on a 50/50 matching basis for acquisition and development of land for public use.	Cost of acquisition for local government is lowered by subsidy.	Federal release of these funds is uncertain and has been extremely limited to date. Competition is extreme.
State grant/low interest loans	States provide matching grants or low interest loans for municipalities to acquire open space.	Encourages localities to preserve open space by leveraging local funds. Donated lands may be used as a match.	Localities must compete for limited funds and be able to match state funds.
Real estate transfer tax	Acquisition funds obtained from a tax on property transfers. Percentage and amount exempted varies with locality.	Growth creates a substantial fund for open space acquisition. Enables local communities to generate their own funds for open space protection.	Places greater burden on new residents than on existing residents. Can inflate real estate values. Effective only in growth situations.
Land gains tax	Capital gains tax on sale or exchange of undeveloped land held for a short period of time. Tax rate varies depending on holding period.	Discourages speculative development. Has a regulatory and revenue impact.	Can inflate real estate values and slow market.
Payment in lieu of dedication	Local government requires developers to pay an impact fee to a municipal trust fund for open space acquisition.	New construction pays for its impact on open space.	Acquisition funds depend on development. May be lack of accountability for funds. Legality of method depends on relationship of open space to new development.
Special assessment district	Special tax district for area benefitted by a public benefit project.	Users finance acqui-sition and manage-ment.	Increases taxes. Timely and costly to implement. Requires 2/3 voter approval in California.
Tax return check off	On state income tax forms, a filer may appropriate a small amount of taxes owed toward revenues for natural lands acquisitions.	Convenient and successful means of generating funds.	Vulnerable to competition from other worthwhile programs.

Financing Option	Explanation	Advantages	Disadvantages
Other funds/taxes	Taxes on cigarettes, sales, gasoline, and natural resource exploitation; revenue from fees and licenses for boat, off-road vehicle, and snowmobile use, park entry, hunting, etc.	Income from fees and licenses pays for resources.	Revenues from taxes can be diverted for other uses unless dedicated to open space. Fees create pressures for money to be spent on special interest uses.
Sale or transfer of tax default property	Sale of tax default property can provide a fund for open space acquisition. Also, if site meets criteria, it can be transferred to appropriate agency for park use.	Funds for acquisition are acquired with little cost to taxpayers.	Need to assure that sale proceeds are specially allocated to open space acquisition. Might not provide a significant income. Very political process.

Financing Options for NonProfit Organizations

Financing Option	Explanation	Advantages	Disadvantages
Loan from institutional or private lender	Conventional loan from bank or savings and loan or private source, such as a foundation or corporation.	Less time-consuming process than fund raising.	Long-term financial commitment for nonprofit organization. Higher interest costs than owner financing. Mortgage lien.
Installment sale	Buyer pays for property over time.	If seller financed, can lower taxes for seller. Buyer can negotiate better sale terms (lower interest rates).	Long-term financial commitment for nonprofit organization. Mortgage lien.
Fundraising	No- or low-interest loans are acquired through program related investments from foundations, nonstandard investments from corporations, or charitable creditors (community members).	Community fundraising creates publicity and support.	A long, uncertain, and time consuming process.
Revolving fund/loans or grants	A public or private organization makes grants to localities or nonprofit organizations for land acquisition based on a project's revenue generating potential.	Encourage projects with revenue generating potential.	Projects with low revenue- generating potential have lower priority.
Partial development/ saleback or lease	Nonprofit organization purchases property, limits future development through restrictive covenants, and resells or leases back part or all of property.	Acquisition is financed by resale or leaseback. Sale can finance preservation of part of site.	Complex negoti-ations. If leaseback, nonprofit organi-zation retains responsibility for land. Finding buyer for restricted pro-perty may be difficult, and land value will be low-ered by restrictions.

Government Financial Incentives for Conservation

Incentive	Explanation	Advantages	Disadvantages
Preferential assessment	Under state laws, agricultural and forest districts can be established to assess land as farmland or forestland rather than at its highest and best use.	Promotes resource conservation and management. Especially benefits landowners in areas with development pressure. Tax base loss can be partially reclaimed through penalty tax on landowners who terminate enrollment.	Voluntary participation. Does not provide long-term protection. Minimum acreage for entry. Strength of program depends on penalty from withdrawals. Local government bears burden of reduced tax base.
Purchase of development rights	Local or state government purchases development rights to maintain land in farm use.	Landowner can derive income from selling development rights and continue to own land. Lower property value should reduce property taxes.	Can be costly, particularly in a community with high real estate values.
Land conservation grants	State programs pay or otherwise enable landowners to preserve land, enhance wildlife, and provide public access.	Landowners derive revenues from preserving land without selling interests in land.	Provision of public expenditures.

Safe Harbors Agreements

Incentive	Explanation	Advantages	Disadvantages
Create incentives by removing restrictions under section 9 of Endangered Species Act. Allows "take" of listed species beyond baseline conditions (i.e., those lands or animals protected at time of signing of agreement).	Private landowners and non-Federal property owners encouraged to restore, enhance and maintain habitats for listed species in return for assurances that additional land-use restrictions as a result of voluntary conservation actions will not be imposed.	Could garner non-Federal landowner's support for species conservation on non-Federal lands. By reducing fear of future additional property use restrictions under Endangered Species Act, landowners may enhance their lands for listed species. Could reduce habitat fragmentation and increase population numbers of listed species.	Could adversely affect populations by serving as biological sink for species attracted to enhanced habitat, only to have habitat later lost to development. May not be adequate incentives other than public relations value, and may not offer value over traditional Habitat Conservation Plans. Opportunities may be few in states with strong coastal protection regulations.

