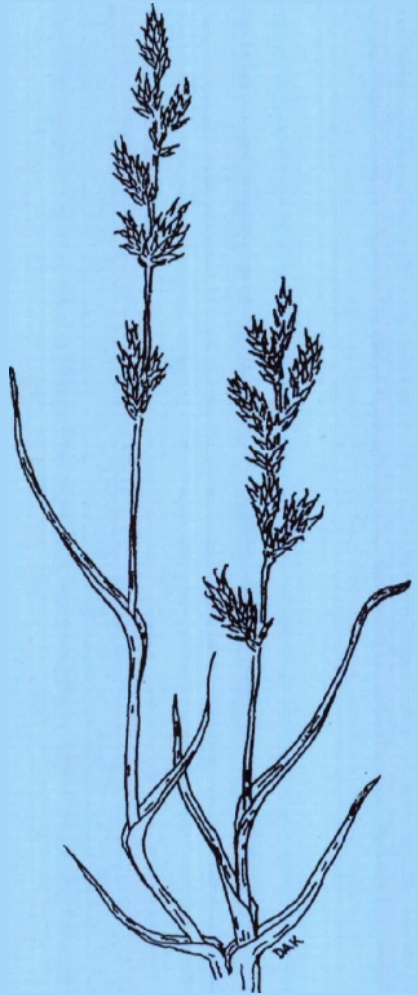


Recovery Plan for Vernal Pools of Southern California



VERNAL POOLS
OF
SOUTHERN CALIFORNIA

RECOVERY PLAN

September 1998

U.S. Department of the Interior
Fish and Wildlife Service
Region One, Portland, Oregon

**VERNAL POOLS
OF
SOUTHERN CALIFORNIA**

RECOVERY PLAN

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Region 1
U.S. Fish and Wildlife Service
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Approved: _____


Manager, California/Nevada Operations Office

Date: _____

9/3/98

DISCLAIMER PAGE

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U.S. Fish and Wildlife Service. 1998. Vernal Pools of Southern California Recovery Plan. U.S. Fish and Wildlife Service, Portland, Oregon. 113+ pp.

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ACKNOWLEDGMENTS

The U. S. Fish and Wildlife Service extends its appreciation to the numerous individuals who, over the course of years, contributed to the conservation of vernal pool species and the development of this plan: Meryl Balko, Tony Bomkamp, Dave Bramlett, Coralie Hull Cobb, George Cox, Jim Dice, Tom Ebert, Wayne Ferren, Bonnie Hendricks, Larry Hendrickson, Robert Holland, Ann Howald, Stacey Huddleson, Paula Jacks, Edie Jacobsen, Dawn Lawson, Emilie Luciani, Kim Marsden, Brenda L. McMillan, Tom Oberbauer, Cameron Patterson, Lauren Wei, John Rieger, Carla Scheidlinger, Marie Simovich, Fred Sproul, Michael Stroud, and Paul Zedler. Further acknowledgments are extended to the various agencies and jurisdictions who have contributed to the preservation and management of this special resource: United States Army Corps of Engineers, Marine Corps Base Camp Pendleton, Naval Facilities Engineering Command, Southwest Division, San Diego Association of Governments, California Department of Fish and Game, California Department of Transportation, District 11, Counties of San Diego, Orange, and Riverside, and the Metropolitan Water District.

Special thanks are extended to Fred M. Roberts, Jr., Julie Vanderwier, Susan Wynn for assistance on the distributional and site-specific information utilized in the development of the maps and tables, and the following individuals who provided valuable peer review: Denton Belk, Ellen Cypher, Eric Stein, and Marie Simovich.

EXECUTIVE SUMMARY OF THE RECOVERY PLAN FOR THE VERNAL POOLS OF SOUTHERN CALIFORNIA

Current Species Status: This plan addresses six vernal pool species that are listed as endangered and one that is proposed for threatened status: *Eryngium aristulatum* var. *parishii* (San Diego button-celery), *Orcuttia californica* (California Orcutt grass), *Pogogyne abramsii* (San Diego mesa mint), *Pogogyne nudiuscula* (Otay mesa mint), Riverside fairy shrimp (*Streptocephalus woottoni*), San Diego fairy shrimp (*Branchinecta sandiegonensis*), and *Navarretia fossalis* (spreading navarretia).

Pogogyne abramsii was listed as endangered on September 28, 1978. *Pogogyne nudiuscula*, *Orcuttia californica*, *Eryngium aristulatum* var. *parishii*, and the Riverside fairy shrimp were listed as endangered on August 3, 1993. The San Diego fairy shrimp was listed as endangered on February 3, 1997. *Navarretia fossalis* was proposed for listing as threatened on December 15, 1994.

Historically, San Diego, vernal pool habitat probably covered no more than 6 percent of the county, approximately 520 square kilometers (200 square miles). Currently levels estimate a loss of vernal pool habitat in the San Diego County around 95 to 97 percent because of intensive cultivation and urbanization (Bauder and McMillan 1998). Lack of historical data precludes the same depth of analysis for Los Angeles County, Riverside County, Orange County, or San Bernardino Counties, but losses are considered nearly total (USFWS 1993). The current distribution of pools in northern Baja California, Mexico, probably comes much closer to the historic condition (Bauder and McMillan 1998).

Habitat Requirements and Limiting Factors: Following winter rainstorms, vernal pools form in depressions above an impervious soil layer or layers. Water evaporates from these pools during the spring and early summer. Vegetation communities associated with adjacent upland habitats that surround the vernal pools in southern California are valley needlegrass grassland, annual grasslands, coastal sage scrub, maritime succulent scrub, and chaparral.

Prior to 1945, the primary threats to southern California vernal pools were grazing, water impoundments, and conversion to agriculture. In recent years, urbanization and construction of infrastructure have resulted in losses of habitat estimated to be as high as 97 percent. Urbanization can directly impact pools through elimination of the habitat by soil alteration, vegetation alteration, alterations in hydrological regimes, and water quality. Where pools remain the indirect threats from dumping, trampling, vehicular activity, runoff, and intrusion of nonnative species can cause profound changes in the pool flora.

Recovery Objective: The goal of this plan is conserve and enhance southern California vernal pool ecosystems, with specific emphasis on stabilizing and protecting existing populations of *Eryngium aristulatum* var. *parishii*, *Pogogyne abramsii*, *Pogogyne nudiuscula*, *Orcuttia californica*, and San Diego and Riverside fairy shrimp so that these species may be reclassified from endangered to threatened status. The goal of this plan for *Navarretia fossalis*, currently proposed for listing as threatened, is to ensure the long-term conservation of this species.

Recovery Criteria:

Reclassification to threatened status may be considered for *Eryngium aristulatum* var. *parishii*, *Pogogyne abramsii*, *Pogogyne nudiuscula*, *Orcuttia californica*; San Diego and Riverside fairy shrimp; and the long-term conservation of *Navarretia fossalis*, a species proposed as threatened, will be assured when the following criteria are met:

1. The following conditions must be met to maintain the current status of *Navarretia fossalis*, *Eryngium aristulatum* var. *parishii*, *Pogogyne abramsii*, *Pogogyne nudiuscula*, *Orcuttia californica*, and San Diego and Riverside fairy shrimp in order to maintain genetic diversity and population stability of the listed species and other sensitive species:

Existing vernal pools currently occupied by *Orcuttia californica*, *Pogogyne nudiuscula*, and Riverside fairy shrimp and their associated

watersheds should be secured from further loss and degradation in a configuration that maintains habitat function and species viability;

Existing vernal pools and their associated watersheds within the Transverse and Los Angeles Basin-Orange Management Areas should be secured from further loss and degradation in a configuration that maintains habitat function and species viability;

Existing vernal pools and their associated watersheds within the San Marcos vernal pool complexes that contain *Navarretia fossalis*, *Eryngium aristulatum* var. *parishii*, or any other vernal pool species, should be secured from further loss and degradation. Habitat functions and species viability for any of the remaining vernal pools and their associated watersheds within the San Marcos complexes must be ensured;

Existing vernal pools and their associated watersheds within the Ramona complexes that contain *Eryngium aristulatum* var. *parishii*, *Navarretia fossalis*, San Diego fairy shrimp, or any other vernal pool species, should be secured from further loss and degradation in a configuration that maintains habitat functions and species viability;

Existing vernal pools and their associated watersheds within the Hemet complexes that contain *Navarretia fossalis*, and *Orcuttia californica*, or any other vernal pool species, should be secured from further loss and degradation in a configuration that maintains habitat functions and species viability,

Existing vernal pools and their associated watersheds located on Stockpen soils (Otay Mesa) should be secured from further loss and degradation in a configuration that maintains habitat functions and species viability, to provide for the recovery of species restricted to this soil type (i.e., *Pogogyne nudiuscula*); and

Remaining vernal pools and their associated watersheds contained within the complexes identified in Table 4 must be secured in a configuration that

maintains habitat function and species viability (as determined by prescribed research tasks).

2. The existing vernal pools and their associated watersheds contained within the complexes identified in Table 5 are secured in a configuration that maintains habitat function and species viability (as determined by recommended research).
3. Secured vernal pools are enhanced or restored such that population levels of existing species are stabilized or increased.
4. Population trends must be shown to be stable or increasing for a minimum of 10 consecutive years prior to consideration for reclassification. Monitoring should continue for a period of at least 10 years following reclassification to ensure population stability.

Delisting of each of the species is conditional on the downlisting criteria shown above, improvement (stabilized or increasing population trends) at all currently known sites; restoration, protection, and management of the minimum habitat area and configuration needed to ensure long-term viability; and establishing historic but locally extirpated species populations when needed to ensure viability.

Actions Needed:

1. Conduct surveys and research essential to the conservation of these species.
2. Secure the existing vernal pools and their associated watersheds.
3. Where necessary reestablish vernal pool habitat to the historical structure.
4. Manage and monitor habitat and listed species.

Recovery Costs (\$1,000's); some Costs are yet to be determined:

Year	Need 1	Need 2	Need 3	Need 4	Total
1999	195	TBD	0	TBD	195
2000	175	TBD	0	TBD	175
2001	100	TBD	125	50	275
2002	100	TBD	75	TBD	175
2003	100	TBD	0	TBD	100
2004	0	TBD	0	TBD	0
2005	0	TBD	0	TBD	0
2006	0	TBD	0	TBD	0
2007	0	TBD	0	TBD	0
2008	0	TBD	0	TBD	0
Total Cost:	670	TBD	200	50	920

Date of Recovery:

Reclassification of the species to threatened could occur as early as 2007, but the date of Recovery cannot be determined at this time.

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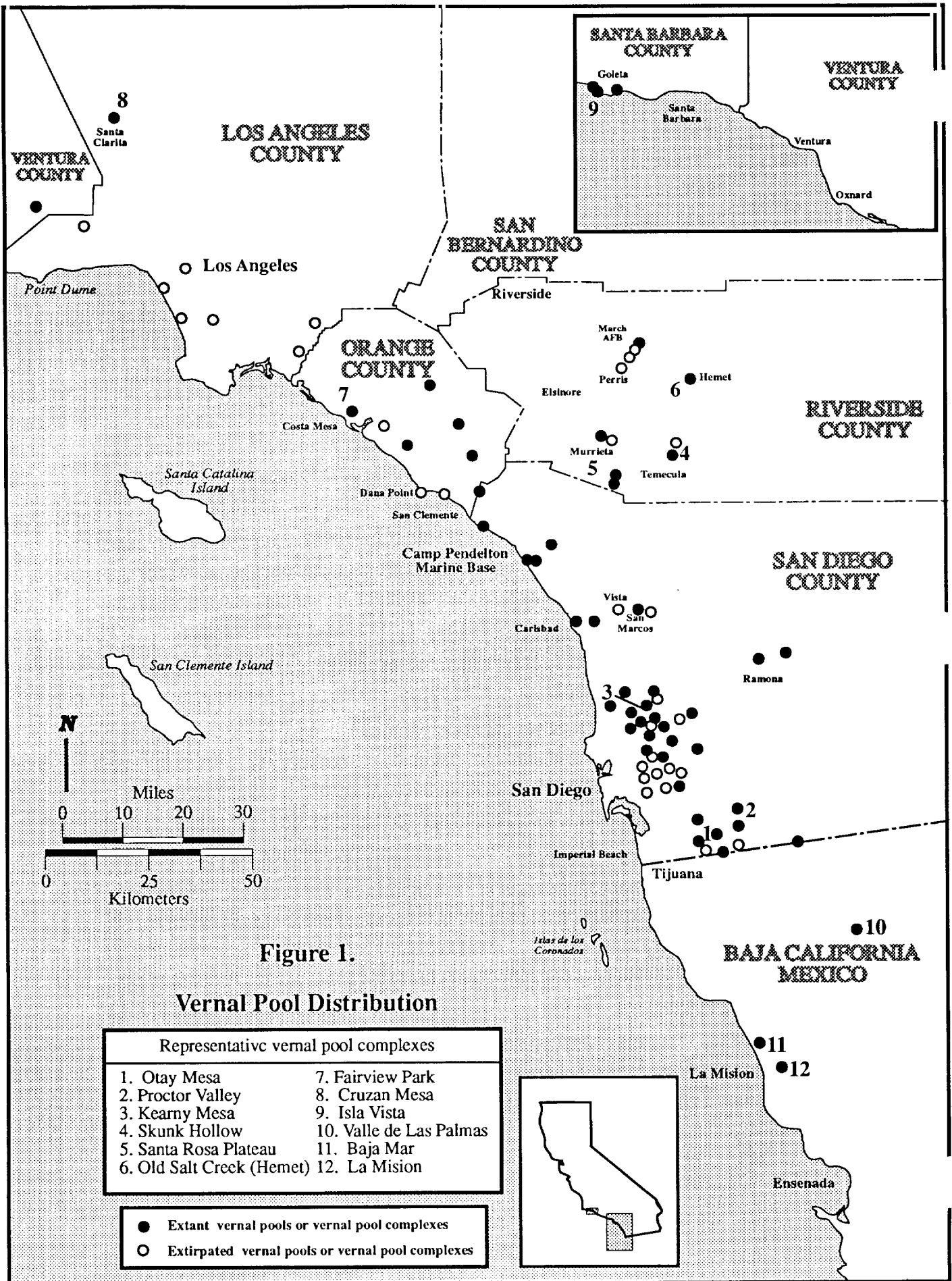
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I. INTRODUCTION

OVERVIEW

In the western United States, vernal pools are a unique, specialized form of seasonal wetlands that occur in a geographical area extending from southern Oregon through California into northern Baja California, Mexico. Pool habitats are not homogeneous throughout this large area because of regional differences in climate, topography, and soils. These differences help to divide California into different subregions, each with a distinctive type or types of pool flora (Holland 1986; Holland and Dains 1990; Bauder and McMillan 1998) and geological characteristics (e.g., claypan, basaltic flow, volcanic mud flow). Although the pools of southern California share some wide-ranging temporary wetlands species with pools in other parts of the State, they support species unique to the area, which helps to set them apart (Stone 1990). All of the listed and proposed species addressed in this recovery plan are restricted to vernal pools, from the scattered and limited pools remaining in southern California on the coastal terraces of Goleta and Isla Vista in Santa Barbara County, to the Simi Hills of eastern Ventura County and the Santa Clarita region of Los Angeles County, east through Orange and western Riverside Counties, and southward to the more extensive vernal pool complexes of San Diego County (Figure 1).

Because of the complexity of vernal pool habitats and their associated watershed, the wide geographic distribution of the various pool species, and the unique ecological parameters associated with each, strategies for the recovery of the species addressed within this plan cannot exclude the surrounding environment. Although not entirely restricted to southern California vernal pools, numerous sensitive species currently without Federal status are associated with vernal pool habitats, including at least 12 endemic plants (Appendix A). The invertebrates of this specialized habitat are not as well studied, and it is likely that additional endemic species may be described with further work. Implementation of the recovery strategy presented in this recovery plan for vernal pool species will also protect other sensitive species and associated vegetation communities, thereby minimizing the potential for additional listing actions under the Endangered



Species Act. The species addressed in this plan for which specific recovery criteria were developed are as follows:

Scientific Name	Common Name	Federal Status
<i>Eryngium aristulatum</i> var. <i>parishii</i>	San Diego button-celery	endangered
<i>Navarretia fossalis</i>	spreading navarretia	proposed threatened
<i>Orcuttia californica</i>	California Orcutt grass	endangered
<i>Pogogyne abramsii</i>	San Diego mesa mint	endangered
<i>Pogogyne nudiuscula</i>	Otay mesa mint	endangered
<i>Branchinecta</i> <i>sandiegonsis</i>	San Diego fairy shrimp	endangered
<i>Streptocephalus woottoni</i>	Riverside fairy shrimp	endangered

Various land owners and agencies have developed a joint agreement to protect much of the known vernal pool habitat of *Downingia concolor* ssp. *brevior* (Cuyamaca Lake downingia) and *Limnanthes gracilis* ssp. *parishii* (Parish's meadowfoam), montane vernal pool species. The conservation requirements of these two species, as well as Cuyamaca larkspur (*Delphinium hesperium* ssp. *cuyamaca*), have been addressed in a Conservation Agreement (USFWS 1996a). The ecology and distribution of the vernal pool fairy shrimp (*Branchinecta lynchi*) is being addressed in the Central Valley Vernal Pool and Multi-Species Draft Recovery Plan (USFWS unpub. 1998). Therefore, these species are not included in this plan.

SPECIES DESCRIPTION AND STATUS

Eryngium aristulatum var. *parishii* (J. Coulter & Rose) Jepson
(San Diego button-celery, Illustration not available)

Eryngium aristulatum var. *parishii* is a member of the carrot family (Apiaceae) and was originally described as *Eryngium parishii* by Coulter and Rose (1900). Some references have confused this taxa (*Eryngium parishii*) with *Eryngium jepsonii* var. *parishii*. (Jepson 1923). Jepson (1936) reflects the Coulter and Rose

(1900) classification. Mathias and Constance (1941) separated *Eryngium aristulatum* from *Eryngium jepsonii* due to morphological characteristics and treated this plant as a variety of *Eryngium aristulatum* (as *Eryngium aristulatum* var. *parishii*). This treatment of *Eryngium aristulatum* (as var. *parishii*), is still recognized in both Munz (1974) and Hickman (1993).

Eryngium aristulatum var. *parishii* is a perennial herb with a persistent tap root. The plant has a spreading to erect habit, reaching a height of 41 centimeters (16 inches) or more. The stems and toothed leaves are gray green with spinose lobes, giving it a prickly appearance. Inflorescences form on short peduncles (stalks) with few to many-flowered heads.

Eryngium aristulatum var. *parishii* is separated from *Eryngium aristulatum* var. *aristulatum* by having styles in fruit that are about the same length as the calyx (outer whorl of protective leaves around the flower) and is separated from *Eryngium aristulatum* var. *hooveri* by having bractlets (modified leaves) without callused margins (Hickman 1993). A population of *Eryngium* has been found on Marine Corps Base Camp Pendleton (MCB Camp Pendleton) that is diagnosable as and may represent a new species (Kim Marsden, pers. comm. 1997).

Eryngium aristulatum var. *parishii* ranges from as far north as the Santa Rosa Plateau, Riverside County, south to the mesas north of Ensenada, Mesa de Colonet, and San Quintin, Baja California, Mexico (Marsden, pers. comm. 1997) (Figure 2). *Eryngium aristulatum* var. *parishii* is found in pools on Del Mar Mesa, Mira Mesa, Kearny Mesa, Marine Corps Air Station Miramar (MCAS Miramar), MCB Camp Pendleton, and at sites within the cities of Tierrasanta, San Marcos, Carlsbad, and Ramona; it was extirpated from a site in the city of La Jolla (Bauder 1986). *Eryngium aristulatum* var. *parishii* is also found in the southern portion of San Diego County on Otay Mesa, near the Lower Otay Reservoir and in Proctor Valley. It also was found near the Tijuana Airport, but is believed to be extirpated at this locale. There are no known herbarium collections of *Eryngium aristulatum* var. *parishii* from the San Diego Mesa (e.g., Normal Heights, San Diego State University).

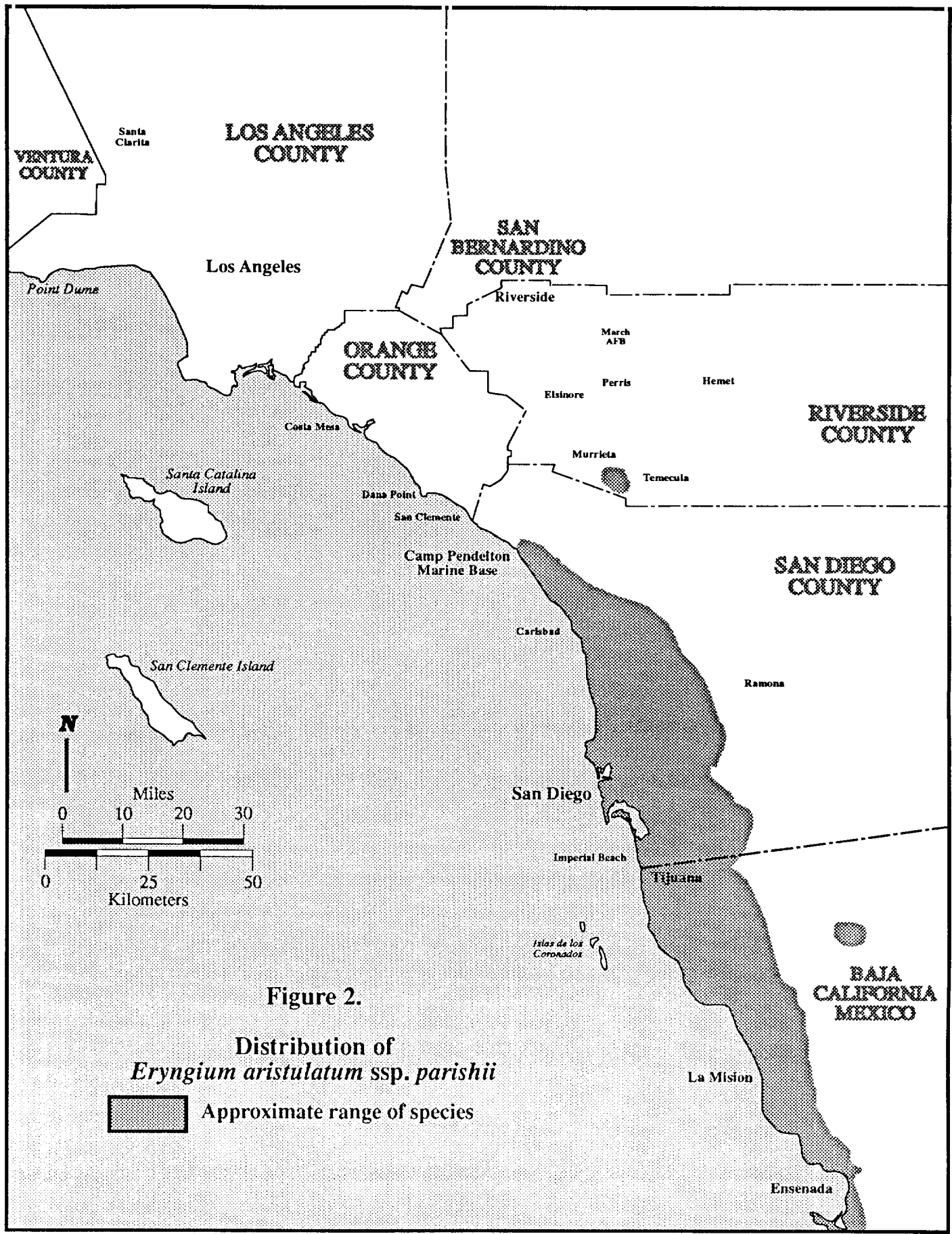



Figure 2.

Distribution of *Eryngium aristulatum ssp. parishii*

 Approximate range of species

Eryngium aristulatum var. *parishii* was listed as endangered on August 3, 1993 (USFWS), after the U.S. Fish and Wildlife Service determined that the present range was being rapidly reduced and the continued existence of the species was being threatened by habitat loss and degradation due to urban and agricultural development, livestock grazing, off-road vehicle use, trampling, invasions from weedy non-native plants, and other factors. The plant has a U.S. Fish and Wildlife Service recovery priority of 3C, indicating that it is a subspecies or variety facing a high degree of threat but having a high potential for recovery. The “C” indicates that the species may be in conflict with construction or development projects. *Eryngium aristulatum* var. *parishii* was listed by the State of California as endangered in July of 1979, under the California Endangered Species Act, and is currently recognized as such.

Navarretia fossalis Moran
(Spreading navarretia, Illustration not available)

Navarretia fossalis is a member of the phlox family (Polemoniaceae). It was first described by Reid Moran in 1977 based on a collection he made in 1969 near La Misión in northwestern Baja California, Mexico. *Navarretia fossalis* is a low, spreading or ascending, annual herb. The lower portions of the stems are mostly bare. The leaves are soft and finely divided, up to 5 centimeters (2 inches) long, and spine-tipped when dry. The flowers are white to lavender white with linear petals and are arranged in flat-topped, compact, leafy heads (USFWS 1994b). Several other species within the genus occur within the range of *Navarretia fossalis*. Two of these species, *Navarretia intertexta* and *Navarretia prostrata*, can occur in similar habitats. *Navarretia fossalis* can be distinguished from these species by the size and shape of the calyx, the position of the corolla (inner floral leaves), and the form of the corolla lobes. All *Navarretia* species can be distinguished from each other by the appearance of the pollen grain surface (Day 1993).

In San Diego County, *Navarretia fossalis* appears to be a vernal pool endemic. However, in Riverside County, it occurs in relatively undisturbed and moderately disturbed vernal pools and in alkali playa habitat near Hemet (Bramlett 1993). The species also occurs in relatively undisturbed and moderately disturbed vernal

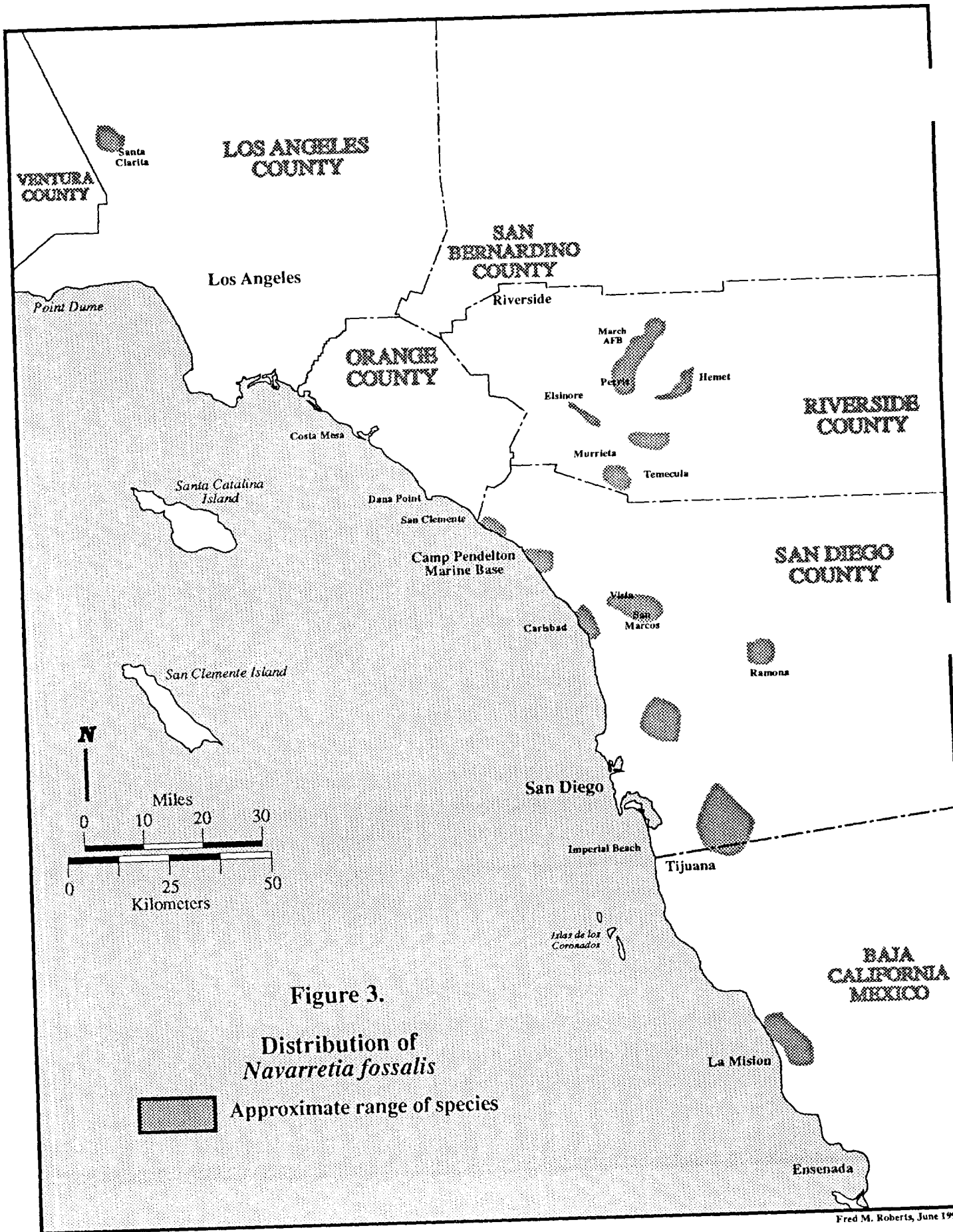
pools and alkali playa habitats along the San Jacinto River in Riverside County and on MCB Camp Pendleton. Historical records indicate that *Navarretia fossalis* is also known from two occurrences near Creston, in San Luis Obispo County.