Regulatory Techniques - Growth Control

Technique	Explanation	Advantages	Disadvantages
Phased growth	Permits a limited amount of growth each year.	Effective as a comprehensive planning strategy.	There must be an equitable system to approve development. Future development pressures difficult to predict.
Moratorium	Legal postponement or delay of land development.	Useful as an interim measure during the formulation of a master development plan.	Provides only a temporary solution and can create a rush on land development prior to taking effect.
Transfer of development rights	An owner of publicly-designated land can sell development rights to other landowners whose property can support increased density.	Cost of preservation absorbed by property owner who purchases development rights.	Difficult to implement. Preservation and receiving areas must be identified.

Regulatory Techniques - Zoning and Subdivision Provisions

Technique	Explanation	Advantages	Disadvantages
Large lot zoning	Large minimum lot sizes restrict the density of the development.	An established land use control used as part of a comprehensive plan.	Since zoning is subject to change, not effective for permanent preservation. Can increase real estate values and infrastructure costs can foster urban sprawl.
Performance zoning	A zone is defined by a list of permitted impacts (based on natural resource data and design guide-lines) as opposed to permitted uses.	Directs development to appropriate places based on a compre-hensive, environ-mentally-based plan. Can be implemented through cluster development.	Difficulties in implementation since environmental impacts can be hard to measure and criteria are hard to establish. Plan can be expensive to prepare.
Carrying capacity zoning	Based on the ability of an area to accommodate growth and development within the limits defined by existing infrastructure and natural resource capabilities. Often called Current Planning Capacity.	Zoning is based on an area's physical capacity to accommodate devel-opment. Can be implemented through cluster development.	Requires a comprehensive environmental inventory for implementation. Determining carrying capacity can be a difficult process, subject to differing opinions, quality-of-life assumptions, and changing technologies.
Cluster Zoning/planned unit development (PUD)	Maintains regular zoning's ratio of housing units to acreage but permits clustered development through undersized lots, thus allowing for open space preservation. A PUD provision allows clustering for a large, mixed-used development.	Flexibility in siting allows preservation of open space areas within development site. Can reduce construction and infrastructure costs.	Open space often preserved in small separate pieces, not necessarily linked to a comprehensive open space system. May increase processing time for development approval. Lack of infrastructure can inhibit technique.
Preservation overlay zoning	At discretion of municipality, overlay zones with development restrictions can be established to protect agricultural and natural areas, scenic views, and historic neighbor-hoods.	Special zones have regulations specific to the needs of a unique area and may be subject to mandatory clustering, performance standards, special permits, and site plan and architectural review.	Language in special district ordinance must be specific enough to avoid varying interpretations.

Technique	Explanation	Advantages	Disadvantages
Exaction	As a condition of obtaining subdivision approval, local government requires developers to pay a fee or dedicate land to a municipal trust fund for open space. Also, states can require open space set-asides as part of environmental review.	New construction pays for its impact on open space.	Acquisition funds dependent on residential development. Commercial development often not subject to exaction fees. Difficult to calculate developer's fair share of costs. New case law restrictions.
Conservation density subdivisions	Permit developers an option of building roads to less expensive specifi-cations in exchange for permanent restrictions in number of units built. Roads can be public or private.	Increases open space and reduces traffic. Discourages higher densities to pay for the higher cost of road building.	Requires enforcement of easements. Private roads limit public access and require homeowner association maintenance.

Regulatory Technique - Conservation/Mitigation Banks

Technique	Explanation	Advantages	Disadvantages
Conservation/ mitigation banks	Wildlife habitat areas are restored and permanently protected by selling credits to offset development impacts elsewhere.	Could advance regional habitat conservation by allowing mitigation credits at sites recognized to be high priority for regional conservation in exchange for areas of minimal habitat value.	If not carefully considered and development projects are not consistent with all Federal and state laws, could facilitate habitat loss. Environmentally controversial.

APPENDIX G. INFORMATION AND EDUCATION MATERIALS

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INTRODUCTION

Public awareness of the plight of California's vernal pool ecosystems is a significant component of its recovery. Increased awareness can lead to greater acceptance and compliance with management measures. Increased awareness may also inspire advocates and volunteers to assist with monitoring and habitat restoration. This Information and Education Plan describes current interpretation activities along with actions and ideas for future work. Key messages, target audiences, strategies, costs, and volunteer management are among some of the elements addressed.

This plan provides direction for an expanded and continuing effort to reach all those who have a stake in the recovery of vernal pool ecosystems. At the broadest level, this effort extends to the public-at-large as concern for endangered species increases. Attention will also be focused upon groups and individuals who have a particular interest in vernal pool recovery.

Activities and demographics vary greatly throughout communities containing vernal pool habitat. Therefore, this plan has been written as a programmatic document; to be used for overall guidance and to generate ideas for regional plans. Ideally, interpretive strategies should be written for specific locations or land ownerships. At a minimum, individualized plans should be developed for the vernal pool regions described in this draft recovery plan.

While several of the described actions may already be in motion, it is recommended that the remaining actions be initiated as soon as possible. These actions are an integral part of recovery, and funding for implementation must be supported accordingly. Although budget constraints may prevent development of a complete program, some recommended actions can still be pursued even where budgets are limited.

The Draft Vernal Pool Ecosystem Recovery Plan calls for the development and implementation of public information and education programs. This Information and Education Plan provides guidance regarding the information and education activities described therein. Specific activities outlined in the recovery plan include: (1) development of a participation plan and submission to the recovery implementation team for review; (2) development of a participation and outreach programs for private landowners; (3) establishment of a mechanism (*e.g.*, funding, *etc.*) to initiate an effective participation and outreach program for private landowners; (4) compilation and review of existing outreach material targeted for private landowners; (5) if necessary, revision of existing outreach materials, or development of new outreach materials for private landowners; (6) distribution of outreach materials to private landowners through existing outreach mechanisms (*i.e.* newsletters, the Internet,

annual meetings of organizations, public meetings); (7) identification of private landowners interested in pursuing recovery and conservation efforts on their lands and prioritization of a list of potential participants; (8) work with private landowners to develop Safe Harbor Agreements, Candidate Conservation Agreements, Memoranda of Understanding, habitat conservation banks, or other appropriate tools for conserving listed species or species of concern on their lands; (9) development of specialized programs to facilitate cooperation and information dispersal/exchange to target audiences (*e.g.*, California Farm Bureau, California Cattlemen's Association, University of California Cooperative Extension, Resource Conservation Districts, County and City Planners, California Builders Association, professional societies, *etc.*); (10) development and implementation of cooperative programs and partnerships with Federal, State, and local agencies to ensure they utilize their authorities to the fullest extent possible to promote the recovery of listed species and the long-term conservation of the species of concern addressed in this draft recovery plan.

PLAN GOALS

The primary goal of this Information and Education Plan is:

- To enhance compliance with management efforts to protect and enhance vernal pool species and their habitat.

Secondary goals are:

- To stimulate public interest, understanding, and support of research and management actions which in turn will increase compliance levels.

- To provide land managers, private landowners, and recreational interest groups with guidance to implement a vernal pool recovery program.

- To stimulate public concern and understanding of unique vernal pool ecosystems that support numerous and diverse species, including special status species.

- To develop internal and external support necessary for funding vernal pool management programs.

These goals will be accomplished through the information and education program described in subsequent sections.

EFFECTIVE OUTREACH TOOLS

Partnerships

Partnerships can include working groups and cost share programs. Cooperation between resource and land management agencies, researchers, interest groups, and private individuals increase effectiveness of outreach efforts and bring more resources - both expertise and money - to the table.

Multi-Disciplinary Outreach

Effective management of vernal pool habitat requires cooperation between different and often divergent interests working together using a positive, unified approach. Vernal pool habitat management needs to incorporate input from biologists, land managers, interpretation specialists, and various interest and user groups to reach recovery goals.

Dedicated Conservationists

The exceptional commitment of professional and volunteer conservationists has been, and should continue to be, an important factor in vernal pool ecosystem recovery.

Communications Techniques

The key to increased public understanding and awareness is using a variety of communication techniques and methods of distribution, including a variety of techniques such as videos, brochures, posters, on-site programs, slide presentations, and news releases.

OUTREACH NEEDS

Targeted Audiences

Key audiences and their primary interests should be determined for specific program objectives. Different groups of people will view vernal pool habitat management in different ways. The ranges of vernal pool species includes a large geographic area that incorporates both small towns and large cities with diverse political views, economic bases, ethnic and socioeconomic groups, literacy levels, environmental values, attitudes about government regulations, etc. Communications intended for different groups and geographic areas need to be designed to address their different perspectives.

Information

Little information is available on how the various target audiences feel about vernal pool habitat management. Experiences of agency personnel indicate that public sentiment varies considerably. An increased understanding will help managers design effective interpretive signs and programs.

Decreased Use of Jargon
Many communications products to date contain a large amount of technical jargon. This not only fails to communicate with readers or viewers, but may even make them antagonistic.

Increased Personalized Communication
The most effective communications, particularly with those directly impacted, are those delivered via a "one-on-one" approach . Although many outreach strategies such as brochures and videos are cost effective and reach wide audiences, they may not sufficiently capture attention or promote understanding.

Improved Internal Communications
Many people within resource management agencies are not getting information about the vernal pool program and the role they can or should play. Improved dissemination of information and coordination between all levels of staff is needed.

Coordination
When agencies, groups, and individuals work independently, work is not done in an efficient, cost effective, or cohesive manner. Working as a team can alleviate inconsistent messages and prevent redundancy in work.

KEY MESSAGES

Different audiences have different questions, concerns, and values that need to be addressed to effectively meet the goals of this plan. Knowing the audience(s) will enable the design of a practical outreach strategy and product specifically tailored to their issues. The following key messages address some of the most frequently asked questions. Although many of the following key messages apply to all target audiences, several may be site- or zone-specific. Individual plans should choose key messages appropriate to their audience(s). Sentences within parentheses reflect considerations to tailor messages to individual plans or outreach materials.

Primary Message

Vernal pool ecosystem recovery can be achieved with minimal disruption of landowner interests through cooperation in the voluntary Vernal Pool Ecosystem Recovery Plan.

Secondary Messages

1. All species, no matter how small or seemingly insignificant, are a critical component of the earth's biodiversity. Maintaining native species diversity is key to sustaining healthy ecosystems capable of adapting to constant change.

2. Vernal pool species and other endangered species are like the miner's canary -- they are a barometer of the health of the ecosystem.

3. The vernal pool ecosystem includes unique and increasingly rare habitats. Several species are found in this system and no other.

4. All wildlife have distinct habitat needs. Specialized species, like vernal pool species, have specific adaptations, and therefore live only in vernal pools.

5. Habitat destruction is the main cause of vernal pool ecosystem decline. Habitat has been lost from urbanization and agricultural conversion, and introduction of nonnative plant species. Loss of vernal pool habitat also affects other plants and animals linked to this unique landform, such as California red-legged frog and California tiger salamander. Managing for vernal pool species requires controlling invasive species and maintaining hydrologic function. Appropriate levels of livestock grazing can play an important role in achieving these management goals

6. Guidelines for using vernal pool habitat in a way that protects species it supports should be specific. Recreationists need to understand that by their very presence, wildlife may be disturbed.

7. Specific sites and types of recreation affect vernal pool species in different ways. Develop key messages targeted to a specific audience explaining how their activity impacts vernal pool species and how modifying their activity can reduce or eliminate these impacts.