This plant species was proposed for listing as threatened on December 15, 1994 (USFWS) after the U.S. Fish and Wildlife Service determined that *Navarretia fossalis* was declining as a result of habitat destruction and fragmentation from agricultural development, pipeline construction, alteration of wetland hydrology by draining or channelization, off-road vehicle activity, cattle and sheep grazing, weed abatement, fire suppression practices, and competition from nonnative plant species. *Navarretia fossalis* is known from widely disjunct and restricted populations extending from the Santa Clarita region of Los Angeles County, east to the western lowlands of Riverside County, south through coastal and foothill San Diego County, south to San Quintin, Baja California, Mexico (Figure 3). Fewer than 30 populations exist in the United States. Nearly 60 percent of these populations are concentrated in 3 locations in California: on Otay Mesa in southern San Diego County, along the San Jacinto River in Riverside County, and near Hemet in western Riverside County (USFWS 1994b).

Orcuttia californica Vasey
(California Orcutt grass, Illustration see Appendix C)

Orcuttia californica is a member of the grass family (Poaceae). *Orcuttia californica* was first collected by Charles Orcutt and was described by Vasey (1886). This plant has been considered the nominate variety of *Orcuttia californica* and two other varieties were also recognized (*O. c.* var. *viscida* and *O. c.* var. *inaequalis*). Reeder (1982) raised all the varieties of *Orcuttia californica* to species status.

This small annual grass reaches about 10 centimeters (4 inches) in height, is bright gray-green, and secretes sticky droplets. Inflorescences, borne from May through July, consist of seven spikelets arranged in two ranks, with the upper spikelets overlapping on a somewhat twisted axis. The three species formerly included within *Orcuttia californica* (*O. californica*, *O. inaequalis*, and *O. viscida*) can be separated from other species of *Orcuttia* by having lemma (lower scales

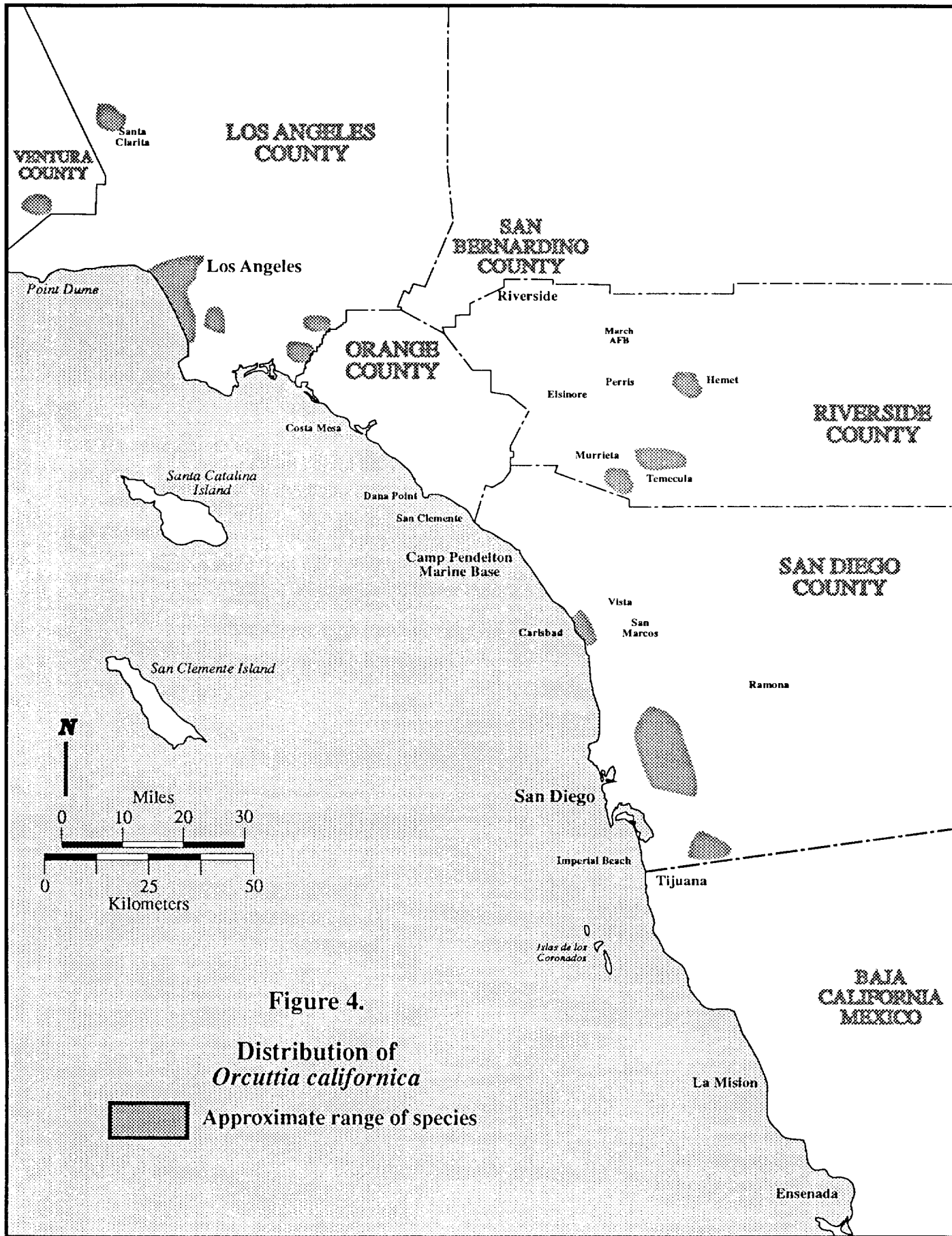


Fred M. Roberts, June 1998

surrounding the flower) teeth unequal, with the central tooth generally the longest (Reeder 1993). *Orcuttia californica* can be separated from *Orcuttia viscida* by having a lemma that is less than 5 millimeters (0.2 inch) long, sharp-pointed or awned teeth, awns (bristles on the seedhead) that are less than 0.5 millimeter (0.02 inch) long, and fruits that are less than 2 millimeters (0.08 inch) long. *Orcuttia californica* can be separated from *Orcuttia inaequalis* by being sparsely hairy with a prostrate stem. In addition, the inflorescence has spikelets that are well separated on the lower part of the axis and are crowded toward the tip (Reeder 1993).

Orcuttia californica has historically been reported from at least four locations in Los Angeles County. However, it is currently known from only two localities near Santa Clarita, California (Cruzan Mesa) and near Woodland Hills (Los Angeles County). An occurrence is known from the Carlsberg vernal pool located in the City of Moorpark in Ventura County. The species is also known from the Santa Rosa Plateau, Skunk Hollow, and a site near Hemet (Riverside County) (Bramlett, pers. comm. 1993) (Figure 4). The species also once occurred near Murrieta Hot Springs, but this population has been extirpated. In San Diego County, *Orcuttia californica* is found in two pools on MCAS Miramar, in the City of Carlsbad (in the same pool as *Eryngium aristulatum* var. *parishii*, *Navarretia fossalis*, and the Riverside and San Diego fairy shrimp), and in four pool complexes on Otay Mesa. In Baja California, Mexico, *Orcuttia californica* has been found on Mesa de Colonet and in pools at San Quintin. These Baja populations are believed to still exist, but in danger of being extirpated due to agricultural conversion.

Orcuttia californica was listed as endangered on August 3, 1993 (USFWS). The U.S. Fish and Wildlife Service determined that the present range was being rapidly reduced and the continued existence of the species was being threatened by habitat loss and degradation due to urban and agricultural development, livestock grazing, off-road vehicle use, trampling, invasions from weedy non-native plants, and other factors. The plant has a U.S. Fish and Wildlife Service recovery priority of 5C, indicating that it is a species facing a high degree of threat and having a low potential for recovery. The “C” indicates that the species may be in conflict with construction or development projects.



Pogogyne abramsii Howell
(San Diego mesa mint, Illustration not available)

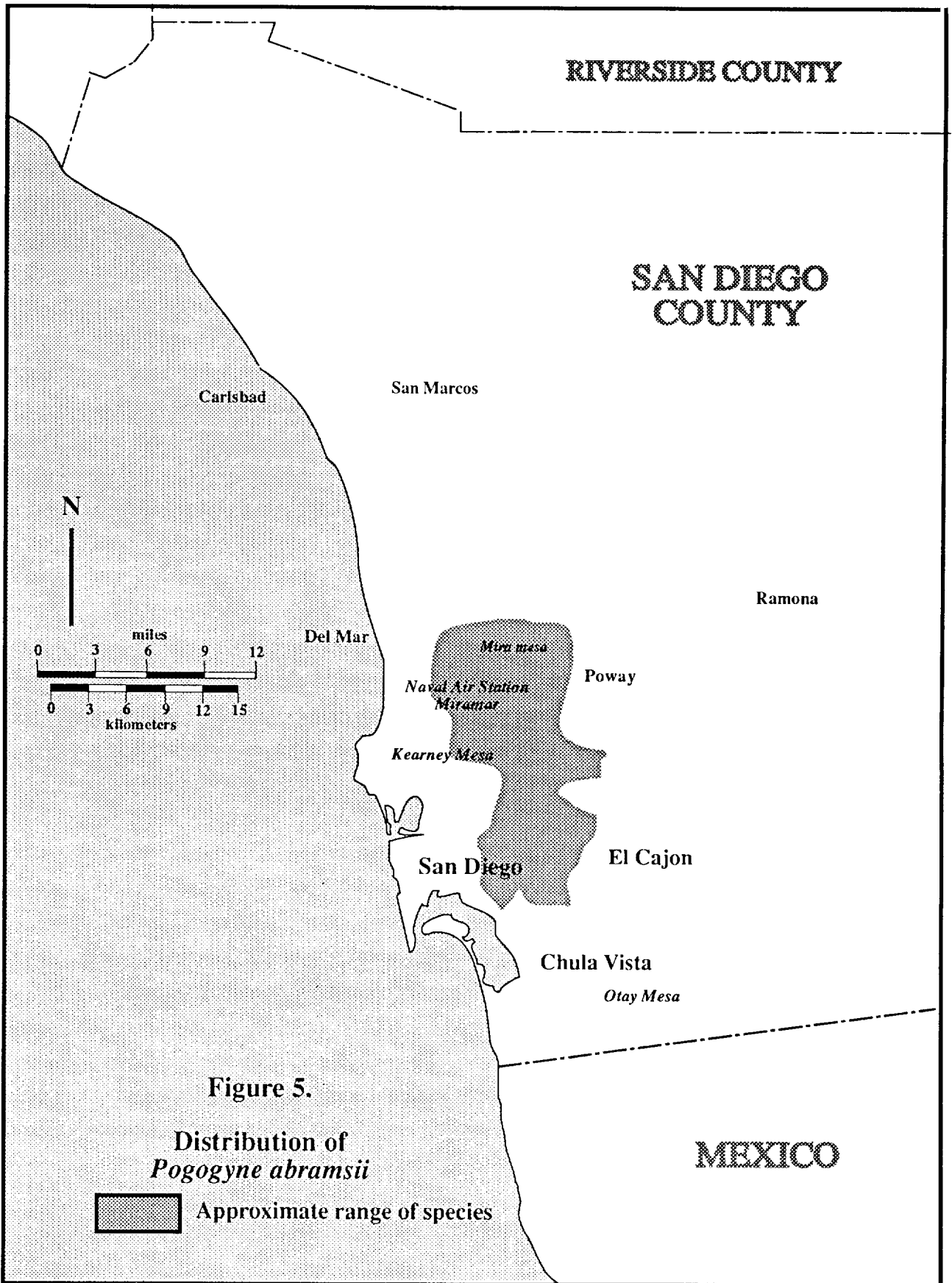
Pogogyne abramsii is an annual herb in the mint family (Lamiaceae). The genus *Pogogyne* was first described by Bentham (1834 cited in Howell 1931) in his monographic study of the mint family, *Labiatarum Genera et Species*. At that time, only three species in the genus had been described. Asa Gray (1876 cited in Howell 1931) described the species *Pogogyne nudiuscula*, which incorporated all the *Pogogyne* species in San Diego County. John Thomas Howell (1931), in his monographic study of the genus *Pogogyne*, separated *Pogogyne nudiuscula* into two species: *Pogogyne nudiuscula* and *Pogogyne abramsii*. *Pogogyne abramsii* was diagnosed by hairs on the calyx and a different bract morphology from *Pogogyne nudiuscula*. Howell did not give a clear description of the distribution of *Pogogyne nudiuscula* and *Pogogyne abramsii*. He considered all populations to be geographically separate. Howell considered all populations of *Pogogyne* north of Mission Valley as *Pogogyne abramsii* and all populations of *Pogogyne* on Otay Mesa as *Pogogyne nudiuscula*. However, it is not clear which species was present on San Diego Mesa, which is located between Mission Valley and Otay Mesa. A major problem in determining the original range of these two species is that almost all of the herbarium collections that might prove useful are very vague on locality. Sites are given as "mesas, San Diego;" "San Diego;" or "mesas near San Diego."

There has been some debate whether *Pogogyne abramsii* is taxonomically distinct from *Pogogyne nudiuscula*. Abrams (1951) recognized this species but considered it possibly not distinct from *Pogogyne nudiuscula*. Current work (Jokerst 1993; McMillan unpublished data 1995) supports taxonomic distinction. Not only do the two species differ in the calyx pubescence (hairiness) and bract morphology, but also in the number of flowers per stem node. All of the current *Pogogyne* populations north of Mission Valley and south of Del Mar Mesa are still considered to be *Pogogyne abramsii*. The populations from the central (San Diego) mesas were probably *Pogogyne abramsii*, but with such limited herbaria records, this question will probably never be fully resolved.

As an herbaceous annual, *Pogogyne abramsii* occasionally reaches 30 centimeters (1 foot) in height and typically blooms from May to early July. The plant can be very branched, and the vegetative and floral portions give off a strong, sweet mint odor. The vegetation develops a reddish tinge as the plant matures and flowers. The flowers are purple with white or yellow throats. *Pogogyne abramsii* typically has only two flowers per node, a hairy calyx, and thin bracts subtending each flower (McMillan unpublished data 1995).

Pogogyne abramsii is endemic to San Diego County. The northern limit of distribution for *Pogogyne abramsii* is Del Mar Mesa, and it occurs south on Mira Mesa, MCAS Miramar, and Kearny Mesa, with a few scattered populations in western Tierrasanta. *Pogogyne abramsii* populations have been extirpated from the Linda Vista area, the vicinity of Balboa Park, Normal Heights, and the area surrounding San Diego State University (Figure 5). Although most of these extirpated populations from the San Diego Mesa are labeled as *Pogogyne nudiuscula* on herbarium collections, these specimens have not been annotated and should be probably be considered *Pogogyne abramsii* (McMillan unpublished data 1995).

Pogogyne abramsii was listed as endangered on September 28, 1978 (USFWS 1984). The U.S. Fish and Wildlife Service determined that the present range was being rapidly reduced and the continued existence of the species was being threatened by highway construction, housing development, off-road vehicle use, illegal dumping, and agricultural conversion. A Recovery Plan for the species was finalized by the U.S. Fish and Wildlife Service in 1984 (USFWS 1984). The plant has a U.S. Fish and Wildlife Service recovery priority of 2C, indicating that it is a species facing a high degree of threat but having a high potential for recovery. The "C" indicates that the species may be in conflict with construction or development projects. *Pogogyne abramsii* was listed by the State of California as endangered in January of 1979, under the California Endangered Species Act, and is currently recognized as such.

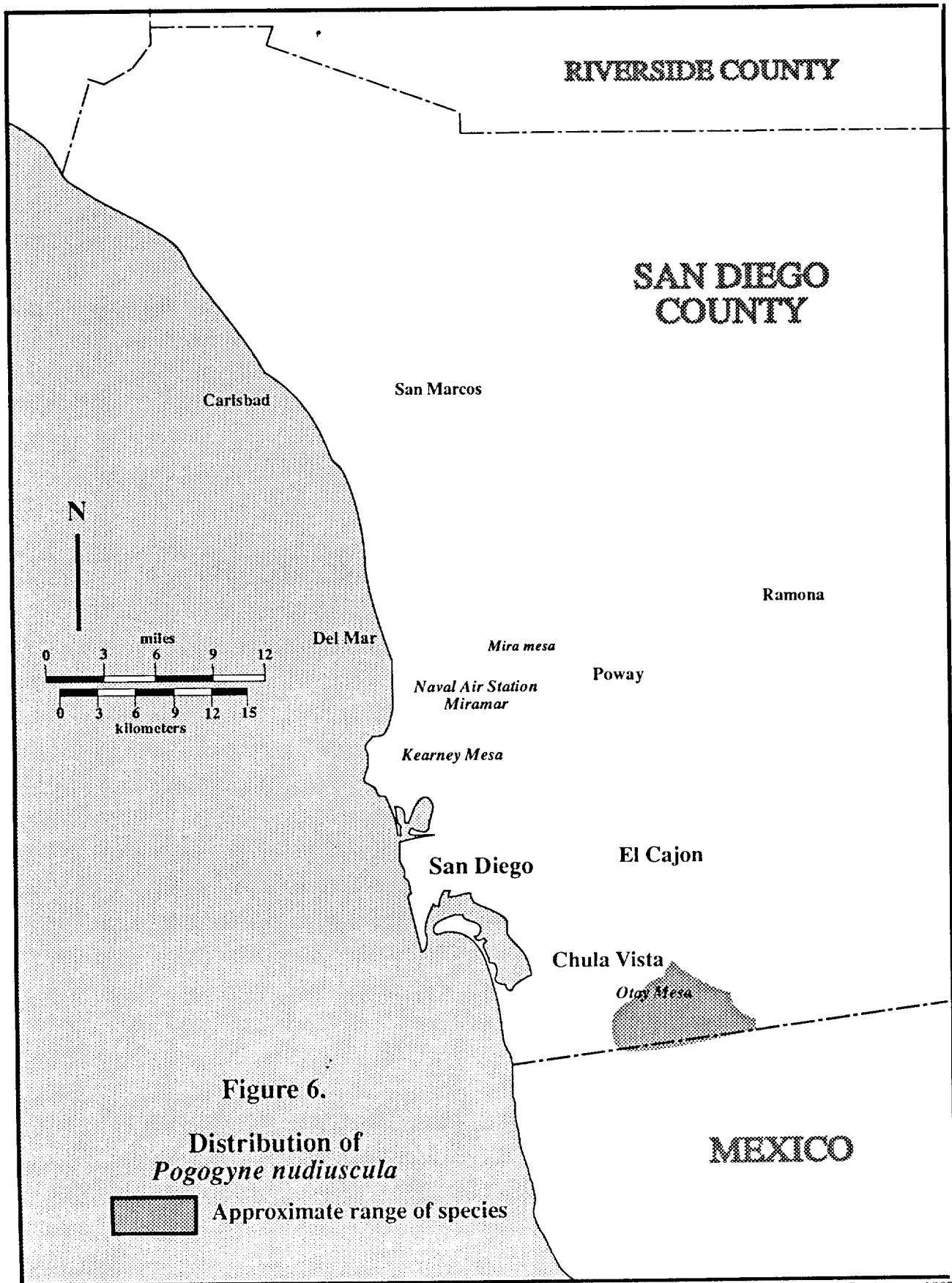


Pogogyne nudiuscula A. Gray
(Otay mesa mint, Illustration Appendix C)

Pogogyne nudiuscula is an annual herb in the mint family (Lamiaceae). As was mentioned in the description for *Pogogyne abramsii*, Howell (1931) considered all *Pogogyne* populations on Otay Mesa to be *Pogogyne nudiuscula*. Many of the older herbarium specimens that might be from the central mesas are labeled as *Pogogyne nudiuscula*, but are likely *Pogogyne abramsii*. Howell considered *Pogogyne nudiuscula* to be diagnosable from *Pogogyne abramsii* by having a glabrous (smooth) calyx and bract with a different morphology. This distinction is supported by current work (Jokerst 1993; McMillan unpublished data 1995), and the species is also diagnosable by usually having at least six flowers per node on the stem.

Pogogyne nudiuscula can reach 30 centimeters (1 foot) or more in height and typically blooms from May or June through early July. The plant is usually not much branched, and the vegetative and floral portions of the plant give off a strong, turpentine mint odor. In contrast to *Pogogyne abramsii* the vegetative portions of the plant do not develop a reddish tinge until the plant is past the flowering period. The flowers are purple with a white throat. *Pogogyne nudiuscula* typically has six flowers (occasionally more) per stem node, a glabrous to minutely pubescent (hairy) calyx, and bracts and leaves which are wider than *Pogogyne abramsii*. A large population of *Pogogyne* was found by Reid Moran in Valle de las Palmas, in Baja California, Mexico, about 32 kilometers (20 miles) south of the Tecate Border crossing, but current work (McMillan unpublished data 1995) supports this population as a unique species. This population can be distinguished from *Pogogyne nudiuscula* on Otay Mesa by the calyx to corolla ratio, the number of flowers per node, and the general size of the floral parts. This population can also be separated from *Pogogyne nudiuscula* by allozyme and DNA data (Hanson unpublished 1995).

Pogogyne nudiuscula currently exists only in seven vernal pool complexes on Otay Mesa (Figure 6). Historically it was known to occur across the international border where the Tijuana International Airport is now located. No Tijuana populations of *Pogogyne nudiuscula* are known to exist today as *Pogogyne nudiuscula* was never known to occur further north than Otay Mesa (see previous discussion).



Fred M. Roberts, Jr. August 1997

Pogogyne nudiuscula was listed as endangered on August 3, 1993 (USFWS). The U.S. Fish and Wildlife Service determined that the present range was being rapidly reduced and the continued existence of the species threatened by habitat loss and degradation due to urban and agricultural development, livestock grazing, off-road vehicle use, trampling, invasions from weedy nonnative plants, and other factors. The plant has a U.S. Fish and Wildlife Service recovery priority of 2C, indicating that it is a species facing a high degree of threat but having a high potential for recovery. The “C” indicates that the species may be in conflict with construction or development projects. *Pogogyne nudiuscula* was listed by the State of California as endangered in July of 1987, under the California Endangered Species Act, and is currently recognized as such.

Branchinecta sandiegonensis Fugate
(San Diego fairy shrimp, Illustration not available)

The San Diego fairy shrimp is a small freshwater crustacean in the family Branchinectidae, of the Order Anostraca. The species was described by Fugate in 1993 based on specimens collected on Del Mar Mesa, San Diego County, California (USFWS 1994c). The San Diego fairy shrimp is closely related to *Branchinecta lynchi*, the vernal pool fairy shrimp, a narrow California endemic and a federally threatened species. The San Diego fairy shrimp was first collected (but identified then as *Branchinecta lindahli*) near Poway and at Ramona, California in 1962 (USFWS 1994c).

The San Diego fairy shrimp is a small and delicate animal with large stalked compound eyes, no carapace, and 11 pairs of swimming legs. Mature males attain 16 millimeters (0.6 inch) in length, and females attain 14 millimeters (0.5 inch) in length. The San Diego fairy shrimp can be distinguished from other fairy shrimp of the same genus by the shape of the second antenna (males), or the shape and length of the ovisac and the presence of paired dorsilateral spines (Fugate 1993).

The San Diego fairy shrimp is a vernal pool habitat specialist, found in small, shallow vernal pools. However, the species occasionally occurs in ditches and road ruts that can support suitable conditions (USFWS 1994c). No individuals have been found in riverine waters, marine waters, or other permanent bodies of

water. The genetic characteristics of the San Diego fairy shrimp, as well as ecological conditions such as watershed contiguity, indicate that populations of these animals are defined by pool complexes rather than by individual vernal pools (Simovich *et al.*, 1992). Individual vernal pools occupied by the San Diego fairy shrimp are most appropriately referred to as subpopulations.

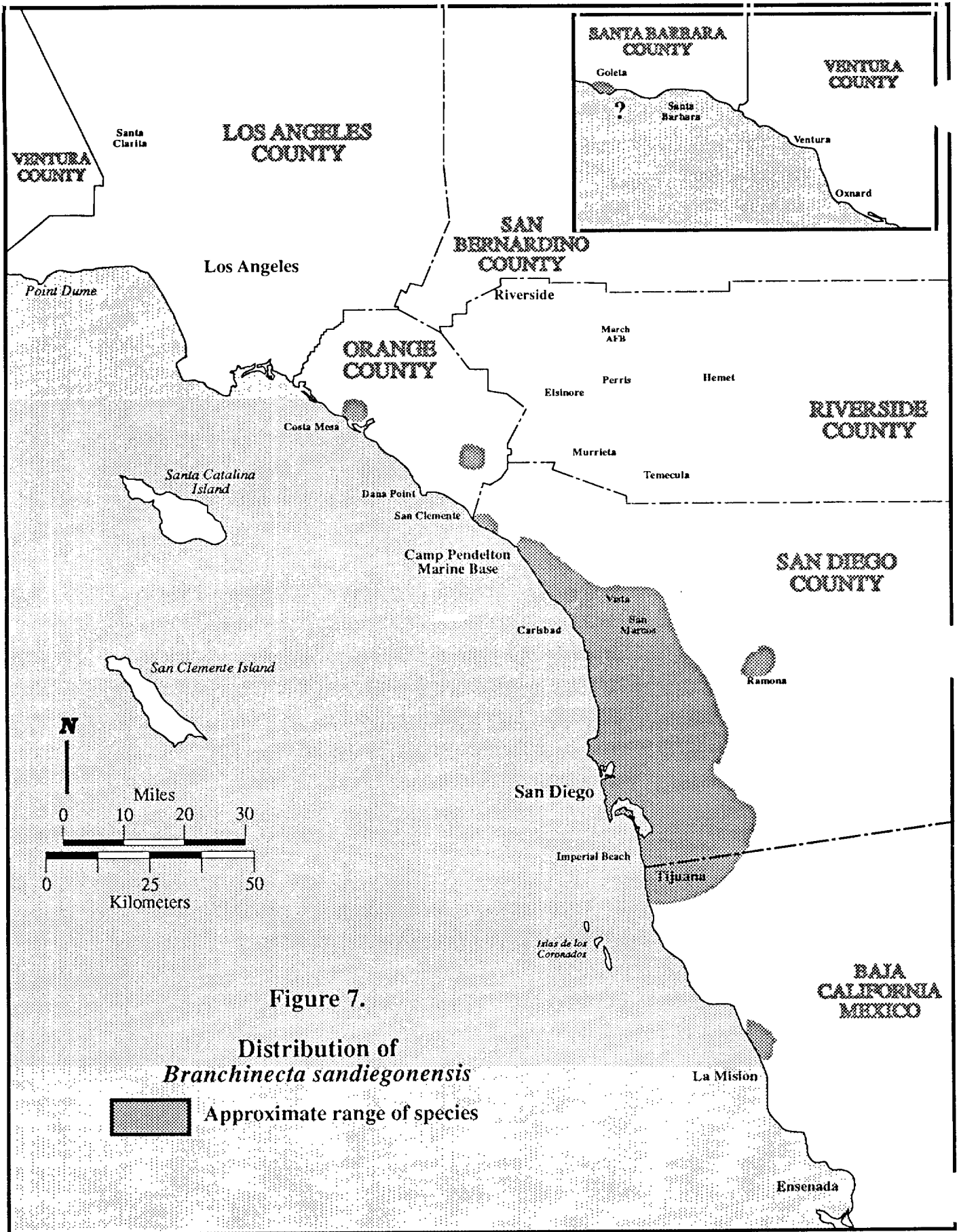
The largest number of vernal pools inhabited by the San Diego fairy shrimp are located in San Diego County. Here, the San Diego fairy shrimp is found from MCB Camp Pendleton, inland to Ramona, and south through Del Mar Mesa, Kearney Mesa, Proctor Valley, and Otay Mesa, and into northwestern Baja California, Mexico. In Baja California, it has been recorded at two localities (Valle de las Palmas south of Tecate and Baja Mar, north of Ensenada)(Brown *et al.*, 1993). Small populations occur in Orange County, and a single isolated female was reported from a vernal pool in Isla Vista, Santa Barbara County, California (USFWS 1994c) (Figure 7).

This species was listed as endangered on February 3, 1997 (USFWS). The U.S. Fish and Wildlife Service determined that the continued survival of the species was threatened by habitat destruction from agricultural and urban development, alteration of wetland hydrology by draining, off-road vehicle activity, cattle grazing, and replacement by other fairy shrimp species that are habitat generalists. The animal has a U.S. Fish and Wildlife Service recovery priority of 2C, indicating that it is a species facing a high degree of threat but having a high potential for recovery. The "C" indicates that the species may be in conflict with construction or development projects.

Streptocephalus woottoni Eng
(Riverside fairy shrimp, Illustration not available)

The Riverside fairy shrimp is a small freshwater crustacean in the Family Streptocephalidae of the Order Anostraca. The species was first collected in 1979 by C.H. Erickson and was identified as a new species in 1985 (Eng *et al.* 1990).

Mature males are between 13 and 25 millimeters (0.5 to 1.0 inch) long. The frontal appendage is cylindrical, bilobed at the tip, and extends only part way to the distal end of the basal segment of the antenna. The spur of the thumb is a



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simple blade like structure. The finger has two teeth; the proximal tooth is shorter than the distal tooth. The distal tooth has a lateral shoulder that is equal to about half the tooth's total length measured along the proximal edge. The cercopods (enhance the rudder-like function of the abdomen) are separate with plumose setae (feathery bristles) along the medial and lateral borders. Mature females are between about 13 and 22 millimeters (0.5 to 0.87 inch) in total length. The brood pouch extends to abdominal segments seven, eight, or nine. The cercopods of females are the same as the males'.

The Riverside fairy shrimp is found in deep, cool water pools and occasionally in depressions (incl. road ruts and ditches) that support suitable habitat. The fairy shrimp species most similar to the Riverside fairy shrimp is the spiny-tail fairy shrimp (*Streptocephalus sealii*), discovered by Ryder in 1879. Plumose setae edge the cercopods of mature male Riverside fairy shrimp, whereas spines replace the setae on the distal half of the cercopods in mature spiny-tail fairy shrimp and desert fairy shrimp (*Streptocephalus similis*), which was discovered by Baird in 1852. Both males and females of Riverside fairy shrimp have the red color of the cercopods covering all the ninth abdominal segment and 30 to 40 percent of the eighth abdominal segment. No red extends onto the abdominal segments of either sex in the spiny-tail fairy shrimp.

The northern range of the Riverside fairy shrimp is defined by Skunk Hollow and the Santa Rosa Plateau in Riverside County and coastal sites in San Diego and Orange Counties (Figure 8). It is documented from one complex on MCAS Miramar, throughout MCB Camp Pendleton, and eight complexes on Otay Mesa. In Baja California, Mexico, it has been found in Valle de las Palmas, and at Bajamar north of Ensenada (Brown, *et al.* 1993).

The Riverside fairy shrimp was listed as endangered on August 3, 1993 (USFWS). The U.S. Fish and Wildlife Service determined that the present range was being rapidly reduced and the continued existence of the species threatened by habitat loss and degradation due to urban and agricultural development, off-road vehicle use, trampling, and other factors. The animal has a U.S. Fish and Wildlife Service recovery priority of 5C, indicating that it is a species facing a high degree of threat and having a low potential for recovery. The "C" indicates that the species may be in conflict with construction or development projects.

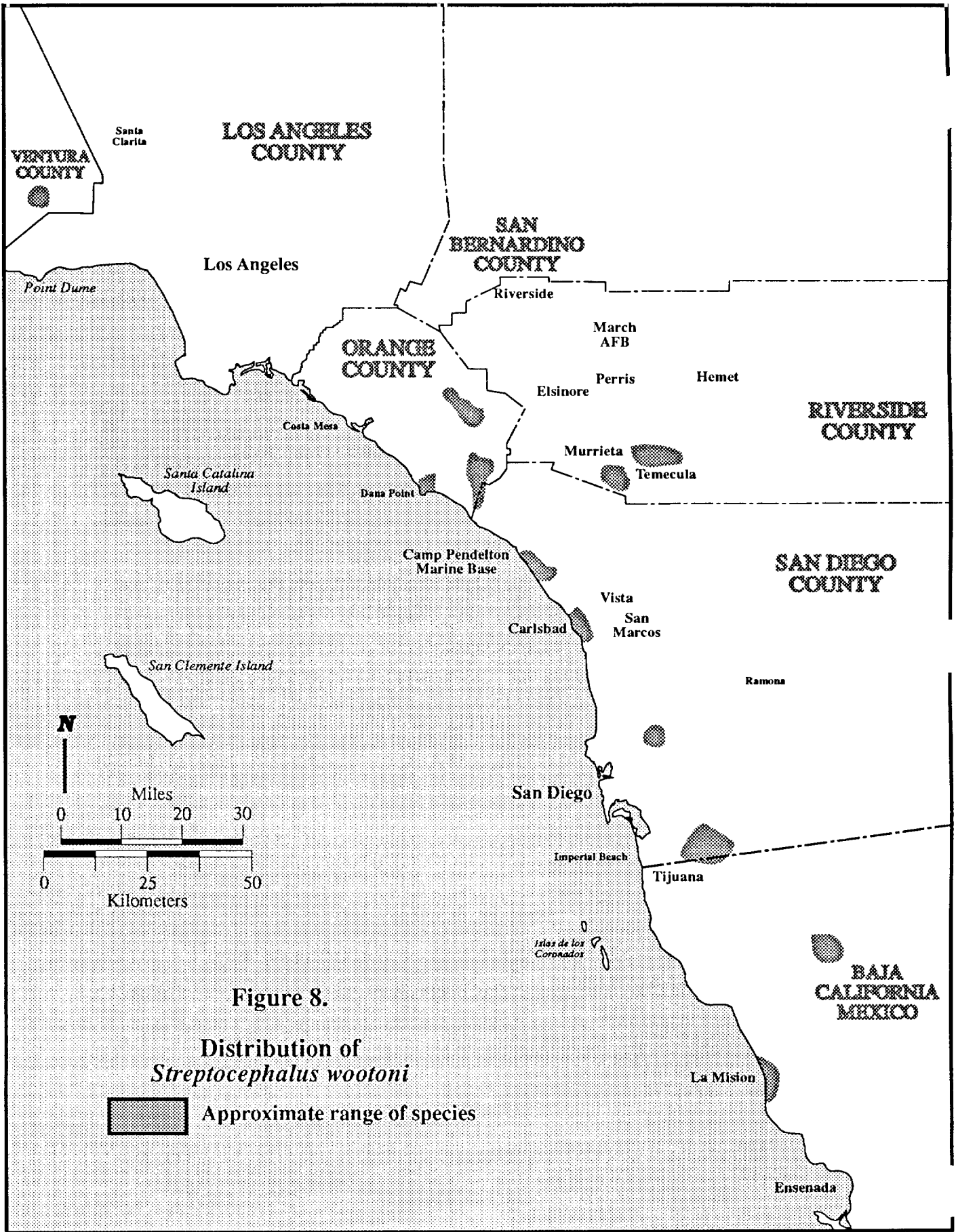


Figure 8.
Distribution of
Streptocephalus wootoni
 [Shaded Box] **Approximate range of species**

ECOSYSTEM DESCRIPTION

Vernal pools are seasonal depressional wetlands with many characteristics common to other wetland classes (Butterwick 1996). Their rich endemic flora and micro fauna set them apart from other temporary wetlands (Stebbins 1976; Thorne 1984). The proliferation of species in these pools may be related to the Mediterranean climate that prevails throughout their range. This climate is characterized by winter rainstorms, followed by a long summer drought. Consequently, pools that may be classified as “vernal” can be found in areas of North America, Chile, South America, South Africa, Australia, and the Mediterranean Basin.

Several plant genera are endemic to California vernal pool habitats (e.g., *Pogogyne*, *Downingia*, *Psilocarphus*, *Orcuttia*, etc.) and many others have the majority of their distributions in vernal moist ponds, seeps, swales, drainages and meadows within the California Floristic Province (Thorne 1984).

Because of a large pool perimeter-surface area, vernal pools are intimately connected to the vegetation community which surrounds them. Numerous plant species are dependent upon southern California vernal pools, and a wide array of plants and animals of restricted distribution are found in the vegetation communities in which the pools occur (Appendix A). The upland vegetation communities associated with vernal pools in southern California include: needlegrass grassland, annual grasslands, coastal sage scrub, maritime succulent scrub, chaparral, coniferous forest, and montane wet meadow.

Some pool species, such as spadefoot toads (*Scaphiopus hammondi*) and Pacific tree frogs (*Hyla regilla*), spend a large portion of their life cycle in the adjacent soils and vegetation, but require ponding water to breed (Simovich 1985). Nearby soils and plants are important to vernal pool pollinators (Leong 1994 and submitted M.S. thesis 1995) and herbivores (Hunt 1989, 1992; Black *et al.* 1993). Pools are utilized by birds and various mammals for food, water, and nesting. Fairy shrimp and other invertebrates provide food for waterfowl, especially ducks (Krapu 1974; Proctor *et al.* 1967; Swanson *et al.* 1974; Silveira 1996).

HABITAT CHARACTERISTICS

Soils, topography, and the Mediterranean climate are dominant factors determining whether ephemeral pools or lakes will form at all. Within the habitat class defined as vernal pools, the distributions of plant and animal species, especially endemics, appear to be affected by subtle differences in duration and pattern of ponding, water and soil chemistry, and sub-regional climatic variables such as the total amount of precipitation, the temperature regime in winter, and the probability of summer precipitation.

Pool Formation

After sufficient rainfall, pools form in depressions above an impervious soil layer or layers. Typically, the depressions are part of an undulating landscape, where soil mounds are interspersed with basins, swales, and drainages. This landscape is frequently called "mima-mound" topography, after the Mima Prairie in Washington where these soil mounds were first described (Cox 1984 a, b). Occasionally, vernal pools or the soils they are located on are degraded (e.g., ditches). These areas often have the ability to function as habitat and may also support vernal pool species.

When pools are filled to capacity, their surface area may be as small as a few square meters, or at the other extreme, approach the size of small lakes. In some cases the individual identity of pools is lost altogether when precipitation is abundant and basins overflow. The watershed for an individual pool may be very localized (Black *et al.* 1993), or it may be part of an extensive and complex watershed as seen in Cuyamaca Valley (Bauder 1994). Larger ponds or vernal lakes may always retain their separateness (e.g., Hidden Lake, Skunk Hollow). Smaller pools may fill for only a couple of weeks, and only on the heaviest rainfall years (e.g., an El Niño event). Larger ponds or vernal lakes typically remain filled for three to five months, but in years of sparse precipitation, may fail to pond at all. Water levels rise and fall during the rainy season, and soils of pool basins may be exposed and re-inundated a number of times before drying in late spring.

Climate

In southern California, climatic variables are most influenced by distance from the coast, topography, and elevation, with yearly average precipitation lowest along the coast and rising with distance inland, to a peak in the peninsular ranges to the east. Precipitation levels then drop abruptly in the rain shadow of the mountains where the upper Sonoran Desert (Colorado Desert) begins.

Within a given rainfall year, most of the precipitation occurs from November through March and is concentrated in about a half dozen storms that may occur within a few months or be spread more evenly over the rainfall season (Mooney and Parsons 1973; Goldman *et al.* 1986). An analysis of long term weather records have shown that a ten year sampling period gives better than an 80 percent representative sample of weather patterns in a given region.

Yearly variability in precipitation is substantial, a feature that is shared by all arid and semiarid climates (Le Houerou 1984; Zedler 1990). Very dry or wet years can follow each other, and no pattern is apparent (Bauder 1987a; Zedler 1987). Since 1850, when record-keeping began in the City of San Diego, yearly precipitation at the Lindbergh Field weather station has ranged from a low of 89 millimeters (3.5 inches) in 1960/61 to a high of 660 millimeters (26 inches) in 1883/84.

Hydrology, Geomorphology, and Water Quality

Pools are dependent on adjacent geomorphology for maintenance of their unique hydrological conditions. Dramatic within- and between-year variability in moisture conditions is the crucial factor in preventing vernal pools from becoming freshwater marshes or dominated by upland shrubs and herbs. Pool plant species tolerate lengthy periods of inundation, but are not truly aquatic, so mortality increases with length of inundation and is usually 100 percent where ponding exceeds six months (Bauder 1987a, 1992). Vernal pool habitats that remain inundated for more than 6 months may exhibit characteristics typical of a freshwater marsh, being dominated by sedges and rushes. Examples would include Skunk Hollow (Zedler *et al.* 1990), Hidden Lake, Lake Cuyamaca, and the Santa Rosa Plateau (Lathrop and Thorne 1976). At the other end of the

moisture gradient, the terrain between pools is dominated by nonnative grassland, chaparral, forest, or savannah vegetation.

Geophysical and chemical factors greatly influence the geographic distribution of pool species (Eng *et al.* 1990; Simovich *et al.* 1996). Modification of alkalinity, pH, turbidity, and water temperature (Simovich *et al.* 1996) may drastically affect certain pool species with very specific tolerance ranges. Seasonality of water quality variables has been documented by Collie and Lathrop (1976) and Simovich and King (1992). Localized variation among pools in hydrological (Zedler *et al.* 1979; Holland and Jain 1984; Bauder 1987a; Ferren and Pritchett 1988), physical, and chemical properties are well established (Ebert and Balko 1987; Simovich and King 1992; King *et al.* 1996; Gonzalez *et al.* 1996).

A steep, small-scale gradient in soil texture, nutrients, water quality, and hydrology extends from the surrounding areas (mounded or otherwise) into the basins (Zedler *et al.* 1979; Bauder 1987a; Zedler *et al.* 1990; Black *et al.* 1993; Black *et al.* 1994). While the nature of subsurface connections is not understood (Hanes, *et al.* 1990; Holland and Dains 1990), studies conducted in vernal pools in the Sacramento Valley indicate that the contribution of subsurface and overland flows is significant only in years of high precipitation when the pools are already saturated (Hanes and Stromberg 1996).

Soils

Critical to the formation of vernal pools is the presence of nearly impermeable surface or subsurface soil layers and flat or gently sloping topography (less than 10 percent slope). In southern California, these impervious layers are typically alluvial materials with clay or clay loam subsoils, and they often form a distinctive micro relief known as Gilgai or mima mound topography (Hallsworth *et al.* 1955; Cox 1984a). Basaltic or granitic substrates (e.g., Hidden Lake and Santa Rosa Plateau in Riverside County) or indurated hardpan layers (e.g., coastal San Diego County) may contribute to poor drainage as well.

On the coastal terraces in San Diego County, pools are associated with the Huerhuero, Stockpen, Redding, and Olivenhain soil series. Huerhuero and

Stockpen soils are derived from marine sediments and terraces. Surface layers are loam to clay loam and moderately to slightly acidic (pH 5.6-6.5). Subsurface layers are mildly to moderately alkaline (pH 7.8-8.2) clays. In contrast to the Huerhuero and Stockpen soils, the Redding and Olivenhain soil series were formed from alluvium. They are moderately to strongly acidic at the surface (pH 5.6-5.8), with strongly acidic subsoils (pH 4.5-5.1). The Redding soil series is notable for a noncontiguous iron-silica cemented hardpan underlying the subsoil. Sometimes it can be found near the surface but otherwise it is located up to four feet below (Greenwood and Abbott 1980; Bowman 1973). On the Del Mar Mesa (Redding gravelly loam), Greenwood and Abbott (1980) found that the expandable smectitic and vermiculitic clay minerals made up 32 percent of the clays in the upper loamy soil layers, increasing to 78 percent in the lower clay layer. The Redding and Olivenhain soils are believed to have supported the majority of the pools historically found in San Diego County. These soils are gravelly or cobbly loam with clay subsoils (Bowman 1973).

With the exception of Proctor Valley (Olivenhain soils) and Marron Valley (Huerhuero soils), soils in most of the inland valleys differ from the coastal terraces. Their origins include acidic igneous rock, weathered sandstone, granitic alluvium, and other substrates. The impervious layer is often sandy clay with pH ranges from mildly acidic (pH 5.8) to moderately alkaline (pH 8.0). In San Marcos Valley, the soils are primarily from the Las Flores and Placentia series. Bosanko and Placentia soils dominate in Ramona, a higher elevation inland valley. The Santa Rosa Plateau has Murrietta stony clay loams and soils of the Las Posas series (Lathrop and Thorne 1976). At Skunk Hollow in Riverside County, the soils in the immediate area of the vernal lake are Las Posas clay loam, Wyman clay loam, and Willows soil, a deep alkaline clay (Zedler *et al.* 1990).

Vernal Pool-like Ephemeral Ponds

In San Diego County and southern Orange County, vernal pool-like ephemeral ponds exist that support the Riverside fairy shrimp, in addition to a wide diversity of vernal pool indicator species (e.g., cloverfern [*Marselia vestita*], clam shrimp [*Cyzicus californicus*]). These ponds are derived from geological activity such as faulting (e.g., sag ponds along San Mateo creek), landslide movement (Orange

County foothills e.g., Saddleback Meadows), or are man-made (such as stock ponds). Although these ephemeral wetlands do not fit the classical description of southern California vernal pools, they function as such in their ability to support vernal pool species. Consequently, these pool types are considered as important habitat for the purpose of recovery of listed species.

Road ruts, man-made ponds, minor impoundments on drainages, and abandoned borrow sites, are generally not considered vernal pools. However, these areas may function as vernal pool habitat by supporting vernal pools species, and may even be a consequence of previous land alterations to historical pool habitat. These areas remain subject to Endangered Species Act requirements if they support listed species, with a determination of their significance to recovery addressed individually.

POOL FLORA

Pool basins have a unique group of plants (Purer 1939), which Robert Thorne (1976) labeled “vernal pool ephemeral.” These plants are supplemented by more typical wetland plants, which are widely distributed in freshwater habitats (Lathrop and Thorne 1983; Thorne 1984). Vernal pool species occupy a habitat neither typically terrestrial nor typically aquatic, and the adaptations required for such a specialized habitat have led to a variety of rare species (Stebbins 1976; Stone 1990).

Endemism is common in vernal pools of the southern region of the California Floristic Province, as are species with highly restricted distributions (Appendix A). San Diego County has two of the nine species in the genus *Pogogyne*, with *Pogogyne abramsii* restricted to the central mesas of the county and the even more narrowly distributed *Pogogyne nudiuscula* being found on Otay Mesa straddling the international border between San Diego County and Baja California, Mexico. *Downingia concolor* ssp. *brevior* is also a San Diego County endemic. Baja California, Mexico, has two narrowly distributed endemic pool species, both in the process of formal description (Marsden, pers. comm. 1997; McMillan pers. comm. 1995). One is a species of *Pogogyne* found only on a mesa in an inland

valley known as Valle de las Palmas, south of the border city of Tecate, and the other is an *Eryngium* species found along the coast in the vicinity of San Quintin.

There is a complex interplay between environmental variation and the response capabilities of various species. Vernal pool plants have evolved traits that enhance survival in uncertain conditions. Most of the vernal pool plant species that commonly occur in southern California vernal pools are adapted to substantial periods of inundation, and many physiological and morphological traits are not expressed unless standing water is present. Naturally-occurring disturbances that can substantially reduce populations of vernal pool plants include unseasonably late rains or a series of drier than average years. Algal blooms sometimes form mats that cover plants and stunt their growth or prevent flowering. The impact of wildfire is uncertain (Cox and Austin 1990), but may contribute to the control of certain nonnative species (Pollak and Kan 1996).

Individual species are distributed along a moisture gradient according to their responses to inundation (Holland and Jain 1977, 1984; Zedler *et al.* 1979; Bauder 1987a; Zedler 1987) and differences in soil moisture (Holland and Dains 1990). In years of average precipitation, upland-to-basin transects or comparisons reveal that 30 to 40 percent of the upland species are nonnative, but less than 10 percent of the pool species are nonnative (Holland and Jain 1977; Bauder 1987a). When precipitation is sparse, nonnative upland species can dominate within pool basins (Bauder 1987a,b). Wetter years reduce the number of nonnative upland species present in basins because of their general intolerance of inundation. Only a limited number of nonnative species, annual beard-grass (*Polypogon monspeliensis*), perennial rye grass (*Lolium perenne*), and brass buttons (*Cotula coronopifolia*), for example, are adapted to the hydrological conditions of the pool habitat. Because they are not eliminated by standing water, these and other nonnative facultative wetland species can account for substantial cover in pools where they become established (Bauder 1988 and unpublished data). Vernal pool species are infrequent above the high water level or outside of connecting swales (Lin 1970; Kopecko and Lathrop 1975; Holland and Jain 1977; 1984; Zedler *et al.* 1979; Bauder 1987a, 1989).

The majority of the pool plant species are annual dicots (Holland 1976; Thorne 1984; Zedler 1990). Perennials are usually monocots such as *Eleocharis macrostachya* or lower vascular plants like *Isoetes* species. Distributions of the perennials are more widespread than that of the annuals (Stebbins 1976). Prominent exceptions are west coast members of the genus *Eryngium*, including *Eryngium aristulatum* var. *parishii*. These species are narrowly distributed, herbaceous perennials. The genus, however, has representatives in many tropical and temperate regions of the world, except tropical Africa (Sheikh 1978).

Breeding systems vary greatly (Stone 1957; Weiler 1962; Griggs 1976; Brown and Jain 1979; Ritland and Subodh 1984). An analysis by Zedler (1990) suggests inbreeding may be the dominant system in native pool plants. Pollinators include solitary ground dwelling bees, bumblebees, honey bees, bee flies and various diptera (flies), coleoptera (beetles), and lepidoptera (butterflies and moths) (Stone 1957; Thorp 1976, 1990; Martin 1986; Ellis and Mills 1991; Black *et al.* 1992; Leong 1994, M.S. thesis submitted 1993).

Gene dispersal may occur via pollen or seed. Outcrossing distances are unknown for most vernal pool species, with the exception of work done on various *Limnanthes* species (Ritland and Subodh 1981, 1984), and little is known about dispersal (Zedler 1990). None of the species have seed morphology associated with animal or wind dispersal, although scattered occurrences of pool plants along well-worn trails that link individual pools over wide areas suggest large animals may contribute to seed dispersal (Cole 1995). Seeds and seedlings of *Downingia* species and *Pogogyne abramsii* float, which may result in limited dispersal opportunities when pools interconnect or lakes fill their basins in years of greater than average precipitation (Bauder 1992; Scheidlinger 1981, 1984). Waterfowl utilize pools, especially the larger ponds or vernal lakes, and they are presumed to carry seeds and invertebrate eggs from pool to pool (Zedler 1987; Proctor *et al.* 1967).

Germination requirements, particularly those of species found at higher elevations, protect them against germination at inopportune times, in particular during an uncommon summer rain (Bauder 1992). *Limnanthes* species germinate only at cool temperatures, and the preferred temperature is correlated with

elevation (Bauder analysis of Toy and Willingham 1966). *Downingia concolor* ssp. *brevior*, a montane species (Cuyamaca Valley), and *Downingia cuspidata* populations from a higher inland valley (Ramona) germinate at cooler temperatures than many coastal pool species (Bauder 1992 and unpublished data 1995). Germination of *Orcuttia* species appears to occur after a period of anaerobic conditions in saturated or inundated soils followed by exposure (Griggs 1976; Griggs and Jain 1983). Fungal growth on the seed coats may also play a role (Griggs 1980). Other pool species germinate readily at a wide range of temperatures, as long as moisture is sufficient (Bauder unpublished data 1995).

Isoetes howellii exhibits Crassulean Acid Metabolism (CAM) when submerged, but ceases to do so if leaves are exposed (Keeley 1981; Keeley *et al.* 1983). The same is true for *Crassula aquatica* (Keeley and Morton 1982). *Pogogyne abramsii*, *Pogogyne nudiuscula*, *Psilocarphus brevissimus*, *Downingia cuspidata*, and *Downingia concolor* ssp. *brevior* display internodal elongation, adventitious roots and reduced branching when grown under water but are branched and shorter when never inundated (Bauder 1987a, and 1992; McMillan pers. comm. 1995). *Callitriche* spp. and *Marsilea vestita* not only elongate when submerged, but they are strongly heterophyllous; that is, they produce two kinds of leaves—one form on submerged stems and the other form on exposed stems (Jones 1955 a,b; Deschamp and Cooke 1982, 1984; Keeley 1990). Aerenchyma, tissue that promotes gas exchange, is prominent in the leaves of *Eryngium aristulatum* var. *parishii* (Sheikh 1978) and stems of both *Downingia cuspidata* and *Downingia concolor* ssp. *brevior*, even in the absence of inundation (Weiler 1962; Bauder 1992). *Isoetes howellii*, *Isoetes orcuttii*, and *Pilularia americana* require inundation for reproduction (Scagel *et al.* 1965)

POOL FAUNA

Vernal pool fauna have been less intensively studied than its flora, despite the diverse array of animals associated with the habitat. Birds, mammals, reptiles, and amphibians all utilize this unique community, but by far the greatest diversity is associated with invertebrate species. In a major study of 14 vernal pool sites in northern California and California's Central Valley (Simovich *et al.* 1992, 1993;

Simovich and King 1992), 67 species of crustaceans were identified as well as over 100 species of molluscs, annelids, insects, and other invertebrates.

Fairy Shrimp

The fairy shrimp (Order Anostraca) are among the most characteristic of the vernal pool invertebrates. Twenty-three described species have been documented in California, 10 of which are endemic to the State (Eng *et al.* 1990; Simovich and Fugate 1992; Fugate 1993). Samples taken in vernal pools in coastal San Diego County (Simovich and Fugate 1992) identified three species of fairy shrimp, two of which are endemic to southern California. The two endemics, the Riverside fairy shrimp and the San Diego fairy shrimp, are federally listed as endangered and are addressed in this plan. *Branchinecta lindahli* (versatile fairy shrimp), a habitat generalist, is common throughout western North America. Occurrences of the vernal pool fairy shrimp have been documented in the Skunk Hollow and Cruzan Mesa pools. The recovery of this federally listed threatened species will be addressed within the Central Valley Vernal Pool and Multi-Species Draft Recovery Plan.