8. Your cooperation will help preserve vernal pool ecosystems. You can help by <u>fill in the blank</u>…(e.g., respecting restricted areas; leaving your pets at home or keeping them on a leash; keeping kites, fires and camping sites well away from nesting areas; observing birds at a distance; and keep beaches litter free).

9. Information for off-road vehicle users will focus on off-road vehicle-related impacts, ways to coexist (primarily through land allocation initiatives).

10. Get Involved. Your participation can help lead to vernal pool ecosystem recovery, thus decreasing the need for further restrictions. Contact your state and federal wildlife agencies for further information.

TARGET AUDIENCES

Audiences who have a stake in vernal pool ecosystem conservation and who should be the target of outreach efforts are described below. Each of these target groups influences or has the potential to influence vernal pool management in a significant way. Audiences include those who will be affected by vernal pool management actions.

Regional and site-specific planning teams need to first evaluate audiences particular to their location. Strategies and key messages can then be tailored to these audiences.

Public at Large
In general, this alludes to a national constituency, although on a practical level it primarily includes people who live within the Central Valley. Coordination of recovery efforts for vernal pool ecosystems in California and Oregon may bring attention of vernal pool ecosystem issues to a national audience. However, the activities in this plan are targeted toward the Central Valley.

General Interest Groups
Particular groups which may prove most receptive to information and education efforts include: civic organizations, scouts and other service organizations; environmental education and outdoor learning centers; and conservation groups.

Local Communities
Local communities have a strong and direct interest in local vernal pool recovery efforts. There are often many different voices speaking on behalf of the community, including those focused on the local economy, those concerned with the quality of the environment, and those who support less tangible values such as individual freedom and community self-rule. While these interests can be found among the public-at-large, they are generally felt and expressed much more cogently in the vicinity of the "action." The local community thus comprises not one audience, but a conglomeration of different audiences related by proximity. However, regional or individual outreach programs may want to develop specific messages targeting user groups within a given community or surrounding area.

Schools
School age children may help reach out to other household members with their knowledge and enthusiasm. Provide buttons, posters, pencils, litter bags and other materials.

Public Officials and Land Managers
Through their role as public servants these individuals often represent the myriad interests of the preceding audiences. However, most are required to bring in the added perspective of stewardship responsibilities, including land use decisions. They may also be interested in related issues, such as predator control and habitat restoration.

Private Landowner
The support of these individuals is essential for the successful recovery plan. Many landowners have cooperated by allowing research and management to proceed on their lands. Others need to be educated and supported in maintaining vernal pools on their property. Reaching this audience is extremely critical, but can be a time-consuming process.

Conservation/Environmental Groups
These groups will generally be strong advocates of vernal pool ecosystem recovery. They constitute an audience in their own right, but they can also be a conduit of information and education to more general audiences.

INFORMATION AND EDUCATION GUIDELINES

The following guidelines should be considered in developing regional or site specific information and education. Evaluation is fundamental to the success of all plans. Be sure to incorporate routine assessment.

Biological

- Ensure the biological requirements of vernal pool species, as identified in the recovery plan, are the focus of outreach activities.

- Emphasize the importance of the entire vernal pool ecosystem.

- Incorporate and highlight with current and national issues such as biodiversity, neotropical migrants, human population growth, international conservation, Western Hemisphere Shorebird Reserve Network and Watchable Wildlife.

Logistical

- Incorporate evaluation. Develop questions to assess effectiveness of program and individual materials.

- Use a team approach. Establish a regional working group if one is not in existence. Utilize this combined expertise and additional resources for an effective and coordinated method.

- Communicate consistently to all land management agencies and the public. Education is a process, not a single event. Target audiences, issues, management activities, and vernal pool ecosystem recovery actions are constantly changing.

- Land management agencies should include staff in all outreach efforts.

Specific Tips (Messages)

- Discuss negative aspects, concerns, and failures as well as successes. Be honest with people.

- Reward and acknowledgment of effort is important to consider when developing messages. Be sure to provide the reasoning behind compliance and provide alternatives.

Specific Tips (Methods)

- Communicate alternatives to restrictions imposed by vernal pool ecosystem management.

- Communicate with local people “face to face” to the extent possible.

- Communicate in a way that is understandable to target audiences.

- Incorporate other languages if needed.

- Avoid jargon and don’t put too many messages in one medium.

- Identify your target audience and be sure your methods and messages are targeted for that audience.

- Involve local people in the process of communicating vernal pool ecosystem information. Invite participation in a regional working group.

MATERIALS AND FORUMS

Direct Contact
Land managers have found one-on-one interaction with beach-users to be the most effective and well received of any outreach method. On-site interpreters can provide explanation to sometimes confusing restrictions. They also provide valuable feedback to the program and provide answers to questions from the public.

Brochures
Brochures can furnish basic facts about vernal pool species and habitat and the need for it's protection. They lend themselves to modification for more specific audiences, such as owners of land containing vernal pool habitat.

Brochures are well suited to on-site audiences. Brochures can also be distributed through commercial outlets, incorporated into presentations and interpretive programs, or mailed.

Fact Sheets/Flyers/Trading Cards
One-page fact sheets (or multi-page pamphlets) involve minimal production effort and cost. They consist primarily of typed information in a format that can be easily copied. Along with standard information, fact sheets and flyers can address points of concern for particular audiences and locales. They can also be used as summaries updating vernal pool ecosystem recovery efforts. Fact sheets can be handed out at distribution points that serve user groups, used in meetings, or mailed.

Restaurant Placemats and Table Tents
While waiting for their meal at a restaurant, many people will read materials placed on tabletops. Advertisers take advantage of this vulnerability by placing ads on tri-fold "table-tents" and placemats. Information could be condensed from brochures onto these formats. This forum would be especially useful for tourists and communities near vernal pool ecosystems.