Differences in species composition of the pools examined corresponded with physical and chemical attributes of the habitat, such as water depth, concentration of solutes, elevation, and biogeographic region (King *et al.* 1996; Simovich *et al.* 1992, 1993; Simovich and King 1992). More recent work by Gonzalez *et al.* (1996), looking at the osmotic regulation of four southern California species of shrimp, has indicated that shrimp have different ways of adjusting to various levels of salts and alkalinity. The San Diego fairy shrimp and the Riverside fairy shrimp are “osmoregulators” that maintain constant internal chemical concentrations, but cannot tolerate wide extremes in sodium or bicarbonate concentrations. Zedler *et al.* (1979) and Ebert and Balko (1987) found that the number of invertebrate species per pool was greater in the larger and deeper pools. They also found that there were fewer species in pools having variable water depth, which dried a number of times during the season. King *et al.* (1996) likewise found that the number of species in northern California pools was greatest in the larger, deeper pools. Dehoney and LaVigne (1984) examined the macroinvertebrate fauna on Otay Mesa in southern San Diego County and found

that species' presence or absence was closely tied to the hydrological regime of the pools.

When water begins to pond after the commencement of the rainy season, shrimp begin to hatch from encysted embryos (frequently referred to as eggs). With hydration of eggs, time to hatching is usually between two and 25 days, depending on species (Hathaway and Simovich 1996). Hatching responses correspond well with what is known of the germination of vernal pool plant species (Bauder 1992 and unpublished data 1995). Shrimp eggs tend to hatch or germinate at cool temperatures, with species-specific differences in responses that are related to temperature regime. Lack of hatching at higher temperatures (greater than 25 degrees Celsius; 77 degrees Fahrenheit) protects *Streptocephalus woottoni* and *Branchinecta sandiegonensis* from the infrequent summer storms that might otherwise be sufficient to stimulate development, but inadequate for the organisms to complete their life cycles. Also, only a portion of the dormant egg bank, often less than 10 percent, hatches with any one hydration (Hathaway and Simovich 1996). Subsequent hydrations may result in a cumulative total of only 30 to 40 percent hatching. Large cyst banks of viable resting eggs in the soil of vernal pools containing populations of fairy shrimps have been well documented by Belk (1998) and Simovich and Hathaway (1997).

Maturation to reproductive age from hatching is approximately 2 weeks for *Branchinecta sandiegonensis* but over 2 months for *Streptocephalus woottoni*. The time period is compressed or expanded, depending on ambient water temperatures (Hathaway and Simovich 1996). The combined greater length of time from hydration to hatching and hatching to maturity, results in a longer time for *Streptocephalus* to complete its life cycle compared to *Branchinecta*. As a consequence, in pools where they co-occur, *Branchinecta* reach adulthood when *Streptocephalus* are still in the larval stage.

The young shrimp swim upside down in the pools as they filter feed on algae and zooplankton with their 11 pairs of leaf-like legs. The shrimp are translucent, and as they mature to reproductive age, the females develop prominent ovisacs while the males' second antennae become modified for clasping the female during mating. The development of shelled eggs in the females' ovisacs is evidence of

fertilization. Females lay 100 to 300 eggs or more, with differences in mean number among species (Hathaway and Simovich 1996). When laid, eggs fall to the soil surface (mud) where they develop to the gastrula (early embryo) stage, then become dormant, entering a state of diapause encysted in their shells. They remain dormant until the next wet season.

Fairy shrimp play an important role in the community ecology of many ephemeral water bodies. They are fed upon by waterfowl (Krapu 1974; Swanson *et al.* 1974) and other vertebrates, such as western spadefoot toad tadpoles (*Scaphiopus hammondi*) (Simovich *et al.* 1991).

Insects

Both aquatic and terrestrial insects are associated with vernal pool habitats, serving as herbivores and predators. But perhaps the most obvious role is that of the pollinator. *Pogogyne abramsii* and *Pogogyne nudiuscula* are insect-pollinated, and in areas surrounded by development and disturbance, the introduced honey bee (*Apis mellifera*) is a common pollinator (Mills n.d.). A large suite of native pollinators frequent southern California pools, including bees of the families Halictidae and Megachilidae, and flies of the family Syrphidae. In areas of lower disturbance, the honey bee can often be replaced by bee flies (Bombyliidae), flower flies (Syrphidae), or ground dwelling bees (Anthophoridae) (Ellis and Mills 1991; McMillan unpublished data 1995). The federally endangered Quino checkerspot butterfly (*Euphydryas editha quino*) is also known to occur in and around vernal pool habitat. The nectar and host plants are often common components of the surrounding vegetation.

Specificity in pollinators of vernal pool species has been well documented in the Central Valley of California (Thorp 1976, 1990; Leong 1994 M.S. thesis submitted 1993). While few empirical studies exist for southern California vernal pools, similar plant-insect specialization is likely and may be essential to successful reproduction of certain species.

Gene flow by pollen is often substantial among plant populations (Ellstrand 1992), and it is especially important when plant populations are rare, small, or

geographically isolated. Fragmentation of plant-pollinator systems has been shown to have detrimental effect on the visitation rates by pollinators, and subsequently, in seed set and genetic polymorphism (Jennersten 1988). Specialization in one or a few closely related vernal pool plant species as pollen sources is often exhibited by solitary bees (family Andrenidae), and the life cycles of these bees and their hosts are closely synchronized. Thorp (1976) showed a significant decline in seed production of *Blennosperma nanum* when its specialist pollinator *Andrena blennospermatis* was absent from its pollinator guild.

Conservation of a matrix of vegetation communities may be necessary to ensure the viability of certain vernal pool plant species. Pollen-mediated gene flow within *Limnanthes* plant populations is restricted because their specialist bees forage within a limited area of their host flowers (Thorp 1990), and adjacent upland habitat is used for nesting by species such as *Andrena*.

Amphibians

Five species of amphibians are expected to utilize vernal pools in southern California: the Pacific treefrog (*Hyla regilla*), western toad (*Bufo boreas*), (western) spadefoot toad (*Scaphiopus hammondi*), and the non-natives, bullfrog (*Rana catesbeiana*), and African clawed frog (*Xenopus laevis*). Treefrogs, western toads, and bullfrogs typically require long-standing or permanent water sources to successfully reproduce, although they will utilize vernal pools for breeding when available (Simovich *et al.* 1996). The short development time exhibited by the spadefoot toad enables them to utilize vernal and ephemeral pool habitat successfully.

Because spadefoot toads spend the majority of the year underground (Ruibal *et al.* 1969), timing of emergence from estivation (summer dormancy) is critical, and should occur when heavy rain and appropriate temperature conditions exist (Bragg 1961). Brattstrom and Bondello (1979) have documented the emergence of spadefoot toads when stimulated by the sounds emitted from motorcycles and off-road vehicles. The sound and vibrations associated with heavy rainfall are the cues spadefoot toads rely on, and not the amount of precipitation. The toads are likely to die if the weather conditions are not correct at the time of emergence.

Because spadefoot toads estivate in terrestrial habitat and burrowing sites have been documented several miles from an aquatic source (Ruibal *et al.* 1969), consideration should be given to conservation of surrounding habitats to assist in the conservation of this species. The effects of nonnative species on native fauna should also be addressed when managing vernal pool habitats. Immature and adult bullfrogs have been well documented to seriously adversely affect native invertebrate and amphibian populations, and have the capacity to completely deplete entire age groups (Simovich *et al.* 1996).

Reptiles

While not dependent on vernal pools, most of the snakes in the southern California area can utilize free water that is found in vernal pool habitat during the aquatic stage. Although not restricted to this habitat type, the two-striped garter snake (*Thamnophis hammondi*) is semi-aquatic and will specifically use vernal pools to feed on animals. These snakes are common in the vernal pools of the Santa Rosa Plateau and Otay Mesa.

Birds

Avian use of vernal pool habitat is typically understated. Vernal pools provide important habitat for resident and migratory birds, particularly waterfowl and shorebirds. Primary use of vernal pools coincides with pool inundation periods and migration. Birds are attracted to the pools, in part because the pools are shallow and provide an optimal feeding depth. However, birds are particularly attracted to the pools because they offer foraging habitat at a time of year when resources are limited (Silveira 1996). Proteins and calcium vital to the energetic needs of migration and reproduction are available through food sources such as invertebrates (Silveira 1996; Proctor *et al.* 1967) and protein rich plants found in and adjacent to vernal pools.

Vernal pool landscapes help link aquatic resources in the California portion of the Pacific Flyway, which is essential when considering the drastic reduction of wetlands due to agriculture and urbanization. While this habitat type is important

to avifauna, birds also contribute to the welfare of the vernal pool system, aiding in dispersal of crustacean cysts (Simovich *et al.* 1996) and plant seeds.

Mammals

While no mammals are restricted to vernal pool habitats, they are attracted to them as a source of food and water, and mammals may serve as agents of seed dispersal. Dalquest and Sheffer (1942) hypothesize the most important mammal in the vernal pool ecosystem is the pocket gopher (*Thomomys bottae*). These small rodents tunnel through the soil, potentially aiding in the formation of Mima mound topography (Cox 1984b).

POOL SPECIES ASSOCIATIONS AND CLASSIFICATION

The unique and discrete nature of vernal pools allow for the development of a classification scheme that will facilitate management and recovery goals of this plan. Aspects of this classification include the consideration of the geographical location of the pools, topographic position (mesa or valley or depression), regional precipitation, soil types, and local variation. Coastal pools are found almost exclusively on mesas, but sustain different species depending on soil series. Inland valleys and mesas contain soils of alluvial derivation (valleys) or volcanic origin (mesas) and have a less moderate temperature regime than coastal areas.

All of the endangered plant and animal species of southern California pools mentioned in this plan are restricted to this region, as are many other sensitive species. Within the region, the distributions of the listed species only partially overlap (Table 1), although the two *Pogogyne* species (*Pogogyne abramsii* and *Pogogyne nudiuscula*) are not believed to have ever co-occurred (McMillan, pers. comm. 1995). Differences in soil type are important correlates with plant species distributions (Bauder and McMillan pers. comm. 1996). For instance, *Pogogyne nudiuscula* occurs only on Stockpen soils, which are limited to Otay Mesa and *Pogogyne abramsii* is found only on Redding soils. The relation of vernal pool animals, invertebrates in particular, to the same variables appears to be similar (Simovich pers. comm. 1995; King *et al.* 1996). For instance, *Orcuttia californica* (Griggs 1980; Griggs and Jain 1983) and Riverside fairy

Table 1
Distribution of Vernal Pool Species in the Management Areas

SPECIES	GOLETA	TRANS-VERSE	LA BASIN/ ORANGE	RIVERSIDE	SAN DIEGO NORTH COASTAL MESAS	SAN DIEGO CENTRAL COASTAL MESAS	SAN DIEGO SOUTH COASTAL MESAS	SAN DIEGO INLAND VALLEY
<i>Eryngium aristulatum</i> var. <i>parishii</i>				SRP	MCB, CL	DM, KM, MM, MR, TR,	OM, PV	SM, RM
<i>Navarretia fossalis</i>		CM		HM,SRP SJR,SKH,	CL, MCB	MR, KM	OM	RM, SM
<i>Orcuttia californica</i>		CM, WH, CB		HM, SKH, SRP	CL	MR	OM	
<i>Pogogyne abramsii</i>						DM, KM, MM, MR, TR		
<i>Pogogyne nudiuscula</i>							OM	
Riverside fairy shrimp		CB	FT, SMD, RMV	TM, SKH, SRP	MCB , CL	MR	OM	
San Diego fairy shrimp			FP, RMV		MCB, CL	DM, KM, MM, MR, TR	OM, PV	RM

COMPLEXES OR ASSOCIATIONS

CB	Carlsberg	HM	Hemet	OM	Otay Mesa	SM	San Marcos
CL	Carlsbad	IV	Isla Vista	PV	Proctor Valley	SMT	San Mateo
CM	Cruzan Mesa	KM	Kearney Mesa	RM	Ramona	SMD	Saddleback Meadows
DM	Del Mar Mesa	MCB	Marine Caorps Base Camp Pendleton	RMV	Rancho Mission Viejo	SRP	Santa Rosa Plateau
FP	Fairview Park	MR	Marine Corps Air Station Miramar	SJR	San Jacinto River	TM	Temecula
FT	Foothill/Trabuco	MM	Miramesa	SKH	Skunk Hollow	TR	Tierrasanta
						WH	Woodland Hills

shrimp (Simovich pers. comm. 1995) may be closely tied to specific moisture requirements.

Data on plant and animal species distributions, soil types and climatic variables provide the basis for recognition of eight distinct Management Areas in southern California (Figure 9), which comprise locally variable vernal pool complexes covered by this plan (Table 1) (Appendix E). An additional Management Area, which encompasses vernal pools in the montane region, is not addressed by this plan but is addressed in the Conservation Agreement for the Preservation of Cuyamaca Lake Downingia, Parish's meadowfoam, and Cuyamaca larkspur (USFWS 1996a).

Within the various Management Areas, pools are not evenly distributed across the landscape. They may appear in clusters subdivided by canyons that dissect the coastal terraces or in basins or valleys separated by major topographical features such as river valleys, hills, or mountains. Overlain on the natural patchiness of the suitable habitat are the distributions of the individual species (Figure 2 through 8). These distributions may reflect a combination of narrow habitat requirements at the micro scale (hydrological regime or water quality, for instance), accidents of dispersal, and local extinctions and reinvasions. Maintenance of viable populations of the listed species and successful implementation of recovery actions is tied to recognition of the habitat differences within the southern California region.

Goleta Management Area

The vernal pools of the Goleta Management Area occur on the coastal terraces of Goleta and Isla Vista, along the narrow plain south of the Santa Ynez Mountains. Three vernal pool groups, one at More Mesa, and small complexes at Ellwood Mesa (9 pools) and Isla Vista (12 pools), occur in this area. Although, these pools are currently isolated and considered to be remnants of a larger historical vernal pool complex, they should be managed as one vernal pool complex. A single San Diego fairy shrimp has been reported from the Isla Vista complex (Figure 10a) (Appendix E), however, none of the other vernal pool species covered by this plan are known to occur in this management area. Although the single record of the

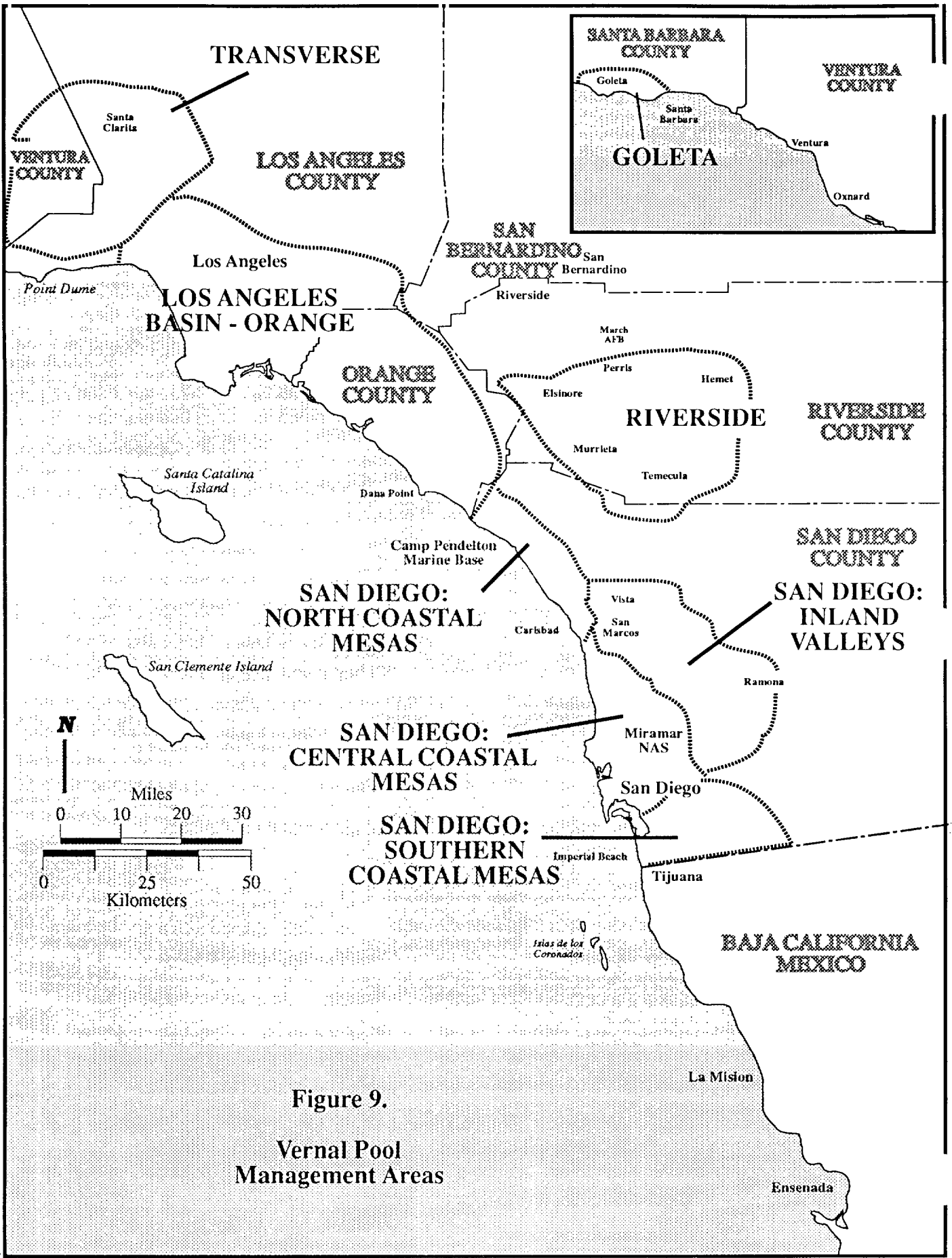


Figure 9.
Vernal Pool
Management Areas

Fred M. Roberts, Jr. August 1997

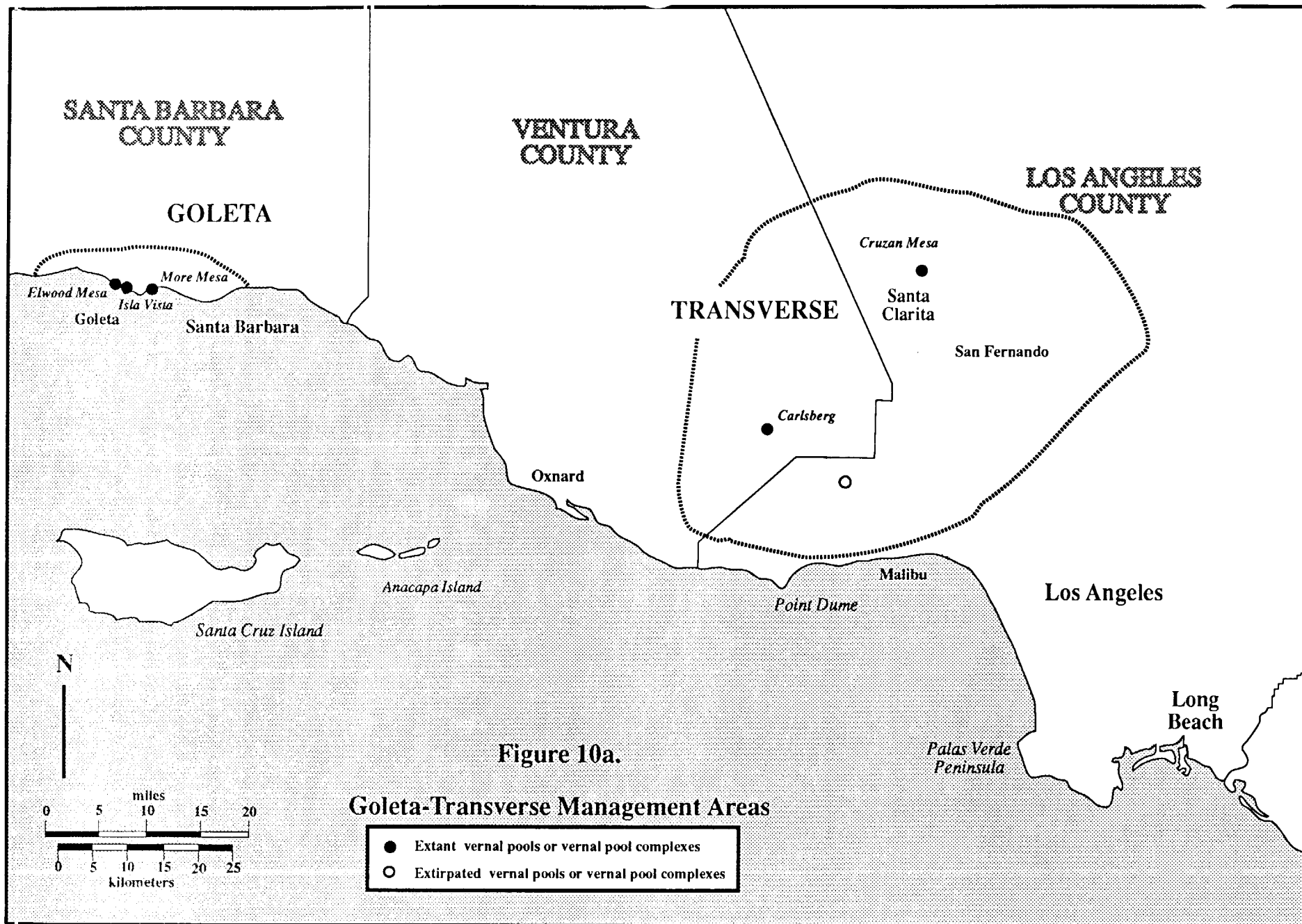


Figure 10a.
Goleta-Transverse Management Areas

- Extant vernal pools or vernal pool complexes
- Extirpated vernal pools or vernal pool complexes

San Diego fairy shrimp may not represent a self sustaining population, it can be interpreted as a colonization event and should not be disregarded as it may provide important information about the short-term viability of populations of fairy shrimp in the Isla Vista vernal pool complex.

Transverse Management Area

The Transverse Management Area is located in inland valleys and mesas north of the Los Angeles Basin in association with the Transverse Mountain Ranges. Two extant vernal pool sites occur within this Management Area: Cruzan Mesa (Los Angeles County) and the Carlsberg vernal pools in Moorpark, on the northern edge of the Santa Monica Mountains (Ventura County) (Figure 10a) (Appendix E). Information regarding these vernal pools is sparse due in part to the fact that these sites are currently under private ownership and difficult to survey. *Orcuttia californica*, *Navarretia fossalis* and vernal pool fairy shrimp can be found in both sites, but the status of these populations is unknown.

Los Angeles Basin-Orange Management Area

The Los Angeles Basin-Orange Management Area occurs within the coastal terraces, valleys, and foothills of the Los Angeles Basin in Los Angeles and Orange Counties, California. The majority of this area is significantly influenced by the marine climate. The full extent of the historic vernal pool distribution within this Management Area is not well understood, and the majority of the known vernal pool sites were extirpated prior to 1950. Of those pools that have survived, most tend to be relatively small complexes that have been poorly surveyed. Only three sites are currently known to be extant: Lomas de Santiago, Rancho Mission Viejo, and the Fairview vernal pools in Costa Mesa (Figure 10b) (Appendix E).

Two areas with vernal pool-like ephemeral ponds are included in this plan because of the presence of Riverside fairy shrimp (San Mateo ponds and the Saddleback Meadows sites). The majority of Orange County foothills (e.g., Saddleback Meadows ponds) are likely the result of landslide topography. Although depauperate in floral diversity, some ponds (i.e., Orange County

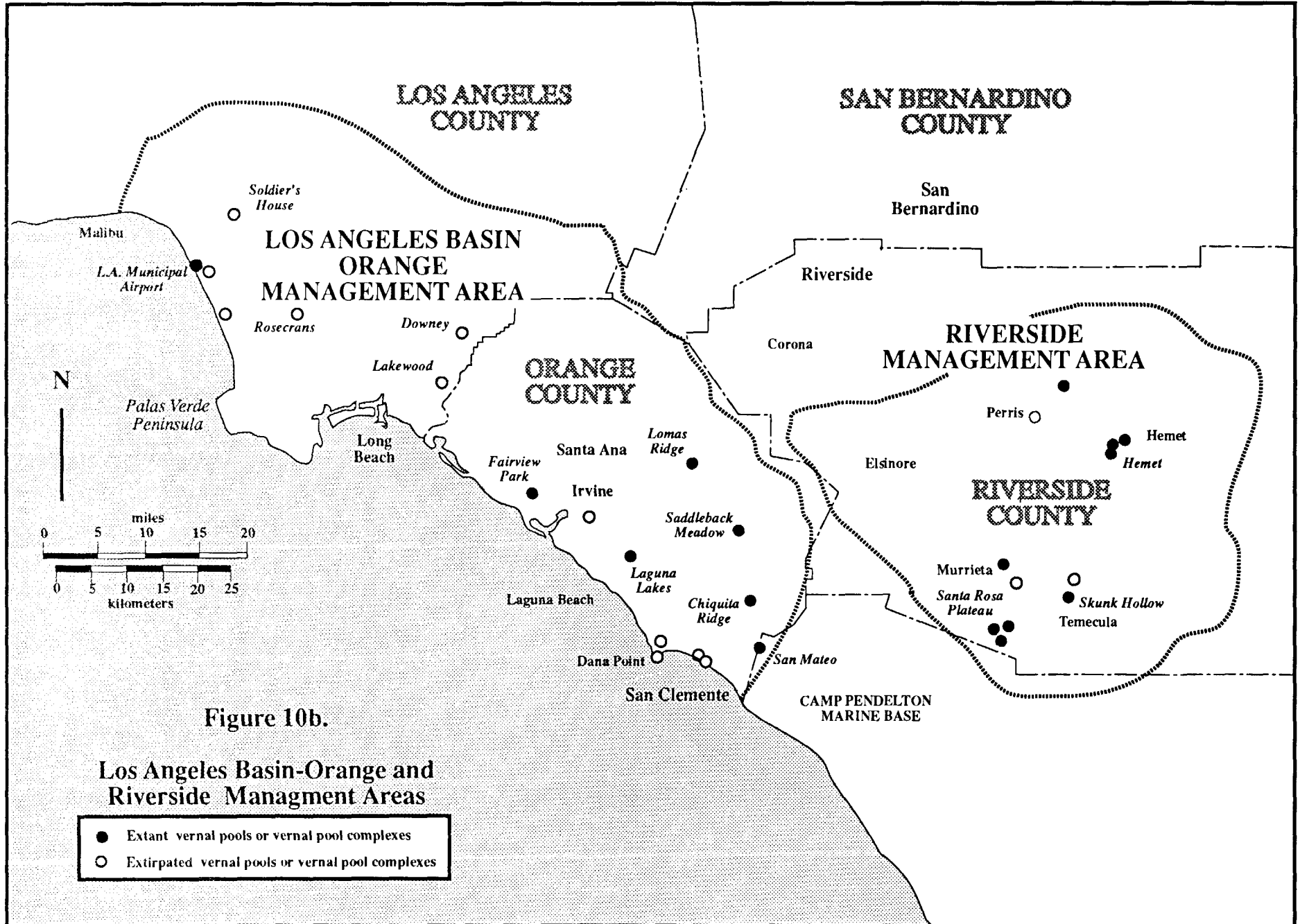


Figure 10b.

Los Angeles Basin-Orange and Riverside Management Areas

- Extant vernal pools or vernal pool complexes
- Extirpated vernal pools or vernal pool complexes

foothills) support the richest invertebrate diversity in Orange County. The lack of indicator plant species is likely a result of intensive grazing by cattle. The San Mateo ponds are a result of fault activity (sag ponds) along the Christianitos Fault.

Riverside Management Area

The vernal pools of Riverside County are found on inland mesas and valleys. The valley pools of this region frequently have a weak to strongly alkali component. Included within the Riverside Management Area are the vernal pools of the Santa Rosa Plateau, Hemet, Temecula, and Skunk Hollow, as well as a number of isolated pools in the vicinity of Murrieta (Figure 10b) (Appendix E). A limited number of vernal pools are also known from along the entire length of the San Jacinto River, from the California Department of Fish and Game San Jacinto Wildlife Area to the City of Perris. The vernal pool complexes found along the San Jacinto River corridor and the alkali playa habitats of this region, are known to support large populations of *Navarretia fossalis*. With the exception of the Santa Rosa Plateau and Skunk Hollow, most of these pools have been extirpated or greatly disturbed. In addition to representatives of the proposed and listed species, with the exception of the two *Pogogyne* species, other sensitive species that are known to occur in these complexes and include vernal pool fairy shrimp, little mousetail (*Myosurus minimus*) and Coulter's goldfields (*Lasthenia glabrata* ssp. *coulteri*).

San Diego: North Coastal Mesas Management Areas

The vernal pools within this Management Area are associated with coastal terraces north of the San Dieguito River within San Diego County. The vernal pool complexes at MCB Camp Pendleton and those within the City of Carlsbad represent this Management Area (Figure 10c) (Appendix E). *Eryngium aristulatum* var. *parishii*, *Navarretia fossalis*, *Orcuttia californica*, and both species of listed fairy shrimp occur in these complexes.

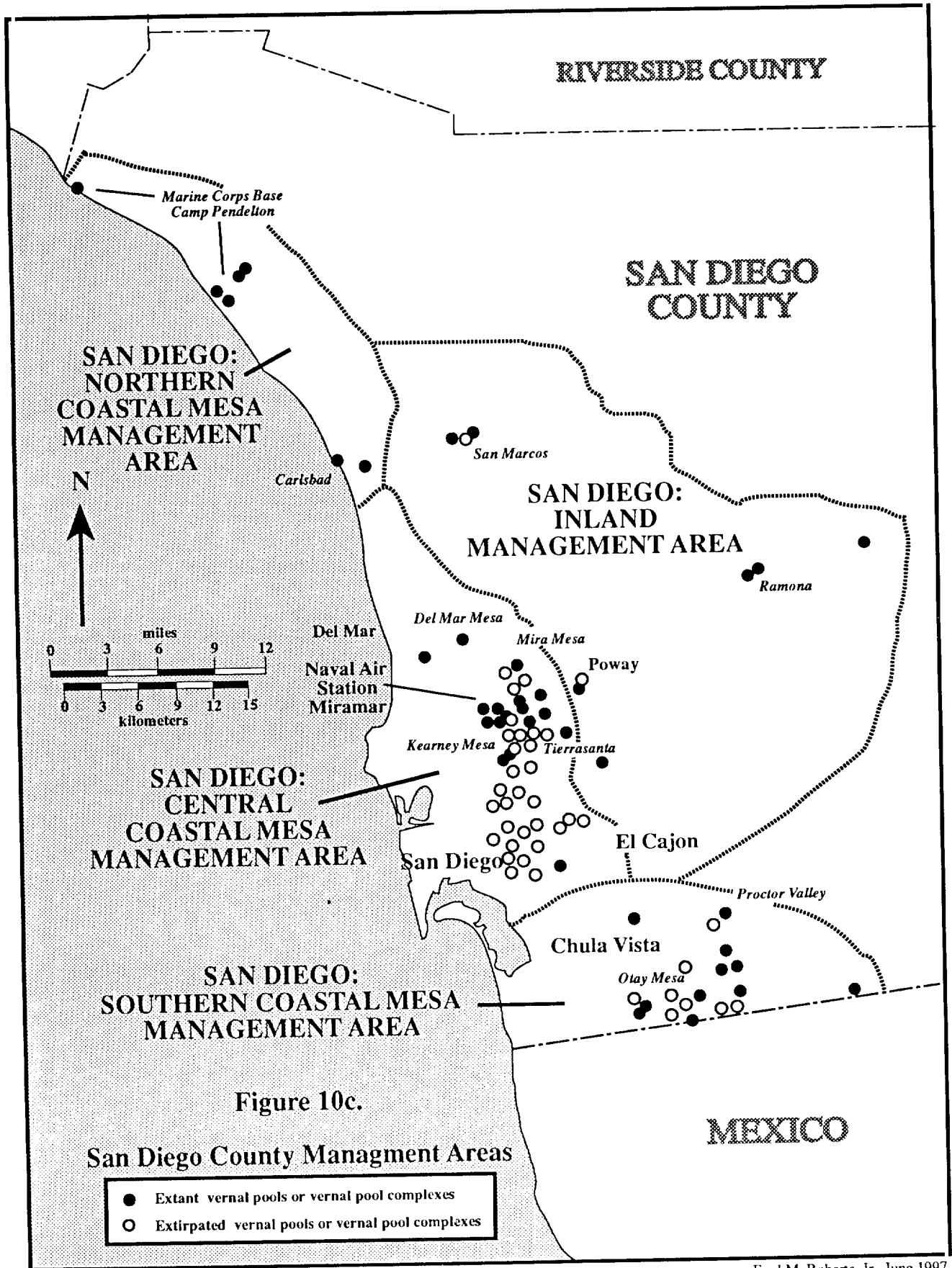


Figure 10c.

San Diego County Management Areas

Fred M. Roberts, Jr. June 1997

San Diego: Central Coastal Mesas Management Areas

The vernal pools within this Management Area are associated with the coastal terraces and mesas of central San Diego County from the San Dieguito River south to San Diego Bay and north of the Sweetwater River (Figure 10c) (Appendix E). This Management Area includes the vernal pools at Del Mar Mesa and Mira Mesa, the Kearny Mesa vernal pool complexes (MCAS Miramar, Tierrasanta, Montgomery Field), and the San Diego Mesa complex (Cholla Heights). Very little remains of the vernal pools along the mesas north and south of the San Diego River Valley. Although the majority of the complexes in the central coastal area still exist, many have been greatly reduced and fragmented as compared to their historical extent. All of the species addressed in this plan, with the exception of *Pogogyne nudiuscula*, occur in this management area.

San Diego: Southern Coastal Mesas Management Areas

The southern San Diego coastal mesa vernal pools include all isolated pools and complexes from the Sweetwater River south to the Mexican border. Included within this Management Area are the National City and Chula Vista pools (mostly extirpated), Border Field pools, Western and Eastern Otay Mesa complexes, Sweetwater Reservoir pools, and the vernal pools in the vicinity of Otay Lake (Figure 10c) (Appendix E). All of the species addressed in this plan, with the exception of *Pogogyne abramsii*, occur in this management area.

San Diego: Inland Valleys Management Areas

The San Diego Inland Valleys Management Area consists of pools situated in San Marcos, Escondido, Valley Center, Ramona, San Dieguito Valley, Poway, El Cajon Valley, Marron Valley, and Proctor Valley. The majority of these pools are isolated to a degree from extreme maritime influence by topography and occur more than nine kilometers (6 miles) from the coast (Figure 10c) (Appendix E). *Eryngium aristulatum* var. *parishii*, *Navarretia fossalis*, and the San Diego fairy shrimp occur in this management area.

HISTORIC AND CURRENT DISTRIBUTION OF THE HABITAT

With the exception of pine forest and chaparral, few of the vegetation communities associated with vernal pool habitat in California were ever widespread, and the majority have suffered nearly as serious declines in distribution as vernal pool habitats themselves (Jones and Stokes 1987; Oberbauer 1990). A report prepared at the request of the California Senate Committee on Natural Resources and Wildlife concluded that "vernal pools of all types, and the species that depend upon them, are among the most threatened of all the State's natural diversity" (Jones and Stokes 1987).

Unlike the Central Valley in California, southern California and Baja California, Mexico, never had expanses of pools stretching for hundreds of miles. In San Diego, vernal pool habitat probably covered no more than 6 percent of the county, approximately 520 square kilometers (200 square miles), prior to intensive cultivation and urbanization (Bauder and McMillan 1998). Currently, loss of vernal pool habitat in the County is estimated at 95 to 97 percent (Bauder 1986, Bauder and McMillan 1998; Oberbauer 1990; Oberbauer, pers. comm. 1996). Lack of historical data precludes the same depth of analysis for Los Angeles County, Riverside County, Orange County, or San Bernardino County, but losses are considered nearly total (USFWS 1993). The current distribution of pools in northern Baja California, Mexico probably comes much closer to the historic condition (Bauder and McMillan 1998).

Most of the remaining vernal pools in San Diego County occur on Redding soils, primarily on MCAS Miramar where approximately 31 square kilometers (19 square miles) of these soils are more or less undeveloped. Within this area, Global Positioning System (GPS) mapping reveals approximately 3,400 individual pools totaling 64 hectares (158 acres) of basin area (Luciani, pers. comm. 1997). Preliminary examination of soils maps indicates that vernal pools closely associated with *Pogogyne abramsii* (Redding series), in the southern half of its historic range, have been completely lost to urban development (Bauder and McMillan unpublished data 1996). Extensive losses of these soils from urban development within the northern half of the species' historic range have further

reduced its potential habitat. The majority of the range of this species is now contained within an 8-kilometer by 18-kilometer (5-mile by 11-mile) area.

The majority of pool habitat in the San Diego: Central Coastal Mesa Management Area, with the exception of MCAS Miramar, has been developed. The entire mesa, which once extended from downtown San Diego to La Mesa on the east, to Interstate 8 on the north, and to State Route 94 on the south, was developed prior to World War II, with the exception of several very small pool remnants in Balboa Park and at the U.S. Navy's former radio station at Chollas Heights.

Pogogyne nudiuscula appears to have occurred only on Stockpen and possibly Huerhuero and Olivenhain soils on the southern coastal mesas. These soils extended from Chula Vista and Imperial Beach on the coast of the Pacific Ocean, 16 kilometers (10 miles) to the east, to the foot of the San Ysidro Mountains. Over half of this area has been lost to urbanization, and the remaining half has either been converted to agricultural use or is in the process of being urbanized. Populations just across the international border in Baja California, Mexico, are part of the same mesa system and believed to have been extirpated some years ago. At present, this species occurs only in a 3-kilometer (2-mile) long arc of habitat less than 1-kilometer (0.6-mile) wide along the southern rim of the Otay River Valley and in one small population 3 to 4 miles away.

On much of the coastal terrace, habitat losses have resulted in a severe reduction of the geographic range of pools and the species found in them. These losses, coupled with fragmentation of the habitat, have accentuated the naturally patchy, discontinuous distribution patterns of most vernal pool species (Bauder 1986, 1993). Because areas within the Management Areas can differ in soil series and amount of precipitation and were historically subdivided by natural features, it is reasonable to assume that some species once present in an area may no longer be represented, and that within-species genetic diversity has been diminished. For example, herbarium specimens of *Pogogyne* species indicate that the populations with important morphological differences have already been extirpated (McMillan pers. comm. 1995). Maintenance of the extant pools, as well as restorable habitat, is essential to the preservation of the remaining diversity and the prevention of further losses.

Losses of pools in the inland valleys have been extensive as well. In fact, pools may have been completely extirpated from some valleys such as Escondido, El Cajon, and Poway. Those remaining in San Marcos, Proctor Valley, and Ramona are few in number, and with the exception of Proctor Valley, have been divided into small pieces by residential, commercial, and industrial development. In Riverside County, no comprehensive assessment can be made of the original extent of pools or the degree of loss, but they are thought to have been numerous, with only a few currently remaining today (Zedler *et al.* 1990; USFWS 1993).

REASONS FOR DECLINE AND CONTINUED THREATS TO THE SPECIES AND THE HABITAT

Prior to 1945, the primary threats to southern California vernal pools were grazing, water impoundments, and conversion to agriculture (Phillips 1960; Bauder 1994). In recent years, urbanization and construction of infrastructure have resulted in losses of habitat estimated to be as high as 97 percent (Oberbauer 1990; Bauder 1986 and unpublished data 1996).

Urban development remains the primary threat to the listed vernal pool species (Bauder 1987b). Some of the proposed projects include expansion of airports and landfills, construction of major roadways, utility infrastructure, resorts and recreational facilities, commercial and industrial properties, and residential housing tracts. Generally, these projects directly impact pools through elimination of the habitat. Where pools remain, dumping, trampling, vehicular activity, runoff, and intrusion of nonnative species are continued threats. Hydrological changes and erosion can cause profound changes in the pool flora (Bauder 1987b, 1992). Even where pools are under protected ownership, vigilant and informed management programs are necessary to prevent degradation of the habitat. Trenching for utilities, on-going operations within easements and lease holdings, responses to emergencies such as fire or air crashes, fuel and chemical spills, and recreational activities can all cause serious damage to vernal pools, particularly during the aquatic or drying phases when soils are most vulnerable and the organisms are growing or reproducing. When disturbance is severe, it can lead to local extirpations of pool species.

Fragmentation and isolation of habitat from the vegetative community in which it occurs, and interactions with other habitat types due to development, also adversely impact vernal pools. Alterations of the surrounding soils, vegetation, drainage patterns, and hydrology can have profound effects on vernal pool organisms by impacting the hydrological regime of the pools and the quality of water. Pools deprived of sufficient moisture are dominated by nonnative upland plants, most notably grassland annuals (Bauder 1987a,b). Presence of pool plants can be significantly diminished by the presence of nonnatives (Bauder 1988), and survivorship and reproduction can be reduced by competition from upland annuals (Bauder 1987a). Likewise, augmented runoff increases mortality of endemic pool species and favors freshwater marsh plants (Bauder 1987b).

Habitat fragmentation also increases the “edge effects.” The distribution of pollinators can change in response to habitat fragmentation (Leong M.S. thesis submitted 1993), and they may be affected by landscape plants in the vicinity. Fragmentation can lead to the elimination of predators, which could lead to population increases of herbivores such as burrowing rodents, rabbits, and quail. Population genetics may also be adversely affected. Watershed contiguity augments gene flow in populations already naturally low in variability (Davies 1996; Proctor *et al.* 1967) by allowing flooding between pools. Vernal pool organisms are typically defined by the complex in which they occur, in part because gene flow between complexes appears to be extremely low (Fugate 1993; Davies 1996). Isolation of pools or modification of the watershed potentially compromises gene flow, resulting in a loss of genetic variability and an increased susceptibility to extinction and reduced fitness (Soule 1986).

Pool fauna can be adversely affected by water pollution (Simovich pers. comm. 1995). Preliminary studies suggest that the eggs of these species are easily crushed by such actions as trampling by human feet or being run over by vehicles (Hathaway *et al.* 1996). The degree of disturbance of competitive or predator/prey interactions of the aquatic fauna is unknown, although nonnative species such as the bullfrog prey heavily on spadefoot toads and fairy shrimp (Morey 1996; Simovich *et al.* 1996). The indigenous flora on which some of the pool species depend can be replaced as a result of the introduction of exotic plants.

Risk of catastrophic loss is substantial for all the regionally restricted vernal pool species, even the numerically abundant ones, because of the combination of their habitat specificity, the spatial distribution of appropriate habitat, and habitat reduction. For example, the area containing the known distribution of the endangered species *Pogogyne nudiuscula* is about three square kilometers (one square mile) (see above). Although their relative distribution is more widespread, *Orcuttia californica* and Riverside fairy shrimp each are known from only a few populations. Therefore, vernal pool species are exceptionally vulnerable to disturbances, accidental or otherwise. Individuals of any given species, however abundant, are in no way independent of each other. A substantial portion of the range or number of the individuals of one or more species could be lost through one incident alone.

CONSERVATION AND PROTECTION MEASURES

A wide variety of conservation measures have been or are being used to protect the vernal pool habitat, with varying degrees of success. The Department of Defense, the City of San Diego, the City of Chula Vista, and the County of San Diego have jurisdiction over the largest number of pools remaining in southern California.

Natural Community Conservation Planning

In 1991, California enacted the Natural Community Conservation Planning Act (NCCP) to address regional conservation needs throughout the State. The initial focus is on the coastal sage scrub community of southern California. Although vernal pool species are not primarily associated with coastal sage scrub, they are considered under the subregional Multiple Species Conservation Planning Program (MSCP) and the Multiple Habitat Conservation Planning Program (MHCP) (Figure 11). These programs, initiated by the City of San Diego, County of San Diego, private interests, and coastal cities in northern San Diego County, are being integrated as a component of the NCCP Program and will extend protection to many natural communities, including vernal pools.

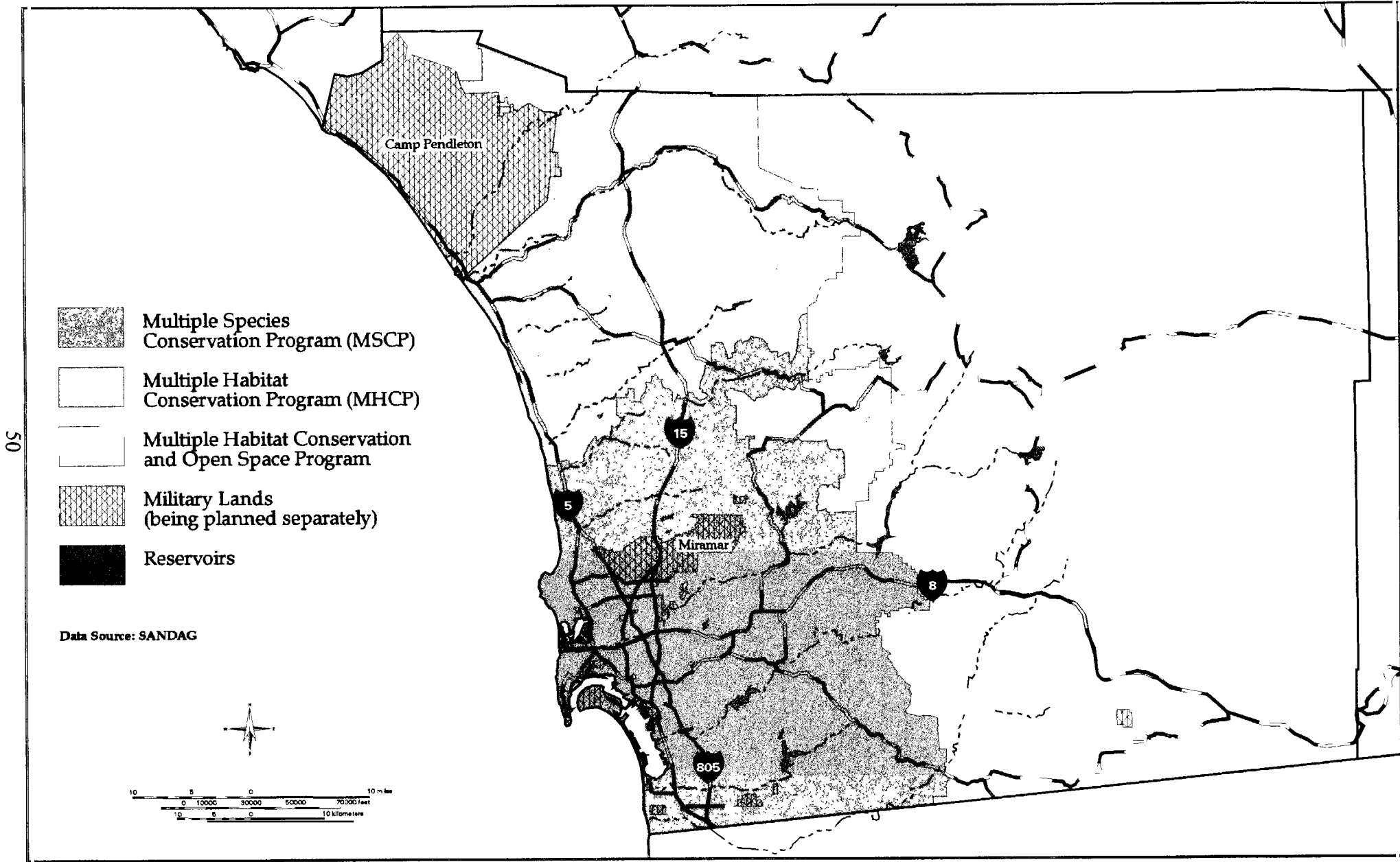


Figure 11. Conservation Programs in San Diego County

The U.S. Fish and Wildlife Service and California Department of Fish and Game approved the MSCP (a framework plan) and the City of San Diego subarea plan (a subcomponent of the subregional plan) in July 1997. Other jurisdictions are expected to complete their subarea planning processes in the future. The MSCP encompasses approximately 235,627 hectares (582,000 acres) of southwestern San Diego County, and involves multiple jurisdictions. The MHCP encompasses roughly 48,118 hectares (118,852 acres) in northwestern San Diego County, and involves seven jurisdictions. This plan is in the predraft phase and has not yet identified areas of protection (Figure 11).

When fully implemented, the subregional MSCP and its component subarea plans will permanently conserve approximately 69,602 hectares (171,917 acres) within the preserve planning area, of which 21,094 hectares (52,102 acres) is under the jurisdiction of the City of San Diego (Ogden 1996). Within the preserve planning area, there are 1,317 hectares (3,254 acres) of vernal pool habitat, including 838 hectares (2,071 acres) on military lands and 479 hectares (1,183 acres) on other public or private lands. Of the 479 hectares (1,183 acres) of vernal pool habitat occurring on nonmilitary lands, approximately 344 hectares (850 acres) (88 percent) are targeted for conservation, although the exact configuration of preservation has not yet been determined.

All subarea plans within the MSCP will require conservation of vernal pool habitat to ensure no net loss of acreage and habitat functions and values, and will require avoidance of impacts to vernal pools to the maximum extent practicable both inside and outside the preserve planning area. Impacts that cannot be avoided should be minimized and mitigated. Vernal pools and their constituent species will continue to be subject to Section 404 of the Clean Water Act, Section 7 of the Endangered Species Act, and California Fish and Game Code 1600 et seq.

In addition to conserving existing vernal pool habitat, the proposed preserve is expected to conserve 3,135 hectares (7,745 acres) (28 percent) of clay soils and 1,108 hectares (2,736 acres) (27 percent) of loams with a clay hardpan that currently remain undeveloped in the Multiple Species Conservation Planning area. This acreage may include areas that have been disturbed, including areas currently in agriculture. Vernal pools within the preserve planning area will be conserved

within areas of connected habitat representing a full range of vegetation communities that will better allow for the continuation of natural processes. Management and monitoring of vernal pools within the preserve planning area will add to the current level of protection for many complexes.

For *Eryngium aristulatum* var. *parishii*, 70 percent of the total point localities occur within the preserve planning area of the MSCP. Sixty percent of the point localities for *Navarretia fossalis* are concentrated in three populations. Approximately 63 percent of one of these populations is included in the preserve planning area. One major population of *Orcuttia californica* occurs within the MSCP Planning area, of which 86 percent is included within the preserve planning area. *Pogogyne abramsii* is entirely endemic to the MSCP Planning area, but the major population for this species occurs on MCAS Miramar, which is outside of the preserve planning area. MCAS Miramar is preparing an Integrated Natural Resources Management Plan which will be coordinated with the U.S. Fish and Wildlife Service (Biological Opinion, 1-6-95-F-33), and California Department of Fish and Game in accordance with the Sikes Act. *Pogogyne nudiuscula* is entirely endemic to the MSCP Planning area. Baja California populations previously identified as *Pogogyne nudiuscula*, are now known to be a different species (McMillan, unpublished data 1995). Within the MSCP Planning area, 91 percent of the point localities occur within the preserve planning area. This species is only known to be found on Stockpen soils on Otay Mesa. The establishment of the preserve will conserve 24 percent of the remaining 18 percent of these soils, or 4 percent of what was historically present.

Vernal Pool Stewardship Project of the
San Diego National Wildlife Refuge

To complement the MSCP and assist in the recovery of vernal pool species, the U.S. Fish and Wildlife Service approved the Vernal Pools Stewardship Project in April 1997. This project will allow the U.S. Fish and Wildlife Service to establish the Vernal Pools Unit of the San Diego National Wildlife Refuge (USFWS 1997). The purpose of this refuge is to provide for the long-term conservation of vernal pool habitats and their associated flora and fauna in the San Diego region. The refuge will allow for the U.S. Fish and Wildlife Service's acquisition and

management of vernal pool habitat. A part of the stewardship project, but not included in the Refuge, the Department of the Navy is committed to continuing conservation of vernal pool resources at MCAS Miramar under existing authorities and through the development of a cooperative agreement with the U.S. Fish and Wildlife Service and California Department of Fish and Game under the Sikes Act. The Stewardship Project is located within the City and County of San Diego, primarily on Otay Mesa, sites near the Otay and Sweetwater Reservoirs, in central San Diego County on Del Mar Mesa, Lopez Ridge, MCAS Miramar and adjacent lands, and Montgomery Field Airport (Figures 12a, b, c). The areas included in the Stewardship Project comprise approximately 3,329 hectares (8,223 acres) and contain approximately 924 hectares (2,282 acres) of the remaining vernal pool habitat in San Diego County. The boundary of the Stewardship Project was approved April 1997.

Marine Corps Air Station Miramar

Department of Defense policy dictates that military lands cannot be set aside as permanent environmental preserves, nor can military lands be used for the mitigation of impacts of actions occurring off the installation that affect the environment. However, military installations are encouraged to prepare integrated natural resources management plans in cooperation with the Service and California Department of Fish and Game in accordance with the Sikes Act. At MCAS Miramar, the Department of the Navy has developed and begun implementing a vernal pool management plan (Bauder and Wier 1991). The Marine Corps has recently committed to do cooperative planning for vernal pools at MCAS Miramar, under the Defense Base Realignment and Closure Act of 1993 (Dept. of the Navy 1996). Vernal pools identified for restoration and preservation are included in specific vernal pool management zones and are identified in the MCAS Miramar Integrated Natural Resources Management Plan that is currently under development.