Posters
Attractive posters illustrating vernal pool ecosystems have been developed. Use of these posters in displays is eye-catching. New posters could be developed to complement videos or other materials.

Maps
Colored maps showing vernal pool species and their habitat can be useful in meetings and publications. Large maps that can be reduced could serve both purposes. Maps may be most useful in conjunction with fact sheets and signs.

Curriculum
Curriculum could be developed for different age groups. Supplemental teacher packets and hand-outs could focus on biodiversity using the vernal pool ecosystem as a case study.

Newsletters/Postcards
Newsletters are useful during important decision-making processes, especially those that actively consider public input. A standard newsletter format that can be modified for particular purposes could expedite public information and involvement. Postcards can also be used as a modified version of a newsletter. Planning and conflict mediation processes may benefit from information exchange through newsletters. Recovery status is well-suited to a newsletter format.

Interpretive Exhibits and Portable Displays
An interpretive exhibit can convey a variety of information about vernal pool ecosystem recovery efforts. A standard exhibit could be designed for both indoor and outdoor display. This display could be permanent or portable for use in schools and at conferences and meetings. A more elaborate exhibit could incorporate slide-tape or video displays. Ideally, this type of exhibit could be built into interpretive facilities.

Signs
High-quality interpretive signs explaining seasonal aspects of vernal pool habitat can be used in high traffic areas.

Media Releases
Public notices and news articles informing the public of vernal pool issues, planning efforts, habitat restoration projects, recovery successes, etc. are issued as an ongoing effort. Unofficial stories and features can also be used to solicit interest. The use of press releases in connection with conservation planning will be a significant aspect of recovery efforts in the future.

Radio Messages
Public service messages on commercial and public radio stations could also promote protection of vernal pool habitat and elicit general support for such protection among a variety of general audiences.

Web Sites/CD-ROM
Access to the Internet is an effective means of communication that can reach a variety of audiences at relatively low cost. Updates and other site maintenance require an investment of time. A master web site could be developed and operated by the U.S. Fish and Wildlife Service with links to other agency vernal pool homepages. These local homepages can also be area- and site-specific. A CD-ROM could include portions of a video program, ideally with interactive elements.

Video Programs
Video programs can allow the distribution of accurate information in a popular form. These videos can be used in a variety of settings, including interpretive facilities, public meetings, classrooms, and for television broadcast. Regional- or site-specific videos addressing vernal pool ecosystem needs and variable local audiences which have an interest in vernal pool conservation are recommended.

Slide-Tape Program
In situations where video display terminals are not available, a slide-tape program could be used, both as part of exhibits and during presentations. The slide-tape program could potentially be customized for certain audiences. Slide programs with a script instead of a tape back-up could provide a cheaper alternative.

Speaking Engagements
Articulate and persuasive speakers could be engaged to address various groups, either in conjunction with audio-visual programs or on their own. Presentations to general interest and advocacy groups could introduce a forum for constructive dialogue and education. Participation in Fourth of July festivities or other summer activities could provide outreach opportunities.

Private Meetings
Meetings held during the course of consultations and negotiations regarding habitat protection can provide a forum for education as well as information exchange about vernal pool species and their habitat.

Public Meetings
Public meetings may occur during the course of conservation planning processes, education, and through environmental review. These meetings could be used to air various concerns about land use conflicts and to gather support for habitat protection. Ultimately, strategies to protect vernal pool species and habitat with the least possible impact on other interests may develop from the discussions in these meetings.

STRATEGIES FOR REACHING AUDIENCES

This Information and Education Plan is designed to use two means to disseminate information and gain support. The first strategy is to reach general target audiences through a variety of methods. The second strategy is to reach affected parties through official planning and consultation processes. To this end, actions developed for this plan consider the following:

- A variety of activities will be directed toward stimulating the interest and support of the general public, including specific target audiences, for the vernal pool ecosystem's protection and recovery; and

- Planning, consultation, and negotiation processes will be used to elicit the cooperation of affected parties such as, landowners, growers, ranchers, developers, and managers. Particular emphasis will be placed on public information as a component of the consultation process.

Materials and programs that can effectively increase understanding of vernal pool issues among local communities are an immediate priority. These materials will be developed and distributed by land managers, the U.S. Fish and Wildlife Service, and regional working groups as funds allow. Materials such as annual updates of recovery activities, information packets focusing on vernal pool habitat protection, and teaching packets will be developed for specific audiences.

Distribution of materials and programs will "fan out" from key areas of concern. In addition, major media contacts and visitor centers will be identified for initial contacts. In this way, the vernal pool information and education program will reach both the key target audiences and the broadest possible segment of the general public in as short a time as possible.

As an adjunct effort, a fairly standardized public involvement process will be followed during the course of planning and consultation processes for vernal pool species, in order to expedite education of the involved parties.

Whenever possible, information and education activities for vernal pool habitat will also be used as an opportunity to stimulate public concern for broader or less-prominent endangered species issues. Using "spin-off" techniques to raise awareness of other endangered species issues during vernal pool ecosystem recovery activities could prove beneficial in gathering broad-based support.

ACTIONS

The following actions should be undertaken to achieve the goals of this Information and Education Plan. The list is in general order of priority. For each action, the target audience(s) and a brief description are provided.

INITIAL ACTIVITIES (First year)
In the short term, these activities lay the groundwork for future outreach efforts, or are already underway and need to be completed (varies regionally).

Action 1. Develop regional vernal pool ecosystem information and education working groups.

Audience: Biological resource and land management agencies, conservation/environmental groups, other interested parties.

Description: Establish a working group dedicated to the implementation of an information and education program for each region described in the recovery plan. These groups will coordinate and customize outreach efforts to their local needs. Regional resources will then be combined to accomplish tasks, develop a regional communication strategy, and apply for grant opportunities.

Each working group will coordinate vernal pool outreach efforts by maintaining current information on the programs of other working groups. In review, they will seek to identify areas of overlap; and possibly combine efforts to effectively reach a broader, even national audience. This could prove particularly true for activities such as widely-circulated articles, public service announcements, curriculum, exhibits, and press releases.

To the maximum extent feasible, the working group will draw other agencies and individuals into this effort to inform and educate the public. They will assist any agency or individual involved or interested in vernal pool ecosystem recovery to design a program that draws from or augments strategies in this plan. Especially encouraged is coordination with individuals representing law enforcement, recreation, interpretation, management, and other disciplines.

Action 2. Develop a master mailing/contact list for each region.

Audience: All

Description: Include the following for each region:

- Affected landowners
- Media contacts
- Chambers of Commerce and similar groups
- Local farming and ranching organizations
- Local building development organizations
- Affected businesses
- Special interest groups
- Conservation groups
- Local government elected officials
- Federal, state, county and city land management agencies, planning agencies, and others with land management responsibilities
- Civic groups
- Schools
- Other interested individuals or groups

Initiate development of the mailing list by defining target areas and providing field personnel, refuge managers, outdoor recreation planners, and others with this plan and/or other instructions for compiling their contacts. Consolidate the lists into a sortable, automated data base. Update/expand the list on a continual or periodic basis.

Action 3. Implement a media relations campaign.

Audience: Public at large, landowners, local communities.

Description: Use various opportunities for exposure of vernal pool issues and successful partnerships. Development of many of these action items will also provide a chance for media exposure or assistance in disseminating information to target audiences through television, radio, newspaper, and magazines. News releases on specific stories or a general information package can be developed to generate media interest. Consider public service announcements and paid programming (commercials or ads) if needed.

Action 4. Develop customized materials for key target audiences.

Audience: The highest priorities, in order, are:

- Landowners and managers
- Affected communities
- Agency personnel

Description: Materials will summarize reasons for implementation of management measures and how users can help in vernal pool ecosystem recovery. General flyers could be developed with inserts available for explanations of site specific circumstances (e.g. maps or messages to particular user groups). As funding allows, develop customized fact sheets or pamphlets (using a standard question and answer format), brochures, slide tape programs, and/or videos for special audiences.

Active involvement of these groups in information development will assure responsiveness to questions and concerns about what effect vernal pool ecosystem recovery efforts will have on their pursuits. Solicit ideas from the various user groups about how protection of the vernal pool ecosystem can be achieved while still allowing individuals to pursue their interests. Incorporate feedback in a question/answer or discussion format to address specific concerns of each user group in the most direct way possible.

Develop annual updates regarding the progress made in vernal pool ecosystem recovery and future needs in terms of both research and management. Distribute these to landowners and land management agencies, either during consultation and negotiation procedures or via the mailing list, as appropriate. Use these updates to invite feedback about their current concerns and any support they may want to offer.

Develop customized brochures, flyers, signs, posters, and other materials. Augment this effort with customized presentations and video showings. Post interpretive signs where appropriate.

When appropriate, bring into play the bigger picture of endangered species. Pursue these efforts within environmental education and interpretive settings where it is likely that the vernal pool ecosystem will be one among a variety of topics.

Action 5. Develop customized regional displays.

Audience: All

Description: Develop a standard display that can be exhibited in visitor centers, on kiosks, on portable stands for use in meetings, classrooms, etc. When possible, erect kiosks with the display in high traffic areas. When feasible, incorporate a video display or slide-tape program into the exhibit.

Action 6. Establish coordinated clearinghouse for vernal pool ecosystem outreach materials.

Audience: Agency personnel, local governments, conservation/environmental groups.

Description: Provide repository of existing materials for use as templates or to be copied to prevent "reinventing the wheel." Announce the availability of new materials to interested individuals and agencies identified on the mailing list.

ONGOING OR PERIODIC ACTIVITIES (After first year)
Activities which occur on a continuing basis or at different times throughout the year need to be pursued in as timely a manner as possible over the foreseeable future.

Action 7. Continue or expand initial efforts to distribute customized materials to key target audiences.

Audience: All

Description: Expand distribution to include various groups on the mailing list, update lists as appropriate, and distribute outreach materials at local town and land use planning meetings.

Distribute outreach materials to local and visitor audiences.

Action 8. Follow a standardized public outreach process during recovery plan release, agency planning and large section 7 consultations.

Audience: All

Description: Continue to use the following planning guidelines for public outreach to gather comments and understanding of the process and decision:

- Update the project-specific mailing/contact list, using the master mailing list as the basic source. Include government officials, agency and organization representatives, affected landowners, media contacts, and interested individuals.

- Issue press releases informing the general public about the progress of the recovery effort.

- Distribute a periodic fact sheet/pamphlet/newsletters to all interested parties. Use maps when appropriate.

- Actively solicit public input via newsletters, public scoping meetings, and meetings with involved parties.

- Distribute available educational materials to involved groups. Give presentations upon request.

Action 9. Conduct "by invitation" tours.

Audience: All

Description: There is no better way to communicate why vernal pool ecosystem recovery is significant than to have people accompany a knowledgeable, enthusiastic expert into the field. A significant effort should be made to get key people on the tours. Groups to include are: chambers of commerce, agency employees, community leaders, legislators, media, school groups, and conservation organization leaders.

Action 10. Enlist corporate support for vernal pool ecosystem protection.