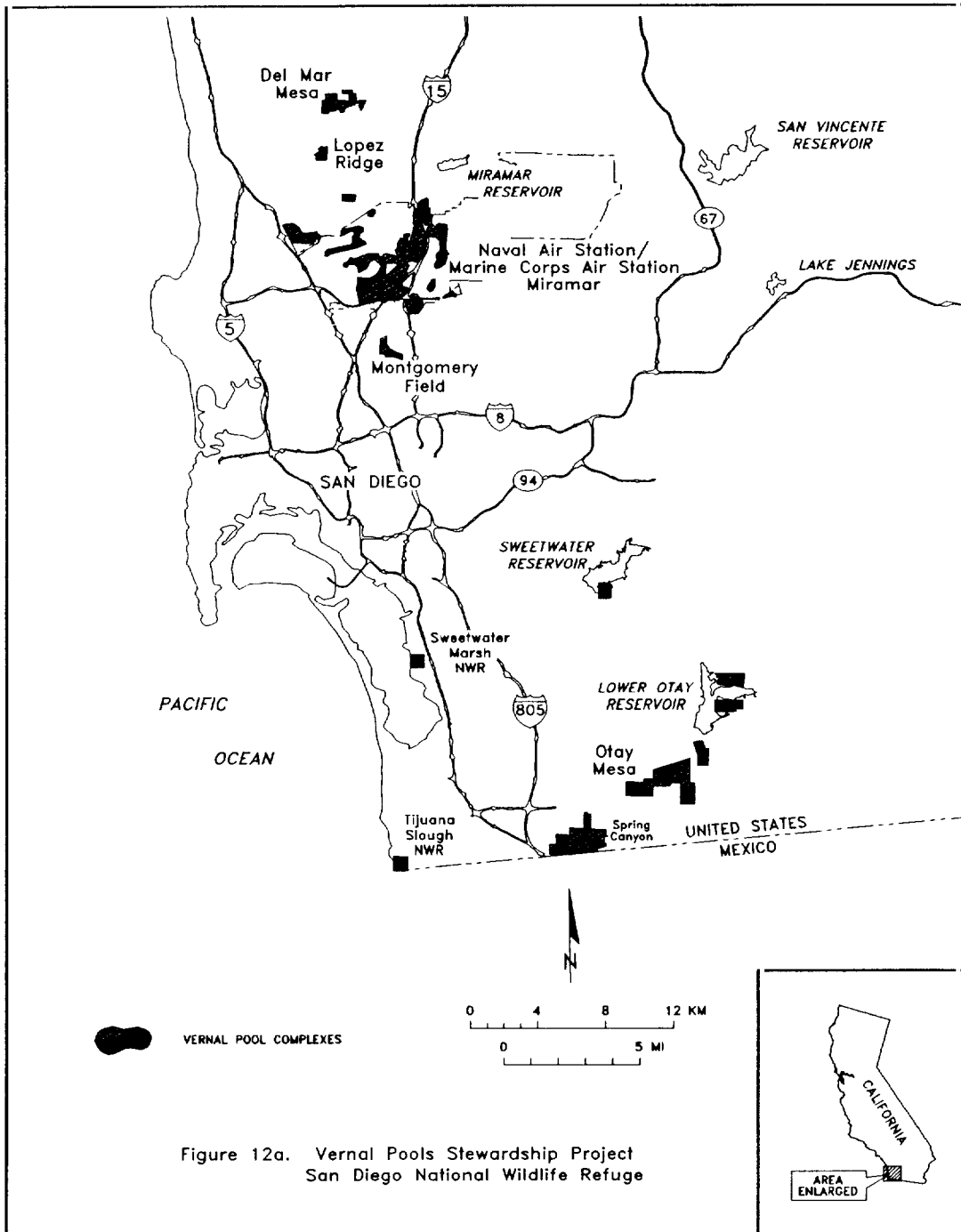


Figure 12a. Vernal Pools Stewardship Project
San Diego National Wildlife Refuge

USFWS April 1997

Vernal Pools Stewardship Project North Area

San Diego National Wildlife Refuge

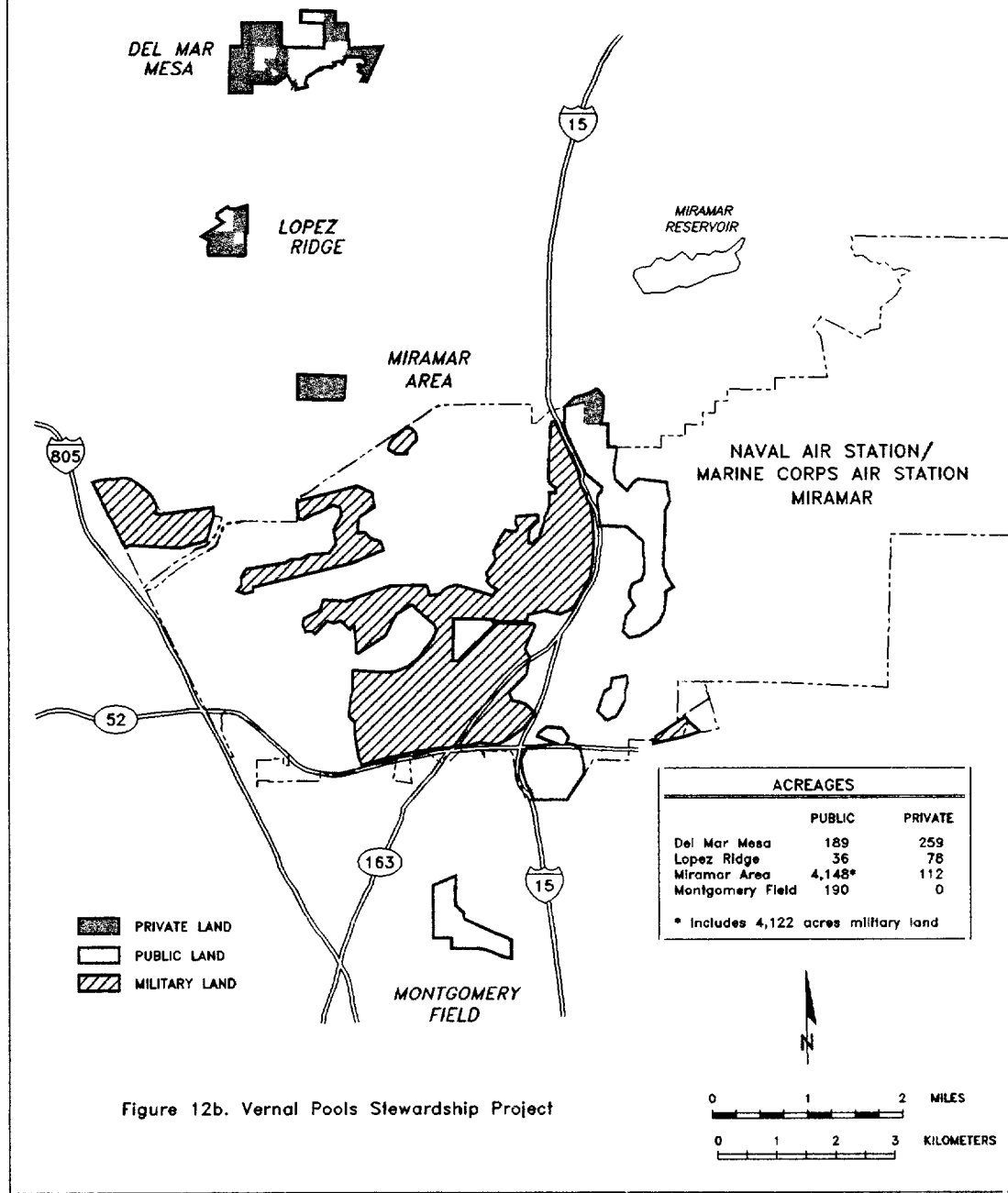


Figure 12b. Vernal Pools Stewardship Project

USFWS April 1997

Vernal Pools Stewardship Area South Area San Diego National Wildlife Refuge

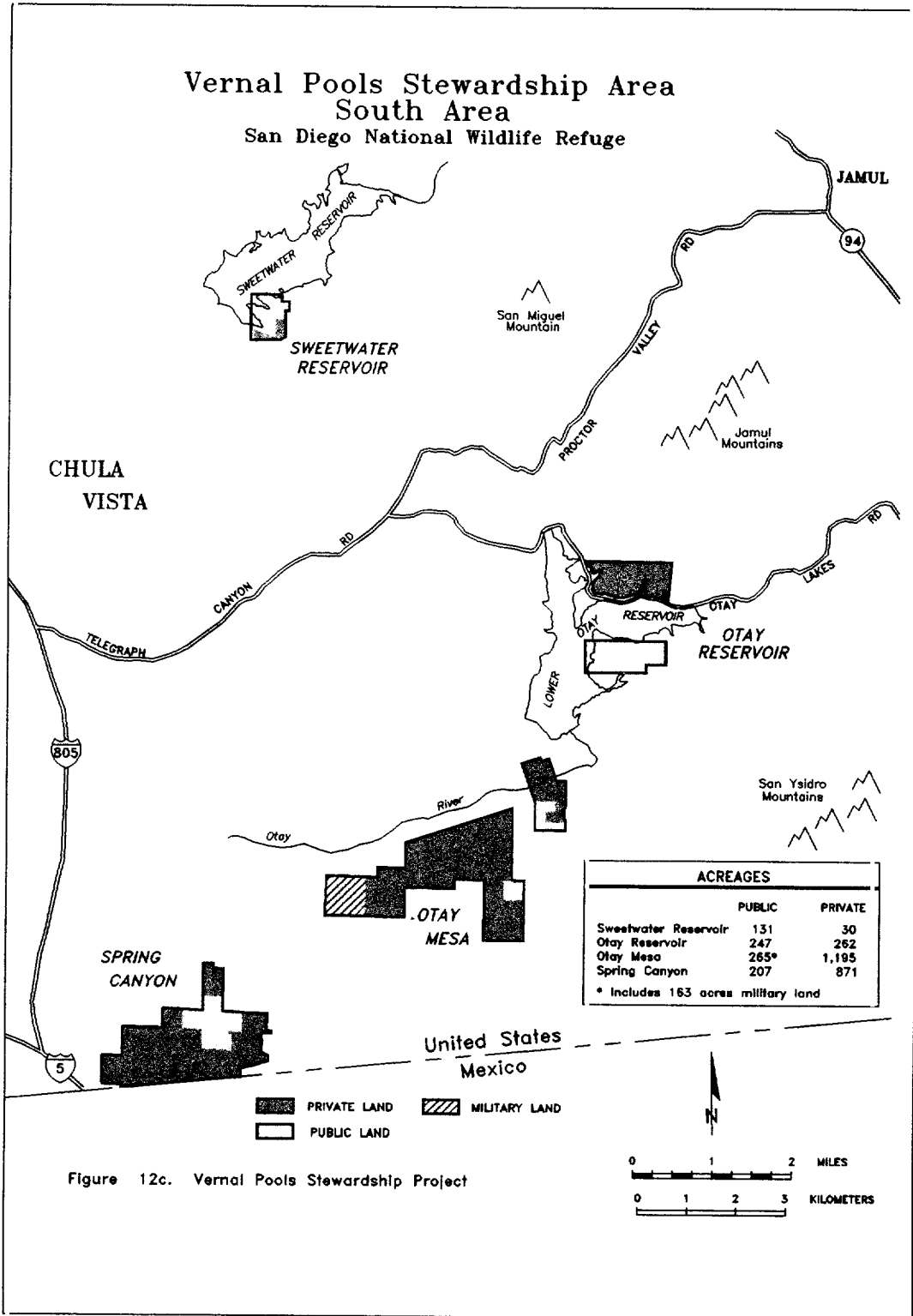


Figure 12c. Vernal Pools Stewardship Project

USFWS April 1987

Marine Corps Base Camp Pendleton

Department of Defense policy dictates that military lands cannot be set aside as permanent environmental preserves, nor can military lands be used for the mitigation of impacts of actions occurring off the installation that affect the environment. However, military installations are encouraged to prepare integrated natural resources management plans in cooperation with the Service and California Department of Fish and Game in accordance with the Sikes Act. MCB Camp Pendleton supports ecosystem and cooperative management, and is currently developing a management plan for the vernal pools at the installation (Jacobsen, pers. comm. 1997). MCB Pendleton is currently proposing to protect approximately one-third of the remaining vernal pools known to occur on the base. Additionally, MCB Camp Pendleton plans to formally consult with the U.S. Fish and Wildlife Service on the base's uplands ecosystem, including vernal pool resources, surveys for which are currently being conducted.

Other Agencies, Municipalities, and Jurisdictions

Section 404 of the Clean Water Act, as regulated by the U.S. Army Corps of Engineers, requires notification for any discharge of dredged or fill material, excavation, or mechanized land clearing in any vernal pool, and requires an individual permit for discharges affecting 0.2 hectares (0.5 acre) or more of vernal pool basin. These regional conditions may lead to additional mitigation needs for vernal pool impacts.

In 1980, the City of San Diego developed a Vernal Pool Preservation Plan designed to accumulate funds to purchase vernal pools as mitigation for losses due to development, but the program had very limited success and is no longer in operation (Bauder 1986). The City of San Diego's "Guidelines for Mima Mound Vernal Pool Habitat" became effective August 2, 1993. These guidelines clarify and supplement the Resource Protection Ordinance of 1992. Upon approval, the draft Environmentally Sensitive Lands Regulations (City of San Diego 1996a) will replace the Resource Protection Ordinance.

Currently, a Vernal Pool Management Plan (City of San Diego 1996b) makes recommendations for management practices and strategies for a few of the sites that support vernal pools for which the City of San Diego is responsible. A non-profit group devoted to science education in the local schools is working on a program that will utilize one of these parcels, which is adjacent to Challenger Junior High School (K. Wild, pers. comm. 1995).

The County of San Diego has a vernal pool zone designator that may be applied to vernal pool areas (County of San Diego 1991). This vernal pool zone designator was only ever intended to be implemented in the Otay Mesa pool complexes. In addition, the County's current, updated Resource Protection Ordinance offers some protection for this habitat (County of San Diego 1991). The County also owns a small amount of vernal pool habitat in Ramona and on Otay Mesa.

The California Department of Transportation owns a number of pools on Del Mar Mesa at the northernmost edge of the central coastal mesas. This property was purchased as mitigation for loss of pools to construction of State Route 52 and Interstate 15.

Nonprofit Entities

Several nonprofit entities own or manage vernal pool habitat. These entities include The Nature Conservancy (Santa Rosa Plateau) and The Environmental Trust (Ramona and Otay Mesa).

RECOVERY STRATEGY

The strategy for recovery of southern California vernal pool species focuses primarily on eliminating and reducing the primary existing threats to their habitats. Specifically, these threats are, habitat destruction and modification, alteration of wetland hydrology, off-road vehicle activity, cattle grazing, and competition from nonnative species. Existing regulatory mechanisms, historically, have not provided adequate protection and management for vernal pool habitat. Consequently the efforts to recover vernal pool species will be twofold: stabilization of the populations through procurement and management of

habitat, and reclassification of the species through restoration and enhancement, which includes recolonization and expansion of existing populations. Integrated into this strategy is the need to protect additional lands to prevent further loss of habitat, to develop and implement management plans to prevent degradation of habitat from severe episodic or on-going disturbance, to restore and enhance habitat, and to reestablish populations where habitat and historical conditions are appropriate.

Protecting habitat from further loss may be achieved through a variety of mechanisms from conservation easements to the purchase of land. Where destruction or adverse modification of habitat is of issue, specific strategies to protect vernal pools could include fencing of livestock where grazing occurs or implementing rotation grazing regimes. Pools affected by vehicular activity, whether recreational off-road or service-related, such as border interdiction or fire-suppression activities, would benefit from either strict prohibition or the development of and adherence to an established protocol when in the vicinity of vernal pool habitat. Ensuring watershed and upland habitat contiguity when designing and managing preserves will provide multiple benefits, from protecting pools from erosion and run-off to promoting genetic vigor. Limiting use of pesticides and herbicides in the vicinity of vernal pool habitat, providing informational programs and public outreach, and eradicating nonnative, competitive species such as bullfrogs and invasive plants are but a few examples of strategies that will minimize the immediate threats to the vernal pool ecosystem and aid in the eventual recovery of those species that are dependent on it.

Critical to the recovery of vernal pool species is the restoration and enhancement of habitat. When considering the potential for expansion and recolonization of pool species, site selection will be dependent on land use considerations, including the willingness of landowners to participate, as well as historical and ecological feasibility.

II. RECOVERY

OBJECTIVE

The goal of this plan is conserve and enhance southern California vernal pool ecosystems, with specific emphasis on stabilizing and protecting existing populations of *Eryngium aristulatum* var. *parishii*, *Pogogyne abramsii*, *Pogogyne nudiuscula*, *Orcuttia californica*, and San Diego and Riverside fairy shrimp so that these species may be reclassified from endangered to threatened status. The goal of this plan for *Navarretia fossalis*, currently proposed for listing as threatened, is to ensure the long-term conservation of this species.

Although protection and management of existing populations will reduce the threat of extinction, they do not eliminate it. Removal of these species from protection under the Endangered Species Act should only be considered when populations have secure habitat, populations are stabilized or increasing (and where necessary, new populations are established), and populations are shown to be self-sustaining.

PRINCIPLES FOLLOWED IN DEVELOPING RECOVERY CRITERIA

The following points form a strategy for the recovery of vernal pool species and their habitats, and provide a basis from which preserve design should be determined:

- Pools are not independent of each other or the vernal pool complex, which includes the watershed. Maintenance of the fullest possible range of biological interactions within and among pools is important to ecosystem function and long-term viability of populations of pool-associated species.
- Although vernal pools in southern California can be differentiated according to distinct geographic Management Areas, preservation of pools must be on a geographical scale for both individual species and the landscape they reside in. Representation of the vernal pools and their associated watersheds within each Management Area is important to the

successful conservation of a full array of vernal pools and their constituent species. Preservation efforts cannot be exclusive of the physical attributes that characterize various complexes and associations (e.g., pool soils and topography), because the habitats that contain vernal pools can be as rare as the individual species associated with them.

- The variation associated with individual pools is great. Although larger pools typically contain more species than smaller pools, the size of the pool or complex should not be the only consideration when ranking preservation factors. Reserve design and size will affect the number and quality of biological interactions and the types and frequency of disturbance. In general, conservation of large sites with habitat heterogeneity (soils, topography, vegetation types) that are located adjacent to lands with compatible uses are preferable to smaller ones with irregular boundaries, habitat uniformity, or proximity to land uses that increase the probability of human disturbance.
- No estimates are currently available as to the effective population size necessary to maintain self-sustaining populations of vernal pool species. However, the extreme rarity and restricted geographic ranges of these species support the need to preserve the maximum amount of remaining existing populations and habitat. This criterion will ensure the maintenance of the broadest array of species, reduce the risk of losing individual species or pool types, retain local genetic differentiation, buffer environmental variation, and provide the opportunity for re-establishment of new populations. To ensure a high probability of survival into the future, prioritization should consider the population ecology (e.g., reproductive rates and strategies, genetic diversity, dispersal mechanisms, density, distribution) of each species.
- Studies of southern California vernal pools suggest that perched water tables associated with a particular pool are very localized. Maintenance of hydrological regimes requires careful site-specific studies.

- Long-term protection of vernal pool habitats and the species dependent on them is enhanced by providing information to the general public, as well as people who work in, or adjacent to, the habitat.

RECOVERY CRITERIA

The following conditions must be met to stabilize the current status of *Navarretia fossalis*, *Eryngium aristulatum* var. *parishii*, *Pogogyne abramsii*, *Pogogyne nudiuscula*, *Orcuttia californica*, and San Diego and Riverside fairy shrimp:

1. In order to maintain genetic diversity and population stability of the listed species and other sensitive species:
 - Existing vernal pools currently occupied by *Orcuttia californica*, *Pogogyne nudiuscula*, and Riverside fairy shrimp and their associated watersheds should be secured from further loss and degradation in a configuration that maintains habitat function and species viability;
 - Existing vernal pools and their associated watersheds within the Transverse and Los Angeles Basin-Orange Management Areas should be secured from further loss and degradation in a configuration that maintains habitat function and species viability;
 - Existing vernal pools and their associated watersheds within the San Marcos vernal pool complexes that contain *Navarretia fossalis*, *Eryngium aristulatum* var. *parishii*, or any other vernal pool species, should be secured from further loss and degradation. Habitat functions and species viability for any of the remaining vernal pools and their associated watersheds within the San Marcos complexes must be ensured;
 - Existing vernal pools and their associated watersheds within the Ramona complexes that contain *Eryngium aristulatum* var. *parishii*, *Navarretia fossalis*, San Diego fairy shrimp, or any other vernal pool species, should be secured from further loss and degradation in a configuration that maintains habitat functions and species viability;

- Existing vernal pools and alkali playas, and their associated watersheds within the Hemet complexes, that contain San Diego fairy shrimp, *Navarretia fossalis* and *Orcuttia californica*, or any other vernal pool species, should be secured from further loss and degradation in a configuration that maintains habitat functions and species viability;
- Existing vernal pools and their associated watersheds located on Stockpen soils (Otay Mesa) should be secured from further loss and degradation in a configuration that maintains habitat functions and species viability, to provide for the recovery of species restricted to this soil type (i.e., *Pogogyne nudiuscula*); and
- Remaining vernal pools and their associated watersheds contained within the complexes identified in Appendix F must be secured in a configuration that maintains habitat function and species viability (as determined by prescribed research tasks).

Reclassification to threatened status may be considered for *Eryngium aristulatum* var. *parishii*, *Pogogyne abramsii*, *Pogogyne nudiuscula*, *Orcuttia californica*; the San Diego and Riverside fairy shrimp; and the long-term conservation of *Navarretia fossalis*, a species proposed as threatened, will be assured, when the following criteria are met (in addition to Criterion 1):

2. The existing vernal pools and their associated watersheds contained within the complexes identified in Appendix G are secured in a configuration that maintains habitat function and species viability (as determined by prescribed research tasks);
3. Secured vernal pools are enhanced or restored such that population levels of existing species are stabilized or increased; and
4. Population trends must be shown to be stable or increasing for a minimum of 10 consecutive years prior to consideration for reclassification.

Monitoring should continue for a period of at least 10 years following reclassification to ensure population stability.

Delisting of each of the species may be considered in the future and is conditioned on the downlisting criteria shown above, improvement (stabilized or increasing population trends) at all currently known sites; restoration, protection, and management of the minimum habitat area and configuration needed to ensure long-term viability; and reestablishing historic but locally extinct species populations when needed to ensure viability. The U.S. Fish and Wildlife Service must also determine that the following factors are no longer present, or continue to adversely affect, *Eryngium aristulatum* var. *parishii*, *Pogogyne abramsii*, *Pogogyne nudiuscula*, *Orcuttia californica*, and the Riverside and San Diego fairy shrimp: (1) the present or threatened destruction, modification, or curtailment of their habitat or range; (2) over utilization for commercial, recreational, scientific, or educational purposes; (3) disease or predation; (4) the inadequacy of existing regulatory mechanisms; and (5) other natural or manmade factors affecting their continued existence (50 CFR 424.11).

The Recovery Plan should be revised if necessary as new information pertinent to these topics becomes available. A revised Recovery Plan would be based on the best available scientific information.

RECOVERY TASKS

1. Design and establish a vernal pool habitat preserve system within each Management Area that will maximize the ecological distribution for each listed and proposed species, minimize risk of habitat loss, retain genetic differentiation, and provide the opportunity for expansion of populations.

Southern California vernal pool habitats are limited in extent but distributed over a wide area. Within this region are distinctly different types of vernal pool habitat, distinguished by climate, soils, and plant and animal species (Appendix E,F, and G). Maintaining habitats within each

Management Area will result in preservation of the fullest range of habitat conditions, provide protection for the widest array of vernal pool organisms, promote stability and recovery of the listed species, and facilitate development of recovery strategies that incorporate the different conditions and needs of each species.

11. Determine the amount and configuration of vernal pools and their associated watersheds within the complexes identified in Appendix E and F necessary to maintain habitat function and species viability.

The goal of vernal pool species recovery is the preservation of habitat sufficient to ensure the long-term survival of the species. Because this plan addresses several species throughout a disjunct range and because each species has independent ecological life histories and physical requirements, the determination of pool preservation will be a complex endeavor. Conservative projections regarding habitat function and species' viability should be applied to preserve design.

Numerous long-term considerations need be made when prioritizing preservation of vernal pool species and their habitats (refer to Recovery Criteria Principles). Short-term considerations include maintenance of hydrological conditions and water quality, and protection from disturbance.

111. Inventory each of the complexes to determine the extent and configuration of the individual vernal pools and their associated watersheds.
112. Inventory each pool within each complex to determine species composition and abundance.

Maintain recognition that the absence of a species in any particular year does not mean that the pool or complex does not provide habitat or that the species is not present. Species may be present as viable seeds or cysts.

113. Develop preserve designs after determining which vernal pools within each complex are necessary to maintain habitat function and species viability.

Preserve boundaries need to be drawn so as to prevent adverse effects on water quantity and quality. Disturbance (e.g., vehicle or human trespass, invasion by exotic species, landscaping) can be minimized by reducing the edge-to-area ratio and including effective natural barriers to preclude access, such as canyons. Offsite effects can also be minimized by easements or agreements with adjacent landowners that result in the compatible uses of lands adjacent to preserves (Jensen *et al.* 1990).

114. Investigate biological factors affecting recovery.

Management of vernal pool habitats will require a greater understanding of some of the ecological functions of vernal pool species. Although preservation of habitat serves a fundamental role in the recovery of these species, numerous threats remain that are not ameliorated solely by preservation. Consequently, further information will be necessary to address many of these management requirements. In order to guide management activities, research should be designed to determine the historic distributions of the listed and proposed species, their physical and chemical

tolerance limits, and their biotic associations, including the role of herbivory, pollinators, and vectors. Disturbances associated with fire, grazing, and nonnative species should be studied to determine their degree of influence on recovery. Genetic variability is key to the long-term viability of vernal pool species, and a better understanding of the population structure and levels of variability will aid in the reestablishment of vernal pool species. This information and others should provide clear direction when defining management goals and priorities.

12. Secure sites identified for preservation through fee title acquisition and conservation agreements.

The most important requirements for the recovery of the southern California vernal pool species is the preservation and restoration of vernal pool habitats. Vernal pool habitat first needs to be secured because urban and infrastructure development are proceeding rapidly throughout the range of *Eryngium aristulatum* var. *parishii*, *Pogogyne abramsii*, *Pogogyne nudiuscula*, *Orcuttia californica*, *Navarretia fossalis*, and San Diego and Riverside fairy shrimp..

Fee title acquisition, conservation easements, long-term leases, cooperative agreements, and plans with willing public agencies and private landowners could be obtained through purchase, donation, transfer, exchange, or written agreement. Lands could also be conveyed to the U.S. Fish and Wildlife Service from landowners to meet mitigation, zoning, or land-use permit requirements.

Conservation easements may protect habitat Although allowing it to remain in private ownership. Some sites are

already in public or agency ownership, such as The Nature Conservancy's Santa Rosa Plateau and the California Department of Transportation's Del Mar Mesa Preserve. Cooperative agreements and coordinated planning and management efforts could assist in conservation efforts, such as the plan being developed by MCAS Miramar. Acquisition of land or interests therein by the U.S. Fish and Wildlife Service for the Vernal Pools Stewardship Project of the San Diego National Wildlife Refuge is another method, as are the regional conservation planning efforts through the Natural Community Conservation Planning Act.

121. Secure existing vernal pools and their associated watersheds in Appendix F and G identified as necessary to maintain habitat function and species viability;
122. Secure existing vernal pools and their associated watersheds currently occupied by *Orcuttia californica*, *Pogogyne nudiuscula*, and the Riverside fairy shrimp;
123. Secure existing vernal pools and their associated watersheds within the Transverse and Los Angeles Basin-Orange Management Areas;
124. Secure existing vernal pools and their associated watersheds within the San Marcos complexes that contain *Navarretia fossalis*, *Eryngium aristulatum* var. *parishii*, *Brodiaea filifolia*, and any other vernal pool species of limited distribution or abundance. Impacts to any of the remaining pools and their associated watersheds must result in no net loss of function and value;

125. Secure existing vernal pools and their associated watersheds within the Ramona complexes that contain *Downingia cuspidata*, *Eryngium aristulatum* var. *parishii*, *Navarretia fossalis*, *Myosurus minimus*, San Diego fairy shrimp, and any other vernal pool species of limited distribution or abundance;
 126. Secure existing vernal pools and their associated watersheds located on Stockpen soils.
 127. Adopt management and mitigation measures described in the Department of the Navy's, Integrated Natural Resources Management Plans, developed by each military installation.
2. Within each Management Area, reestablish vernal pool habitat to historic structure and composition to increase genetic diversity and population stability.

Given the extreme reduction of vernal pool habitat in southern California, preservation and maintenance of the few remaining pools and their complexes is inadequate to buffer against catastrophic events, population dynamics (e.g., survivorship and reproduction), and edge effects. Destruction and degradation of vernal pool habitats have resulted in extensive losses of species dependent upon them. For some species in particular (e.g., *Pogogyne nudiuscula*) a single random event could result in complete extinction.