Audience: All

Description: Large landowners or developers can be approached for providing support in specific situations. If this strategy is pursued, a prospectus-type brochure should be prepared explaining the public service aspects and the marketing advantages that could be gained by promoting an image of environmental responsibility. Corporate support could range from underwriting recovery projects to making a simple statement of support in their advertisements or on their packaging (the milk carton route). Regional working groups should research and solicit grant opportunities as an avenue to corporate support.

Action 11. Develop educational curriculum, presentations and speakers bureau.

Audience: Schools, environmental educators, interpreters, youth clubs, civic groups.

Description: Develop curriculum with lesson plans and activities targeted to grade levels. Utilize materials from other activities, such as brochures, posters, fact sheets, maps, videos, or a slide-tape program.

Modify the above teaching package into a standardized presentation for civic and school groups, and other general interest organizations. Inform key groups of the availability of such a program through the mailing list or through notices in brochures.

Action 12. Produce videos.

Audience: All

Description: Produce video for target audiences. Ideally, several videos could be produced; each targeted to a different audience. Otherwise, produce a 15-minute video to use primarily in educational and planning settings; and a 30-second public service announcement to use in informational and commercial contexts.

Announce availability of the videos to field office staff and through the mailing list. Provide press releases to distribute them to the media, commercial outlets, and for public and private functions. Also, distribute copies of the videos to key visitor contact points, including Federal and state facilities. In particular, distribute the educational video to individuals whose property contains vernal pool habitat.

RESPONSIBILITIES

Assistance to agencies who manage vernal pool habitat is an ongoing activity that occurs primarily under section 7 of the Endangered Species Act. In particular, the U.S. Fish and Wildlife Service works closely with state and local agencies to implement vernal pool protection and recovery plans, and other management actions to protect vernal pool habitat.

State agencies also play a role in vernal pool management in their oversight of state wildlife regulations. Although these Federal and state agencies provide oversight and support to vernal pool ecosystem management, ultimately responsibility lies with individual land managers. Local land managers need to ensure that vernal pool ecosystem information and education efforts are appropriately and adequately implemented to support protection of vernal pool habitat at sites under their jurisdiction.

Vernal pools extend across multiple counties in California and Oregon, making a coordinated outreach effort difficult and complicated. Regional working groups will ideally reduce some of this complication. However, there needs to be a means for

connection between these groups. The U.S. Fish and Wildlife Service is best suited to play a leadership role in providing advice and coordination and can also be valuable clearinghouse for existing materials. The U.S. Fish and Wildlife Service should assure that long-term funding is allocated to support a staff position to coordinate outreach efforts as part of other recovery plan implementation duties. Partnerships will be the key to employing an effective information and education program aimed at recovering the vernal pool ecosystem.

APPENDIX H. GUIDANCE TO MINIMIZE THE POTENTIAL TRANSMISSION OF DISEASE AND OTHER PATHOGENS BETWEEN AQUATIC SYSTEMS

In order to minimize the potential transmission of disease and other pathogens, the following guidance has been developed for disinfecting equipment and clothing after surveying a wetland and before entering a new wetland, unless the two wetlands are hydrologically connected to one another. These recommendations are adapted from the Declining Amphibian Population Task Force's Code which can be found in their entirety at: http://www.mpm.edu/collect/vertzo/herp/daptf/fcode.html.

a. All dirt and debris, including mud, snails, plant material (including fruits and seeds), and algae, should be removed from nets, traps, boots, vehicle tires and all other surfaces that have come into contact with water. Cleaned items should be rinsed with clean water before leaving each study site.

b. Boots, nets, traps, etc., should then be scrubbed with either a 70 percent ethanol solution, a bleach solution (0.5 to 1.0 cup of bleach to 1.0 gallon of water), QUAT 128 (quaternary ammonium, use 1:60 dilution), or a 6 percent sodium hypochlorite 3 solution and rinsed clean with water between study sites. Cleaning equipment in the immediate vicinity of a pond or wetland should be avoided. Care should be taken so that all traces of the disinfectant are removed before entering the next aquatic habitat.

c. When working at sites with known or suspected disease problems, disposable gloves should be worn and changed between handling each animal.

d. Used cleaning materials (liquids, etc.) should be disposed of safely, and if necessary, taken back to the lab for proper disposal. Used disposable gloves should be retained for safe disposal in sealed bags.

Appendix I. Threats to the listed Vernal Pool Species and Steps Within The Recovery Plan for Threat Reduction or Elimination.