Pogogyne abramsii populations have been extirpated from the Linda Vista area, the vicinity of Balboa Park, Normal Heights, and the area surrounding San Diego State University. *Pogogyne nudiuscula* currently exists only in a small number of pools on Otay Mesa. *Eryngium aristulatum* var. *parishii* has been extirpated from a site in La Jolla, and is believed to be extirpated from near the Tijuana Airport where it previously

existed. Sites previously documented to have contained *Orcuttia californica* in Los Angeles County, Ventura, and Murrieta Hot Springs have been extirpated; and the Riverside fairy shrimp is limited now in distribution to only a few vernal pool complexes in a limited geographical area. Restoration and reintroduction are necessary to expand the current ranges of these endemic species to reduce risk of extinction through random and natural events.

Within the complexes identified in Appendix F and G, sites should be reviewed to identify and assess the suitability of sites and individual vernal pools that are eligible for restoration. The need for restoration of vernal pool habitats and their constituent species can be distinguished from enhancement or management needs by virtue of the often extreme modification or degradation of the habitat to which they have been subjected. Disturbances can permanently affect soil drainage and pool hydrology as well as water quality and temperature. In some cases, habitat is so severely degraded that visible characteristics typically associated with vernal pool habitat have been obscured and total reconstruction may be necessary to achieve a functioning level again. Former evidence of the habitat is necessary to ensure the suitability of a site. Suitable sites should include appropriate soil types, water chemistry, ponding patterns, and historic species distributions. Topographic features may or may not be initially present, depending on the degree of previous habitat modification.

Restoration plans should address primarily the reestablishment of the physical and biotic characteristics of vernal pool habitat, including soil properties, water quality, topography, hydrology, nutrient cycling, species diversity, and species interactions, such that critical functions can become self-sustaining. Vernal pool habitats and pool basins are frequently subjected to soil disturbances as a result of vehicular activity, agriculture, and human or domestic animal foot traffic. These habitats are especially vulnerable during the wet phase, when the clay soils are easily compacted. Tire ruts, hoof prints, roads, and trails can result in the direct elimination of vernal pool species by alteration of hydrology (Bauder, pers. obs. 1995).

Pools should be individually assessed to determine the need for enhancement or restoration to achieve integrity.

Because southern California vernal pool species are habitat specialists closely tied to soil types and climatic variables, and have naturally limited distributions, considerations of these restrictive requirements will guide the selection of suitable sites for the re-establishment new populations. Historic distribution, soil surveys, floristic data, climatic, water quality, and hydrologic variables will assist in this evaluation.

Priorities for the establishment of new populations should be determined. The most narrowly distributed, least abundant, and most threatened species addressed in this plan are *Pogogyne nudiuscula*, *Orcuttia californica*, and the Riverside fairy shrimp. Primary consideration should be given to the reestablishment of these species. Ecological and reproductive requirements of the species under consideration should be evaluated.

In most cases, the historic distributions of vernal pool species can be reconstructed and the landscape restored sufficiently to allow for the reestablishment and expansion of populations. Limits to natural distributions must be recognized, however, and species reintroduction should not substitute for protection of existing natural populations.

Some experimentation will be required to determine the most effective methods for reintroduction of vernal pool species into currently unoccupied habitat. Methods to consider could include captive propagation, nursery-grown plants, seed collection, donor pools, or vegetative propagation. Care must be taken to ensure parent populations are not adversely affected.

3. Within each Management Area, rehabilitate and enhance secured vernal pool habitats and their constituent species.

Certain activities can dramatically affect the physical and biotic characteristics of the vernal pool habitats, and few vernal pools, if any, are free from disturbances associated with humans or domestic animals. Off-road vehicle activity, trash dumping, invasion by nonnative species, watershed modification, and domestic livestock are all examples of impacts that can adversely affect habitat and the species therein. Vernal pool habitats are expected to benefit when enhancement or rehabilitation efforts are properly applied. These efforts are less intensive than restoration efforts, typically because the physical features associated with the habitats are largely intact.

Rehabilitation and enhancement augment the physical and biotic characteristics of vernal pool habitat. Typically, the physical features are intact but degraded and require minimal to moderate modification and manipulation. Reestablishment of vernal pool species into enhanced pools may be a consideration. Pool hydrology and chemistry may require augmentation by ensuring appropriate runoff. Pool depth, water duration, and basin surface area can vary with year to year precipitation and air temperature, but they typically exhibit an average range of conditions. Significant modification of the watershed may result in changes in these normal parameters, resulting in conditions that adversely affect vernal pool function. Nonnative organisms in vernal pool systems have adverse effects on the native species and subsequently compromise the integrity of native species. The elimination of nonnative species should be considered in all plans.

4. Manage protected habitat.

Site-specific management plans will need to be developed for each preserve that consider ownership, size and shape, land use history, joint uses, adjacent land uses, and other factors. In general, management plans prepared for all preserves should restrict access (vehicles, humans, or large domestic animals); prohibit or redirect recreational activities; regulate use of toxic substances (herbicides, pesticides, hydrocarbons, and other chemicals) and dumping; prevent water pollution or altered hydrology; and

control exotic plant and animal species. Contingency plans need to be in place for emergencies such as air crashes, fire, toxic spills, law enforcement pursuits, and dam or road washouts.

Care must be taken to ensure that the watersheds of the pools and the complexes in which they reside are maintained in a functioning state. Consideration should be given to those actions (e.g., runoff, erosion, turbidity) that may compromise or conflict with pool hydrology when planning adjacent land uses. Effective management of nonnative species may be achieved in part, by ensuring appropriate hydrologic regimes. Interim management, such as controlled burns (Simovich *et al.* 1996; Pollak and Kan 1996), may be necessary to reduce or eradicate nonnative species to levels that do not adversely affect the native species. Bullfrogs are recognized predators (Morey 1996; Simovich *et al.* 1996) of vernal pool species and eradication of larvae, post-metamorphic, and adult frogs should be a task item in all vernal pool management plans. The effect of various nonnative control regimes, the containment of toxins and pollution, and vehicular use in preserved areas should be addressed. Pools and their watersheds should be secured and protected from runoff, spills, and mosquito abatement and landscaping activities that involve the use of herbicides, pesticides, mulch, and fertilizers. Petroleum byproducts, detergents, and insecticides are examples of substances that can be lethal or toxic to vernal pool organisms (Simovich *et al.* 1996). All trash and refuse should be removed from pools. Site-specific evaluations should be conducted to determine the suitability of grazing practices within each Management Area.

Recognizing that funding will not be immediately available to accomplish all of the specific tasks that become part of an approved management plan, it is important to begin with those actions that will prevent further damage to the habitat. The first priority of the preserve management plans should be to modify on-going activities or planned development that will result in habitat fragmentation or loss, and alteration of pool hydrology or water quality. Second is the need to limit access by means of fencing, signing, barriers, and road and trail closures. To further reduce the threat to the

species, it is important that people who have permitted access to preserves, including emergency response personnel and recreation users, be informed about the value, sensitivity and location of the resource. Development of public viewing areas and a public outreach program can be initiated as preserves are protected.

Off-road recreational activities, construction staging, fire, emergency, and border patrol activities are contributing factors to habitat disturbance; therefore, vehicular travel should be restricted to designated roads and existing hardscape (paved or graveled surfaces). Barriers such as fencing should be considered to limit access, and groups or individuals with access to vernal pool habitat (e.g., resource agencies, researchers, utility companies) should be informed as to the management needs of this habitat type. Vehicles and construction staging areas should be contained in parking lots or hardscape areas.

5. Monitor protected habitat and listed species.

Monitoring is essential to provide baseline data against which to judge the changes and variations in plant and animal populations over time, as well as the success of specific management actions. The type, intensity, timing, and frequency of monitoring need to be tied to the objectives of each plan. Data collection protocols should be simple and repeatable; use established sampling schemes such as plots, transects, or photopoints; and use accepted scientific and statistical procedures. Goals, methods, standards, and success criteria should be reviewed by qualified professionals familiar with vernal pools and the adjacent habitat, and approved by the U.S. Fish and Wildlife Service. Monitoring should always be carried out by qualified biologists.

Baseline monitoring of reference (control) pools is important to provide a comparison by which to judge the stability of habitat quality, fluctuations in response to weather variability, and acceptable ranges of environmental variables for populations of vernal pool species. Monitoring of restored areas should be based on quantifiable restoration goals developed in

relation to adjacent undisturbed habitat (reference habitat) and should extend for 10 years after completion of the restoration actions.

To be considered completed and successful at the end of the 10-year monitoring period, restored areas must be similar in appearance, species composition, and ecosystem function to the reference habitat.

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IV. IMPLEMENTATION SCHEDULE

The implementation schedule outlines recommended actions and estimated cost associated with the recovery program for the Vernal Pools of Southern California. It is a guide for meeting the objective discussed in Part II of this recovery plan. This schedule indicates task priorities, numbers, and descriptions; duration of each task; responsible agencies; and estimated costs. These actions, when accomplished, should bring about the recovery of the six vernal pool species and protect their habitat.

The actions identified in the implementation schedule, when accomplished, should lead to a better understanding of the current distribution and status of the vernal pool species, protection of the habitat, stabilize the existing populations, and allow for an increase in population sizes and numbers. Initiation of these actions is subject to availability of funds.

Priorities in column one of the implementation schedule are assigned as follows:

- Priority 1:** An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

- Priority 2:** An action that must be taken to prevent a significant decline in population or habitat quality, or some other significant negative impact short of extinction.

- Priority 3:** All other actions necessary to meet the recovery objective.

Acronyms used in the Implementation Schedule

ACOE	Army Corps of Engineers
BRD	Biological Resources Division of the U.S. Geological Survey
CDFG	California Department of Fish and Game
DOD	Department of Defense
FHWA	Federal Highway Administration
LOC	Appropriate Local Agencies
TBD	To Be Determined
USFWS	Fish and Wildlife Service

RECOVERY PLAN IMPLEMENTATION SCHEDULE FOR VERNAL POOLS OF SOUTHERN CALIFORNIA

Priority	Task Number	Task Description	Task Duration (Years)	Responsible Agencies	Total Estimated Cost (\$1000's)	Costs (\$1000s)									
						FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Need 1 Conduct surveys and research essential to the conservation of these species.															
1	111	Inventory each of the complexes to determine the extent and configuration of the individual vernal pools and their associated watersheds	2	FWS, ACOE, DOD, BRD, CDFG	50	25	25								
1	112	Inventory each pool within each complex to determine the species composition and abundance	2	ALL	100	50	50								
1	113	Develop preserve designs after determining which vernal pools within each complex are necessary to maintain habitat function and species viability	1	FWS, BRD, DOD, LOC	20	20									
1	114	Investigate biological factors affecting recovery	5	ALL	500	100	100	100	100	100					
Total Need 1					670	195	175	100	100	100					
Need 2 Secure the existing vernal pools and their associated watersheds.															
1	121	Secure the existing vernal pools and their associated watersheds in Tables 4 and 5 identified as necessary to maintain habitat function and species viability	TBD	ALL	TBD										
1	122	Secure the existing vernal pools and their associated watersheds currently occupied by <i>Orcuttia californica</i> , <i>Pogogyne nudiuscula</i> , and the Riverside fairy shrimp	TBD	ALL	TBD										
1	123	Secure the existing vernal pools and their associated watersheds within the Transverse and LA Basin/Orange Management Areas	TBD	ALL	TBD										
1	124	Secure the existing vernal pools and their associated watersheds within the San Marcos complexes that contain <i>Navarretia fossalis</i> , <i>Eryngium aristulatum</i> var. <i>parishii</i> , <i>Brodiaea filifolia</i> , and any other vernal pool species of limited distribution or abundance.	TBD	ALL	TBD										

RECOVERY PLAN IMPLEMENTATION SCHEDULE FOR VERNAL POOLS OF SOUTHERN CALIFORNIA

Priority	Task Number	Task Description	Task Duration (Years)	Responsible Agencies	Total Estimated Cost (\$1000's)	Cost (\$1000s)									
						FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
1	125	Secure the existing vernal pools and their associated watersheds within the Ramona complexes that contain <i>Downingia cuspidata</i> , <i>Eryngium aristulatum</i> var. <i>parishii</i> , <i>Navarretia fossalis</i> , <i>Myosurus minimus</i> , and any other vernal pool species of limited distribution or abundance	TBD	ALL	TBD										
1	126	Secure the existing vernal pools and their associated watersheds located on Stockpen soils	TBD	ALL	TBD										
Total Need 2			TBD		TBD										
Need 3 Where necessary reestablish vernal pool habitat to the historical structure.															
2	2	Within each Management Area, reestablish vernal pool habitat to historic structure and composition to increase genetic diversity and population stability.	1	ALL	105			65	40						
2	3	Within each Management Area, rehabilitate and enhance secured vernal pool habitats and their constituent species	1	ALL	95			60	35						
Total Need 3					200			125	75						
Need 4 Manage and monitor habitat and listed species.															
2	4	Manage protected habitat	2	ALL	25			25							
2	5	Monitor protected habitat and listed species	10	ALL	25			25							
Total Need 4			50		50			50							
Total Cost					970	195	175	275	175	100					

Appendix A

Species of Special Concern In and Adjacent to Vernal Pool Habitat in Southern California

Species	State/Federal Legal Status	CNPS Code/Special Status
PLANTS		
<i>Ambrosia pumila</i> San Diego ambrosia	--/--	1B
<i>Brodiaea filifolia</i> Thread-leaved brodiaea	CE/FPT	1B
<i>Brodiaea orcuttii</i> Orcutt's brodiaea	--/--	1B
<i>Downingia concolor</i> var. <i>brevior</i> Cuyamaca Lake downingia	CE/--	1B
<i>Eryngium aristulatum</i> var. <i>parishii</i> San Diego button-celery	CE/FE	1B
<i>Limnanthes gracilis</i> var. <i>parishii</i> Parish's meadowfoam	CE/--	1B
<i>Myosurus minimus</i> Little mousetail	--/--	3
<i>Navarretia fossalis</i> Spreading navarretia	--/FPT	1B
<i>Ophioglossum californicum</i> California adder's-tongue fern	--/---	4
<i>Orcuttia californica</i> California Orcutt grass	CE/FE	1B
<i>Pogogyne abramsii</i> San Diego mesa mint	CE/FE	1B
<i>Pogogyne nudiuscula</i> Otay mesa mint	CE/FE	1B
<i>Trichostema austromontanum</i> ssp. <i>compactum</i> Hidden Lake blue curls	--/C1	1B
INVERTEBRATES		
San Diego fairy shrimp <i>Branchinecta sandiegonensis</i>	--/FE	--

Appendix A (Continued)

Species	State/Federal Legal Status	Special Status
Riverside fairy shrimp <i>Streptocephalus woottoni</i>	--/FE	--
Vernal pool fairy shrimp <i>Branchinecta lynchi</i>	--/FT	-
 AMPHIBIANS		
Western spadefoot toad <i>Scaphiopus hammondii</i>	--/--	CSC
 REPTILES		
Orange-throated whiptail <i>Cnemidophorus hyperythrus beldingi</i>	--/--	CSC, HT
Northern red diamond rattlesnake <i>Crotalus ruber ruber</i>	--/--	CSC
San Diego horned lizard <i>Phrynosoma coronatum blainvillii</i>	--/--	CSC, HT
Two-striped garter snake <i>Thamnophis hammondii</i>	--/--	CSC, HT
 BIRDS		
Black-shouldered kite <i>Elanus caeruleus</i>	--/--	CFP
Northern harrier <i>Circus cyaneus</i>	--/--	CSC
Burrowing owl <i>Athene cunicularia</i>	--/--	CSC
Coastal California gnatcatcher <i>Polioptila californica californica</i>	FT/--	CSC
Bell's sage sparrow <i>Amphispiza belli</i>	--/--	CSC
 MAMMALS		
Pacific pocket mouse <i>Perognathus longimembris pacificus</i>	FE/--	CSC

Appendix A (Continued)

Abbreviation Key

FEDERALLY LISTED AND CANDIDATE SPECIES

FE	Federal endangered species
FT	Federal threatened species
FPE	Federal proposed endangered species
FPT	Federal proposed threatened species
C1	Federal candidate for listing; species for which the U. S. Fish and Wildlife Service has substantial information to support listing as threatened or endangered.

CALIFORNIA LISTED AND CANDIDATE SPECIES

CE	California endangered species
CR	California rare species

SPECIAL STATUS

CALIFORNIA DEPARTMENT OF FISH AND GAME

CFP	California fully protected
CSC	California species of special concern

CALIFORNIA NATIVE PLANT SOCIETY (CNPS) CODE

1B	Plants rare, threatened, or endangered in California and elsewhere
3	Plants about which we need more information -- a review list
4	Plants of limited distribution -- a watch list

SAN DIEGO

HT	San Diego Herpetological Society threatened
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Appendix B

Definition of Terms

Conservation Potential

- Determined by the current existing conditions, surrounding land use and species composition. This may include management, restoration/enhancement, or none if existing conditions don't allow for the continued existence of the species or vernal pool complex.

Divorced From Natural Habitat

- Not surrounded by habitat dominated by native vegetation, or restorable to native vegetation. Lacking important animal ecosystem components such as pollinators, probable dispersers and predators or herbivores.

Enhancement

- The improvement of the physical and biotic characteristics of vernal pool habitat such that natural processes and productivity are augmented.

Hydrologic Processes

- The cycle and effects of water movement that incorporates the atmosphere and land: the conditions associated with the properties, distribution, duration, depth, and chemical makeup of the surface and soil waters.

Large Site

- Pool or pools are embedded in an area dominated by native vegetation, or potentially restorable to native vegetation.
- Native vegetation is or can be restored to use by native pollinators, amphibians, birds and both small and large mammals, especially deer.

Monitoring

- Repeat collection of data to establish baseline reference on population, distribution, hydrology and other pool attributes needed to assess ecosystem function.
- Purpose is to document the stability of populations and judge the success of restoration actions and the effectiveness of management practices.

Nonnative Plant and Animal Control

- Exotic plants that are present within pool basins during years of average or greater than average precipitation are reduced to less than 5 percent cover every year for a continuous period of 10 years .
- Exotic plants can in no year exceed 25 percent cover of pool basins.
- Exotic herbivores or predators of vernal pool organisms are reduced to levels that do not jeopardize a population. Determination of these levels will depend on additional research findings.

Preservation

- An area secured with an active and adaptive management plan in perpetuity.

Restorable Vernal Pool Habitat

- Pool habitat is potentially restorable if soil profile is sufficiently intact or requires minor modifications in order to maintain pool hydrology.

Restoration

- Reestablishment of the physical and biotic characteristics of vernal pool habitat such that critical functions are restored.
- Resembles a reference habitat in regard to the following attributes: soil properties, water quality, topography, hydrology, nutrient cycling, species diversity and species interactions.

Revegetation

- Site can be brought to dominance with appropriate native plants.
- All ecosystem functions may not be reestablished.

Secured

- The preservation of a site with an active and adaptive management plan, in perpetuity. This would include enhancement/restoration as needed.

Self-sustaining

- The ability of an ecosystem to perpetuate itself through processes operating within the community without human intervention or assistance.

Small Site

- As with large site, but fragmented or isolated to such a degree that large mammals are no longer evident.

Suitable Vernal Pool Habitat

- Soil and hydrological properties are within the range of occupied pools within their associations.

Suitable Vernal Pool Hydrology

- Hydrology is within the range for pools in the subtype.
- Hydrology shall not be matched to the extreme in either direction (rarely or shallowly, inundated to frequently and deeply inundated) known to support the species in question in that sub-type, unless only one pool exists. In that case, pool hydrology must be within the range of conditions documented to sustain populations of the species in other sub-types.
- Hydrological regimes must be documented with 10 consecutive years of data.
- Documentation must include the following data for each year: total number of days inundated at the deepest elevation, percent of basin surface inundated at time of maximum depth, percent of basin exposed during each between-storm interval, and rate of water level drop after each storm.

Suitable Water Quality

- Within the range of alkalinity, total dissolved solids, concentrations of salts, conductivity, and pH known to support populations of pool species, especially invertebrates.
- Devoid of, or with sufficiently low concentrations, of chemicals, nutrients, suspended matter, sediments, and other substances that adversely affect pool species. In some cases ranges of tolerance must be determined by further research.

Vernal Pool

- (As defined by the U.S. Army Corps of Engineers): Wetlands that seasonally pond in small depressions as a result of a shallow, relatively impermeable layer (e.g., clay or other impervious soil or rock layer) that restricts downward percolation of water. The dominant water source for vernal pools is precipitation with pools typically filling after fall and winter rains and evaporating during spring and summer. These seasonal ponds are fragile, easily disturbed ecosystems that provide habitat for indigenous, specialized assemblages of flora and fauna, including several

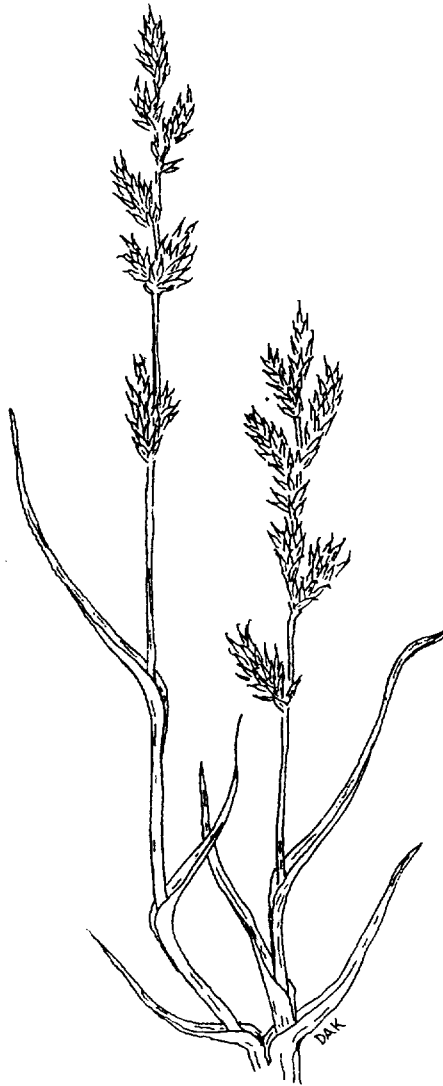
species which are either proposed or already Federally listed as threatened or endangered.

Vernal Pool Functions

- Surface Water Storage In Pool: The capacity of the pool basin to seasonally pond and retain surface water for long durations. The dominant water source is from precipitation either directly into the pool or via sub-surface flow from the sides of the vernal pool basin.
- Subsurface Water Exchange: The capacity of the sub-surface area above the restrictive layer to hold water and allow the exchange of water between the pool basin and surrounding landscape (pool banks and mound areas).
- Surface Water Conveyance: Inter-storm conveyance of concentrated flow into and out of pool basins through swales. Swales are defined as surface features which convey concentrated flow, but lack a defined bed and bank (an undefined drainage).
- Element cycling: The import, transformation, and removal of nutrients, contaminants, and other elements and compounds via biotic and abiotic processes.
- Maintains Characteristic Vegetation: The capability of perpetuating predominantly native vegetation through a variety of morphological, reproductive and developmental adaptations and spore or seed dispersal mechanisms in response to the extreme environmental conditions of wetting and drying. Emphasis is on the dynamics and structure of the vegetation as revealed by species phenology, composition and abundance.
- Maintains Characteristic Aquatic Invertebrates: The capability of perpetuating invertebrate populations through a variety of reproductive and developmental adaptations in response to the extreme environmental conditions of wetting and drying. Emphasis is on the dynamics and structure of the invertebrate ecology of vernal pools as revealed by species composition and abundance.
- Maintains Characteristic Vertebrate Populations: The capability of providing some life history requirements for populations of vertebrate species which rely upon vernal pools for habitat and for activities such as reproduction, development, and feeding.

Appendix C

Illustrations



California Orcutt Grass (*Orcuttia californica*)

Illustration by D. Ann Kreager



Otay Mesa Mint (*Pogogyne nudiuscula*)

Illustration by Scott C. McMillian

Appendix D
Vernal Pool Plant Species Within the Management Areas

Key

T'verse	Transverse	SDCn	San Diego Central Coastal Mesas
LA/Or	LA Basin/Orange County	SDSo	San Diego South Coastal Mesas
R'side	Riverside County	SDInl	San Diego Inland Valley
SDNo	San Diego North Coastal Mesas		

SPECIES	Goleta	T'verse	LA/Or	R'side	SDNo	SDCn	SDSo	SDInl
<i>Alopecurus saccatus (howellii)</i>				X				
<i>Ambrosia pumila</i>				X	X	X	X	
<i>Bergia texana</i>				X			X	
<i>Brodiaea filifolia</i>				X	X			X
<i>Brodiaea jolonensis</i>	X		X		X	X	X	X
<i>Brodiaea orcuttii</i>				X		X	X	X
<i>Callitriche marginata</i>	X		X	X	X	X	X	X
<i>Centunculus minimus</i>	X				X	X	X	X
<i>Crassula aquatica</i>	X		X	X	X	X	X	X
<i>Deschampsia danthoniodes</i>	X			X	X	X	X	X
<i>Downingia concolor</i> var. <i>brevior</i>							X	X
<i>Downingia cuspidata</i>						X	X	X
<i>Echinodorus berteroi</i>				X				
<i>Elatine brachysperma</i>				X		X	X	X
<i>Elatine californica</i>				X		X		
<i>Eleocharis acicularis</i>	X			X		X		
<i>Eleocharis macrostachya</i>	X		X	X	X	X	X	X
<i>Eleocharis montevidnesis</i>							X	
<i>Epilobium pygmaeum</i>			X	X			X	X
<i>Eryngium aristulatum</i> var. <i>parishii</i>				X	X	X	X	X
<i>Eryngium</i> sp. nova					X			
<i>Eryngium vaseyi</i>	X							
<i>Isoetes howellii</i>						X	X	
<i>Isoetes orcuttii</i>						X	X	X
<i>Juncus bufonius</i>	X		X	X	X	X	X	X
<i>Juncus triformis</i>								
<i>Lasthenia glabrata</i> spp. <i>coulteri</i>			X	X				
<i>Lepidium latipes</i>							X	
<i>Lepidium nitidum</i>	X		X	X		X	X	X
<i>Lilaea scilloides</i>						X	X	X

Appendix D
(continued)
Vernal Pool Plant Species Within the Management Areas

SPECIES	Goleta	T'verse	LA/Or	R'side	SDNo	SDCn	SDSo	SDInl
<i>Limnanthes gracilis</i> ssp <i>parishii</i>				X	X			X
<i>Lythrum hyssopifolia</i>	X		X			X	X	X
<i>Malvella leprosa</i>			X	X	X	X	X	
<i>Marsilea vestita</i>			X	X			X	
<i>Mimulus latidens</i>							X	
<i>Montia fontana</i>					X	X		
<i>Myosurus minimus</i> var. <i>apus</i>			X	X		X	X	X
<i>Myosurus minimus</i> var. <i>filiformis</i>						X	X	X
<i>Nama stenocarpum</i>			X		X		X	
<i>Navarretia fossalis</i>		X		X	X	X	X	X
<i>Navarretia hamata</i>						X	X	
<i>Navarretia intertexta</i>								
<i>Navarretia prostrata</i>			X					
<i>Ophioglossum californicum</i>						X	X	
<i>Orcuttia californica</i>		X		X		X	X	
<i>Phalaris lemmonii</i>	X		X		X	X	X	X
<i>Pilularia americana</i>	X		X	X		X	X	X
<i>Plagiobothrys acanthocarpus</i>			X			X	X	X
<i>Plagiobothrys leptocladus</i>				X				
<i>Plagiobothrys undulatus</i>	X							
<i>Plantago elongata</i>			X	X		X	X	X
<i>Plantago erecta</i>			X			X	X	X
<i>Pogogyne abramsii</i>				X		X		
<i>Pogogyne nudiuscula</i>							X	
<i>Psilocarphus brevissimus</i>	X		X	X	X	X	X	X
<i>Psilocarphus tenellus</i>						X	X	
<i>Rotala ramosior</i>				X			X	
<i>Sibara virginica</i>	X			X				
<i>Trifolium depauperatum</i> var. <i>amplectans</i>						X	X	
<i>Verbena bracteata</i>			X	X			X	
<i>Veronica peregrina</i> var. <i>xalapensis</i>				X				

Appendix E
Status of the Vernal Pool Species Within the Management Areas

KEY:

The numbers in the species columns represent the number of pools the species is known to be present in.

¹Positive identification require

X species present

Xh species extirpated

Pogogyne abramsii (Pa), *Pogogyne nudiuscula* (Pn), *Orcuttia californica* (Oc), *Eryngium aristulatum* var. *parishii* (Ea), *Navarretia fossalis* (Nf), San Diego fairy shrimp (SF), and Riverside fairy shrimp (RF).

Note: the information within this table represents current available information and is subject to modification as additional or new data is presented.

E1

Management Area	Complex	Minimum Number of Pools or Complexes	Ownership or Management	Status	Conservation Potential	Pa	Pn	Oc	Ea	Nf	SF	RF
SD South	J1	0	Private	filled	none		Xh		Xh	Xh	Xh	Xh
SD South	J2	57-129	Private	mitigation	restoration		3		22	4	14	70
SD South	J3	4	Private	filled	restoration					1		
SD South	J4-7	176	Private	mitigation/dev	enhancement				1	1		1
SD South	J11E	3	Private		enhancement				X			X
SD South	J11W	5	Private		enhancement			X				X
SD South	J12	3	Private		enhancement			X				
SD South	J13S	14	Private		enhancement			X	X	X	X	
SD South	J13N	7	Private	mitigation	management			2	3	X	X	
SD South	J13E	2	Private		enhancement				X			

E2

Management Area	Complex	Minimum Number of Pools or Complexes	Ownership or Management	Status	Conservation Potential	Pa	Pn	Oc	Ea	Nf	SF	RF
SD South	J14	20	Private		enhancement		2			X		
SD South	J15	13	Private	mitigation	management				13		X	1
SD South	J16-17	37	City SD	mitigation	enhancement				7	7	X	X
SD South	J18	1	City SD	mitigation	enhancement							
SD South	J19	0	Private	agriculture	restoration			Xh	Xh	Xh		
SD South	J20	0	Private		restoration				Xh			
SD South	J21	7	Private		restoration		Xh		X			
SD South	J22	3	Private		restoration				X	X		
SD South	J23-24	617	Private		management		25		28			
SD South	J25	177	Private		management		55		11			
SD South	J26	30	Private	mitigation	management		15		X			
SD South	J27	5	Private	mitigation	enhancement		Xh		5	Xh		
SD South	J28W	2	Private		restoration		Xh		Xh	Xh		
SD South	J28E	9	Private		enhancement		Xh	Xh	7	Xh		
SD South	J29-30	323	Private		restoration enhancement		17		106	X	X	2
SD South	K1	7	Private		restoration							
SD South	K3-4	25	Private		restoration				10	Xh		

E3

Management Area	Complex	Minimum Number of Pools or Complexes	Ownership or Management	Status	Conservation Potential	Pa	Pn	Oc	Ea	Nf	SF	RF
SD South	K5	7	Private		restoration				5			
SD South	K6	12	Private	proposed development	enhancement							
SD South	K7	2	Private		restoration							
SD South	K8+	14	Private		restoration							
SD South	K9+	9	Private		restoration							
SD South	K10+	15	Private		restoration							
SD South	K12+	7	Private		restoration							
SD South	K13+	5	Private		restoration							
SD South	K14+	6	Private		restoration							
SD South	K15+	10	Private		enhancement							
SD South	K16+	1	Private		restoration							
SD South	K17+	8	Private		restoration							
SD South	Marron Valley	6	City SD/ MWWD		protection management							
SD South	LL	2	Caltrans		management	X						
SD South	M2	5	Private		restoration							
SD South	M3	4h	Private		restoration							

E4

Management Area	Complex	Minimum Number of Pools or Complexes	Ownership or Management	Status	Conservation Potential	Pa	Pn	Oc	Ea	Nf	SF	RF
SD South	M4	1	Private		restoration							
SD South	M5+	1	Private		restoration							
SD South	R1	14	City SD		enhancement					X		
SD South	R2+	9	Private		management							
SD South	R3+	3	Private		enhancement				X			
SD South	R4+	2	Private		restoration							
SD South	S1-3	12	Water District/Private		enhancement					3		
SD South	Chollas	39	Navy		mitigation				6		X	
SD South	O1	0	Private		restoration?				Xh			
SD Central	Q1	6	Grossmont College		enhancement						X?	
SD Central	G1	146	DOD	Proposed Refuge	management	36			1		X	
SD Central	G2	88	DOD	Proposed Refuge	management	5					X	
SD Central	N1-4,6	196	City of SD		management	153			3	Xh		
SD Central	BB	34	Private	mitigation	management	18			6	1	4	
SD Central	Teledyne	40	Private	proposed development	management	1						

ES

Management Area	Complex	Minimum Number of Pools or Complexes	Ownership or Management	Status	Conservation Potential	Pa	Pn	Oc	Ea	Nf	SF	RF
SD Central	Sander		City SD/ES		potential development	X					X	
SD Central	FF1-2	59	DOD	managed	management/restoration				8		X	
SD Central	GG1	67	DOD	managed	management/restoration	X			1		X	
SD Central	GG2+	2	DOD	managed	management/restoration				1		X	
SD Central	Z11+	12	DOD	developed	management/restoration							
SD Central	HH3+	20	DOD	developed	management/restoration						X	
SD Central	HH4+	unmapped	DOD	managed	management/restoration							
SD Central	HH1+	102	DOD	managed	management/restoration	30		X	57	X	X	
SD Central	HH2+	17	DOD	managed	management/restoration						X	
SD Central	W4	unmapped	DOD	managed	management/restoration							

E6

Management Area	Complex	Minimum Number of Pools or Complexes	Ownership or Management	Status	Conservation Potential	Pa	Pn	Oc	Ea	Nf	SF	RF
SD Central	W3	20	DOD	managed	management/ restoration	X			X			
SD Central	W1-2	57	DOD	managed	management/ restoration	X			X			
SD Central	V	42	DOD		management/ restoration	X			X			
SD Central	AA-2	27	DOD	managed	management/ restoration							
SD Central	I7	63	DOD	managed	management/ restoration	10			19		X	
SD Central	Z6-7	50	DOD	managed	management/ restoration				23		X	
SD Central	Z9	11	DOD	managed	management/ restoration							
SD Central	Z1-3	149	DOD	managed	management/ restoration	X			X		X	
SD Central	X1-4	193	DOD	managed	management/ restoration	X			X		X	
SD Central	Z10	9	DOD	managed	management/ restoration							

E7

Management Area	Complex	Minimum Number of Pools or Complexes	Ownership or Management	Status	Conservation Potential	Pa	Pn	Oc	Ea	Nf	SF	RF
SD Central	GG3+	28	DOD	managed	management/ restoration							
SD Central	AA1 west	53	DOD	managed	management/ restoration	X					X	
SD Central	AA9	138	DOD	managed	management/ restoration	X			X		X	
SD Central	AA1 east	20	DOD	managed	management/ restoration	7					X	X
SD Central	AA1 south	47	DOD	managed	management/ restoration	5					X	
SD Central	AA10	152	DOD	managed	management/ restoration	59					X	
SD Central	AA11	96	DOD	managed	management/ restoration	X			X			
SD Central	AA12 north+	2	DOD	managed	management/ restoration	X						
SD Central	AA12	15	DOD	managed	management/ restoration	X						
SD Central	AA12 south	11	DOD	managed	management/ restoration	X						

E8

Management Area	Complex	Minimum Number of Pools or Complexes	Ownership or Management	Status	Conservation Potential	Pa	Pn	Oc	Ea	Nf	SF	RF
SD Central	AA8	35	DOD	managed	management/ restoration	X					X	
SD Central	A4	45	DOD	managed	management/ restoration	22					X	
SD Central	AA3	22	DOD	managed	management/ restoration	X			X		X	
SD Central	AA13	29	DOD	managed	management/ restoration	X						
SD Central	AA4-7	162	DOD	proposed refuge	management/ restoration	X					X	
SD Central	F north	142	DOD	managed	management/ restoration	X			X			
SD Central	F16-17	15	DOD	managed	management/ restoration	X					X	
SD Central	U19	21	DOD	managed	management/ restoration	14			3		X	
SD Central	U10	6	private	managed	management/ restoration	X					X	
SD Central	U North	772	DOD	managed	management/ restoration	X		X	X		X	

E10

Management Area	Complex	Minimum Number of Pools or Complexes	Ownership or Management	Status	Conservation Potential	Pa	Pn	Oc	Ea	Nf	SF	RF
SD Central	D1	3	Private			X						
SD Central	D5-6	76	City SD	mitigation	management	X			X			
SD Central	C10-16,26	39	City SD		management	17			2		X	
SD Central	Maddox Park	38	School District		restoration						X	
SD Central	C18	5	Private	mitigation	management	X						
SD Central	C27	64	Private	proposed development	restoration						X	
SD Central	B5	1	Caltrans	mitigation	management	X					X	
SD Central	B6	1	Caltrans	mitigation	management	X					X	
SD Central	B7-8W	5	Private	proposed development	restoration						1	
SD Central	B7-8E	17	City SD	mitigation	management	X					X	
SD Central	B2	23	Private	mitigation	management	X					X	
SD Central	B11	12	Private		restoration	X						
SD Central	H1-3	45	City SD	mitigation	management	X			X			
SD Central	H4-10	27	Caltrans	mitigation	management	X			X			
SD Central	H13-15	60	Caltrans	mitigation	management	X			X			

E11

Management Area	Complex	Minimum Number of Pools or Complexes	Ownership or Management	Status	Conservation Potential	Pa	Pn	Oc	Ea	Nf	SF	RF
SD Central	H17	18h	Private		restoration							
SD Central	H18-23	60	Caltrans	mitigation	management	X			X			
SD Central	H24-26	20h	Private		restoration	X			X			
SD Central	H?Subarea 3	2?	Private		restoration				1		1	
SD Central	Hsubarea 4	69	Private	proposed development	restoration							
SD Central	H31-32Sorrento Hills	7	Private	filled								
SD Central	H33	2	SDGE?		restoration							
SD Central	H36Subarea 5	5	Private	proposed development	restoration							
SD Central	H?Neigh. 8a		Private	proposed development	restoration							
SD Central	H?Black Mountain	2	Private	filled	restoration							
SD Central	CC		Private		restoration							
SD Central	DD1	3	Private									
SD Central	DD4	3	Private		restoration							

E12

Management Area	Complex	Minimum Number of Pools or Complexes	Ownership or Management	Status	Conservation Potential	Pa	Pn	Oc	Ea	Nf	SF	RF
SD Central	M.T. Westridge		City SD/Parks		management							
SD Central	Grassland		City SD/ County Parks		management							
SD Inland	RamonaT	39+	County of SD-Airports		restoration					X	X	
SD Inland	Highland Valley	3+	Private		management							
SD Inland	Main Street	6	Private		management					Xh		
SD Inland	TaHwy 67 & 15th (SE)	1	Private	proposed development	enhancement						X	
SD Inland	Tb Hwy 67 & Hunter (SE)	1		private	enhancement						X	
SD Inland	TcLa Brea & Kalbaugh (SE)	1	Private		management						1	
SD Inland	Montecito Road	1	Private		management						X	
SD Inland	Hwy 67 & Kalbaugh area	1	Private		management						X	

E13

Management Area	Complex	Minimum Number of Pools or Complexes	Ownership or Management	Status	Conservation Potential	Pa	Pn	Oc	Ea	Nf	SF	RF
SD Inland	Ramona High School	5PSBS 1989; Pentis 1997	Private		management						X1	
SD Inland	L1-6	30	Private		enhancement				X			
SD Inland	L7-8	5	Private	proposed development	none							
SD Inland	L9-10	10:22 AM	Private		enhancement				X			
SD Inland	L11-13	10:22 AM	Private		enhancement							
SD Inland	L14+	9	Private		restoration							
SD Inland	L15+	5	Private		enhancement							
SD Inland	L16+	10:22 AM	Private		restoration							
SD Inland	L17+	10	Private		enhancement							
SD Inland	L18+	10	Private		restoration				Xh			
SD Inland	L19+	5	Private		restoration							
SD Inland	L20+	10:22 AM	Private		enhancement							
SD North	JJ2	3	Private/Cnty SD		management							
SD North	JJ1		Poinsettia Train Station	mitigation	management			X	X	X	X	1
SD North	JJ3	10	Private	mitigation/dev	management							

E14

Management Area	Complex	Minimum Number of Pools or Complexes	Ownership or Management	Status	Conservation Potential	Pa	Pn	Oc	Ea	Nf	SF	RF
SD North	Wire Mtn	24 complexes	DOD		management/ restoration				52	X	X	X
SD North	Basilone	1 complex	DOD		management/ restoration							
SD North	Las Pulgas	64 complexes	DOD		management/ restoration						X	X
SD North	Cocklebur Mesa	10 complexes	DOD		management/ restoration						X	X
SD North	Stuart Mesa	27 complexes	DOD		management/ restoration					X	X	X
SD North	O'Neill	5 complexes	DOD		management/ restoration						X	X
SD North	San Mateo	17 complexes	DOD		management/ restoration						X	X
SD North	State Park Lease Area	1 complex	DOD		management/ restoration						X	
Riverside	Hemet/ Salt Creek		Private/Public		enhancement			X		X		
Riverside	Skunk Hollow	1	Private		management			1	1			1
Riverside	San Jacinto		Private		enhancement					X		

E15

Management Area	Complex	Minimum Number of Pools or Complexes	Ownership or Management	Status	Conservation Potential	Pa	Pn	Oc	Ea	Nf	SF	RF
Riverside	Santa Rosa Plateau	15-20	Nature Conservancy		management			X	X	X		X
LA/Orange	Saddle-back	8	Private		enhancement							8
LA/Orange	El Toro	1	DOD		management/ restoration							1
LA/Orange	Chiquita Ridge	2	Private		enhancement							X
LA/Orange	Fairview Park	8	City Costa Mesa	mitigation	management						X	
LA/Orange	Whiting Ranch		Private									
LA/Orange	O'Neill Park											
LA/Orange	Rancho Laguna		Private									
LA/Orange	San Clemente		State Park									
LA/Orange	Badlands Park		Private									
LA/Orange	Woodland Hills		Private					X				

Appendix F

**Vernal Pool Complexes Within Management Areas
Identified as Necessary to Stabilize the Proposed and Listed Vernal Pool**

KEY

X - Present

NP - Not Present

Data is incomplete for some species (indicated by blank spaces); blank spaces, therefore, do not necessarily indicate species absence. Vernal pools designated in this table, must be secure in a configuration that maintains habitat function and viability.

Goleta and Transverse Management Area

Species	<i>Eryngium aristulatum</i> <i>var. parishii</i>	<i>Pogogyne</i> <i>abramsii</i>	<i>Pogogyne</i> <i>nudiuscula</i>	<i>Orcuttia</i> <i>californica</i>	<i>Navarretia</i> <i>fossalis</i>	Riverside Fairy Shrimp	San Diego Fairy Shrimp
Complex							
Carlsberg	NP	NP	NP	X		X	
Cruzan Mesa	NP	NP	NP	X	X		

Los Angeles Basin-Orange Management Area

Species	<i>Eryngium aristulatum</i> <i>var. parishii</i>	<i>Pogogyne</i> <i>abramsii</i>	<i>Pogogyne</i> <i>nudiuscula</i>	<i>Orcuttia</i> <i>californica</i>	<i>Navarretia</i> <i>fossalis</i>	Riverside Fairy Shrimp	San Diego Fairy Shrimp
Complex							
Chiquita Ridge	NP	NP	NP			X	
El Toro	NP	NP	NP			X	
Fairview Park	NP	NP	NP				X
Orange County Foothills (undescribed)						X	
Saddleback Meadow	NP	NP	NP			X	
San Clemente State Park						X	X

F1

Appendix F (Continued)

Riverside Management Area

Species	<i>Eryngium aristulatum</i> var. <i>parishii</i>	<i>Pogogyne abramsii</i>	<i>Pogogyne nudiuscula</i>	<i>Orcuttia californica</i>	<i>Navarretia fossalis</i>	Riverside Fairy Shrimp	San Diego Fairy Shrimp
Complex							
Hemet/Salt Creek	NP	NP	NP	X	X		
San Jacinto	NP	NP	NP		X		
Santa Rosa Plateau	X			X	X	X	
Skunk Hollow/Murrietta	NP	NP	NP	X		X	
Temecula					X	X	

San Diego: North Coastal Management Area

Species	<i>Eryngium aristulatum</i> var. <i>parishii</i>	<i>Pogogyne abramsii</i>	<i>Pogogyne nudiuscula</i>	<i>Orcuttia californica</i>	<i>Navarretia fossalis</i>	Riverside Fairy Shrimp	San Diego Fairy Shrimp
Complex							
Cockleburr	NP	NP	NP	NP		X	X
Las Pulgas	NP	NP	NP	NP	NP	X	X
San Mateo	NP	NP	NP	NP	NP	X	X
State Park Lease Area	NP	NP	NP	NP	NP	NP	X
Stuart Mesa	NP	NP	NP		X	X	X
Wire Mountain	X	NP	NP		X	X	X
JJ1 Palomar Airport	NP	NP	NP	NP			X
JJ2 Poinsettia Lane	X	NP	NP	X	X	X	X

F2

Appendix F (Continued)

San Diego: Central Coastal Management Area

F3

Species Complex	<i>Eryngium aristulatum</i> var. <i>parishii</i>	<i>Pogogyne abramsii</i>	<i>Pogogyne nudiusscula</i>	<i>Orcuttia californica</i>	<i>Navarretia fossalis</i>	Riverside Fairy Shrimp	San Diego Fairy Shrimp
Chollas Heights	X	NP	NP	NP	NP	NP	X
A4 Tierrasanta	NP	X	NP	NP			X
B Mira Mesa North	X	X	NP	NP			X
C10-16,26 Mira Mesa Central	X	X	NP	NP			X
D5-8 Mira Mesa South	X	X	NP	NP			
F1-27 Kearny Villa South	X	X	NP	NP			X
G1-2 Tierrasanta South	X	X	NP	NP			X
G 3 (newly described)		X	NP	NP			X
H 1-10, 13-15, 18-23, 33 Penasquitos North/Del Mar Mesa	X	X	NP				X
I 7 Eastgate Mall/ Miramar Industrial	X	X	NP				X
N1-4, 6 Montgomery Field		X	NP		X		X

Appendix F (Continued)

San Diego: Central Coastal Management Area

Species	<i>Eryngium aristulatum</i> var. <i>parishii</i>	<i>Pogogyne abramsii</i>	<i>Pogogyne nudiuscula</i>	<i>Orcuttia californica</i>	<i>Navarretia fossalis</i>	Riverside Fairy Shrimp	San Diego Fairy Shrimp
U 1-13 Landmark/ U-North	X	X	NP	X			X
V 1-4 Sim J. Harris	X	X	NP				
W 1-4 South Miramar	X	X	NP				
X 1-4 West Miramar	X	X	NP				
X 5 Nobel Drive			NP				X
Z 1-3, 6,7, 10 Westgate Miramar	X	X	NP				X
AA 1-7, 9-13 East Miramar		X	NP			X	X
EE1-2 Miramar Interior	X	X	NP		X		X
HH 1-4 Miramar Interior	X	X	NP	X			X
RR 1,2 Miramar Interior	X	X	NP				X

F4

Appendix F (Continued)

San Diego: South Coastal Management Area

Species	<i>Eryngium aristulatum</i> var. <i>parishii</i>	<i>Pogogyne abramsii</i>	<i>Pogogyne nudiuscula</i>	<i>Orcuttia californica</i>	<i>Navarretia fossalis</i>	Riverside Fairy Shrimp	San Diego Fairy Shrimp
J2,5,7,11-21,23-30 Otay Mesa	X	NP	X	X	X	X	X
K3-5 Otay River	X	NP	NP		X		
R Proctor Valley	X	NP	NP		X		
Sweetwater Lake	NP	NP	NP		X		

San Diego: Inland Valleys Management Area

Species	<i>Eryngium aristulatum</i> var. <i>parishii</i>	<i>Pogogyne abramsii</i>	<i>Pogogyne nudiuscula</i>	<i>Orcuttia californica</i>	<i>Navarretia fossalis</i>	Riverside Fairy Shrimp	San Diego Fairy Shrimp
L1-6, 9-13San Marcos	X	NP	NP	NP	X		X*
L (undescribed)		NP	NP				
Ramona	X	NP	NP		X		X

Note: The letter codes used in this table are taken from "San Diego Vernal Pools: Recent and Projected Losses; their Condition; and Threats to their Existence. 1979-1990"; California Department of Fish and Game, 1986. These codes were employed to generalize pool complexes and associations and were developed specifically for San Diego County. Because the boundaries ascribed to these codes are map constructs they may not reflect undescribed, newly described, restorable, or presently unoccupied habitat. Complexes annotated as undescribed reflect areas where pools are likely to or do occur but none have been mapped.

* if detected

Appendix G

**Vernal Pool Complexes Within Management Areas
Identified as Necessary to Reclassify the Proposed and Listed Vernal Pool Species**

Key

X- Present NP - Not Present

Data is incomplete for some species, therefore, blank spaces do not necessarily indicate species absence. Vernal pool complexes identified in this table should be secured (in addition to those species and pool complexes listed in Table 4), in a manner that allows population levels of existing species to stabilize or increase.

Goleta and Transverse Management Areas

Species	<i>Eryngium aristulatum</i> var. <i>parishii</i>	<i>Pogogyne abramsii</i>	<i>Pogogyne nudiuscula</i>	<i>Orcuttia californica</i>	<i>Navarretia fossalis</i>	Riverside Fairy Shrimp	San Diego Fairy Shrimp
Isla Vista	NP	NP	NP	NP	NP	NP	
Ellwood Mesa	NP	NP	NP	NP	NP	NP	
More Mesa	NP	NP	NP	NP	NP	NP	

San Diego: North Coastal Management Area

Species	<i>Eryngium aristulatum</i> var. <i>parishii</i>	<i>Pogogyne abramsii</i>	<i>Pogogyne nudiuscula</i>	<i>Orcuttia californica</i>	<i>Navarretia fossalis</i>	Riverside Fairy Shrimp	San Diego Fairy Shrimp
Basilone	NP	NP	NP	NP	NP		
O'Neill	NP	NP	NP	NP	NP	X	X

G1

Appendix G (Continued)

San Diego: Central Coastal Management Area

Species Complex	<i>Eryngium aristulatum</i> var. <i>parishii</i>	<i>Pogogyne abramsii</i>	<i>Pogogyne nudiusscula</i>	<i>Orcuttia californica</i>	<i>Navarretia fossalis</i>	Riverside Fairy Shrimp	San Diego Fairy Shrimp
Maddox Park	X	X	NP				
D1 Mira Mesa South	X?	X	NP				
F28 Kearny Villa South		X	NP				
GA Miramar Interior	X		NP				
H24-26 Penasquitos North	X	X	NP				
H (undescribed)			NP				X
I 1, 6 B,C Miramar Industrial	X	X	NP				
U15, 19 Landmark/ Sander, Cubic Pools	X	X	NP	X			X
AA 8 East Miramar	X		NP				X
BB 2 New Century	X	X	NP	NP	X	NP	X
FF1-2 Miramar Interior	X	X (historic)	NP				X
GG1-3 Miramar Interior	X	X	NP				

G2

Appendix G (Continued)

San Diego: South Coastal Management Area

Species	<i>Eryngium aristulatum</i> var. <i>parishii</i>	<i>Pogogyne abramsii</i>	<i>Pogogyne nudiuscula</i>	<i>Orcuttia californica</i>	<i>Navarretia fossalis</i>	Riverside Fairy Shrimp	San Diego Fairy Shrimp
Complex							
Naval Radar Receiving Facility, Imperial Beach		NP	NP				
Tijuana Estuary			NP				X
J (undescribed)	X	NP			X		
J 3, 22 Otay Mesa	X				X		
K1,2,6,7 Otay River					X		X

San Diego: Inland Valleys Management Area

Species	<i>Eryngium aristulatum</i> var. <i>parishii</i>	<i>Pogogyne abramsii</i>	<i>Pogogyne nudiuscula</i>	<i>Orcuttia californica</i>	<i>Navarretia fossalis</i>	Riverside Fairy Shrimp	San Diego Fairy Shrimp
Complex							
L 7,8, 14-20 San Marcos		NP	NP	NP	X		X
L (undescribed)		NP	NP				
T Ramona		NP	NP		X		X

Note: The letter codes used in this table are taken from "San Diego Vernal Pools: Recent and Projected Losses; their Condition; and Threats to their Existence. 1979-1990"; California Department of Fish and Game, 1986. These codes were employed to generalize pool complexes and associations and were developed specifically for San Diego County. Because the boundaries ascribed to these codes are map constructs they may not reflect undescribed, newly described, restorable, or presently unoccupied habitat. Complexes annotated as undescribed reflect areas where pools are likely to or do occur but are currently unmapped.

Appendix H

Summary of the Agency and Public Comments on the Draft Vernal Pool Recovery Plan

On September 26, 1997, the Service released the Draft Recovery Plan for the Vernal Pools of Southern California for a 60 day comment period that ended February 12, 1998, for Federal agencies, State and local governments, and members of the public (63 **Federal Register** 1976).

Twenty-one letters were received, each containing varying numbers of comments. The local jurisdictions that responded included the County of San Diego and the City of Temecula in Riverside County. The Service sent letters to 13 people considered experts with vernal pool habitat to solicit comments on the Draft Recovery Plan. Responses were received from 4 of these experts, who provided comments and recommendations on the need to protect vernal pool habitat in southern California and the associated endemic suite of species.

The number of letter received by affiliation:

Federal agencies	6 letters
State government	1 letter
Academia/professionals	8 letters (4 peer reviewers)
Environmental/conservation organizations	no letters
Local governments	2 letters
Business/Industry	1 letter

Summary of Significant Comments and Service Responses

The Service reviewed all of the comments received during the comment period. Comments received were generally positive, providing recommendations for research/conservation strategies, correcting and updating specific locality descriptions and information, and were

generally favorable and in support of the goal and approach taken. All applicable comments have been addressed in, or incorporated into, the body of the Final Recovery Plan. The substantive comments and the Service's response to each are summarized as follows:

Comment: Further surveys are needed in the Goleta and Transverse Management Areas, in the existing vernal pool complexes, and to locate new populations and pool complexes.

Response: The Service agrees that further surveys are a vital component of endemic vernal pool species recovery. Local involvement is critically needed for the protection and management of these species. The recovery plan calls for additional research to be conducted under the Goleta and Transverse Management Area and under recovery criteria 2.

Comment: The justification for the 10 consecutive years of monitoring, required for vernal pools to reach recovery, is not clear.

Response: To allow for periods of drought or other adverse natural environmental conditions, 10 consecutive years of monitoring (based on historic weather records), is able to capture fluctuations in weather patterns (i.e., El Niño events). Although 10 consecutive years of monitoring may not capture all variables, the Service maintains that it is a reasonable time period to assess the stability of a given vernal pool ecosystem.

Comment: Define vernal pool - recommend using the U.S. Army Corps of Engineer's definition.

Response: The Service has included the U.S. Army Corps of Engineer's definition of a vernal pool (see Appendix B), as well as, incorporating a more general ecological definition in the beginning of the document under the Introduction.

Comment: The recovery plan should provide for more specific details and criteria on the implementation on the recovery plan and how habitat will be acquired and restored.

Response: The recovery plan provides guidance and direction on the actions needed to protect and manage vernal pool habitat and the associated endemic species, so that it is no longer endangered. It is not intended to provide specific and rigid instructions for these activities. Differing situations will necessarily require that the appropriate activities be tailored for each situation.

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September 1998