SPECIES	LISTING FACTOR[1]	THREAT	TASK NUMBERS	RECOVERY CRITERIA[2]
All listed vernal pool species	A	Habitat loss (due to urban development, agricultural conversion, mining)	1.4, 5.1, 5.2	1A, 1B, 1D, 5A, 5B, 5C, 5D
All listed vernal pool species	A	Habitat degradation (erosion, siltation, soil disruption)	1.4, 2.1, 2.3, 2.4, 4.1.4, 4.1.5, 4.2.4, 5.1, 5.2	1E, 2A, 2B, 2C, 3B, 4A, 5A, 5B, 5C, 5D
All listed vernal pool species	A	Altered hydrology	2.1, 2.3, 2.4, 4.1.4, 4.1.5, 4.2.4, 5.1, 5.2	1E, 2A, 2B, 2C, 3B, 4A, 5A, 5B, 5C, 5D
All listed vernal pool species	A	Inappropriate fire regime	2.1, 2.3, 2.4, 4.1.4, 4.2.2, 4.2.4, 5.1, 5.2	2A, 2B, 2C, 3B, 4A, 5A, 5B, 5C, 5D
All listed vernal pool species	A, C	Inappropriate livestock grazing regime	2.1, 2.3, 2.4, 4.1.4, 4.2.3, 4.2.4, 5.1, 5.2	2A, 2B, 2C, 3B, 4A, 5A, 5B, 5C, 5D
All listed vernal pool species	A, E	Habitat fragmentation	1.4, 4.1.3, 4.1.4, 4.1.5, 4.2.1, 5.1, 5.2	1A, 1B, 1D, 4A, 5A, 5B, 5C, 5D
All listed vernal pool species	A, E	Trash dumping	2.1, 2.3, 2.4, 4.2.4, 5.1, 5.2	2A, 2B, 2C, 3B, 4A, 5A, 5B, 5C, 5D
All listed vernal pool species	A, E	Recreational use (off-road vehicles, bicycling)	2.1, 2.3, 2.4, 4.2.4, 5.1, 5.2	2A, 2B, 2C, 3B, 4A, 5A, 5B, 5C, 5D
All listed vernal pool species	A, E	Vandalism	2.1, 2.3, 2.4, 4.2.4, 5.1, 5.2	2A, 2B, 2C, 3B, 4A, 5A, 5B, 5C, 5D
Delta green ground beetle	B	Overcollection	2.1, 2.3, 2.4, 4.2.4, 5.1, 5.2	2A, 2B, 3B
All listed vernal pool crustaceans	C	Predation by nonnative aquatic species	2.1, 2.3, 2.4, 4.1.4, 4.2.4, 4.3.4, 5.1, 5.2	1E, 2A, 2B, 2C, 3B, 4A, 5A, 5B, 5C, 5D
Neostapfia colusana *Orcuttia inaequalis* *Tuctoria mucronata*	C	Herbivory by grasshoppers	2.1, 2.3, 2.4, 4.1.4, 4.2.4, 4.3.6, 5.1, 5.2	2A, 2B, 2C, 3B, 4A, 5A, 5B, 5C, 5D
Vernal pool tadpole shrimp possibly others	C	Disease	4.1.4, 4.1.5	3B
All listed vernal pool species	D	Lack of adequate protection from State and Federal legislation	beyond scope of recovery plan	N/A
All listed vernal pool species	D	Need for management planning	1.4, 2.3	1A, 1B, 1D, 2A, 2B

SPECIES	LISTING FACTOR[1]	THREAT	TASK NUMBERS	RECOVERY CRITERIA[2]
All listed vernal pool species	E	Loss of genetic diversity	4.1.1	3B, 4B
All listed vernal pool species	E	Contaminants	2.1, 2.3, 2.4, 4.1.4, 4.2.4, 4.3.1, 4.3.2, 5.1, 5.2	2A, 2B, 2C, 3B, 4A, 5A, 5B, 5C, 5D
Castilleja campestris ssp. *succulenta* *Chamaesyce hooveri* *Eryngium constancei* *Lasthenia conjugens* *Limnanthes floccosa* ssp. *californica* *Navarretia leucocephala* ssp. *pauciflora* *Navarretia leucocephala* ssp. *plieantha* *Parvisedum leiocarpum*	E	Loss of pollinators	2.1, 2.3, 2.4, 4.1.4, 4.2.4, 4.3.5, 5.1, 5.2	2A, 2B, 2C, 3B, 4A, 5A, 5B, 5C, 5D
All listed vernal pool species	E	Inadequate monitoring/survey information	1.1, 1.2, 1.3, 2.1, 2.2, 2.3, 2.4, 2.5.4, 2.5.5, 2.5.6, 3.1, 3.2, 3.3, 3.4, 4.1.3, 4.2.4, 5.1, 5.2	1D, 1E, 2C, 3A, 3B, 4A, 5A, 5B, 5C, 5D
All listed vernal pool species	E	Stochastic events	2.5.1, 2.5.2, 2.5.3, 2.5.4, 2.5.5, 2.5.6, 4.1.6	1A, 1B, 1C, 2D, 3A, 4C
All listed vernal pool plants	E	Competition from invasive plants	2.1, 2.3, 2.4, 4.1.4, 4.2.4, 4.3.7, 5.1, 5.2	2A, 2B, 2C, 3B, 4A, 5A, 5B, 5C, 5D

1. Listing factors are:
   (A) the present or threatened destruction, modification, or curtailment of its habitat or range;
   (B) overutilization for commercial, recreational, scientific, or educational purposes;
   (C) disease or predation;
   (D) the inadequacy of existing regulatory mechanisms; or
   (E) other natural or manmade factors affecting its continued existence.
2. Recovery criteria are:
   1A: Suitable vernal pool habitat within each prioritized core area for the species is protected.
   1B: Species occurrences distributed across the species geographic and genetic range are protected.
   1C: Reintroductions and introductions must be carried out and meet success criteria.
   1D: Additional occurrences that are determined essential to recovery are protected.
   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.

2A: Habitat management and monitoring plans that ensure maintenance of vernal pool ecosystem function and population viability have been developed and implemented for all habitat protected.
2B: Mechanisms are in place to provide for long-term management and monitoring.
2C: Monitoring indicates ecosystem function has been maintained in the areas protected.
2D: Seed banking actions have been completed.
3A: Status surveys, status reviews, and population monitoring show populations within each vernal pool region where the species occur are viable.
3B: Status surveys, status reviews, and habitat monitoring show that threats have been ameliorated or eliminated.
4A: Research actions on species biology and ecology, habitat management and restoration, and methods to eliminate or ameliorate threats have been completed and incorporated into management plans.
4B: Research on genetic structure has been completed and results incorporated into management plans.
5A: Recovery Implementation Team is established and functioning to oversee rangewide recovery efforts.
5B: Vernal Pool Region working groups are established and functioning to oversee regional recovery efforts.
5C: Participation plans for each Vernal Pool Region have been completed and implemented.
5D: Vernal Pool Region working groups have developed and implemented outreach and incentive programs that develop partnerships.