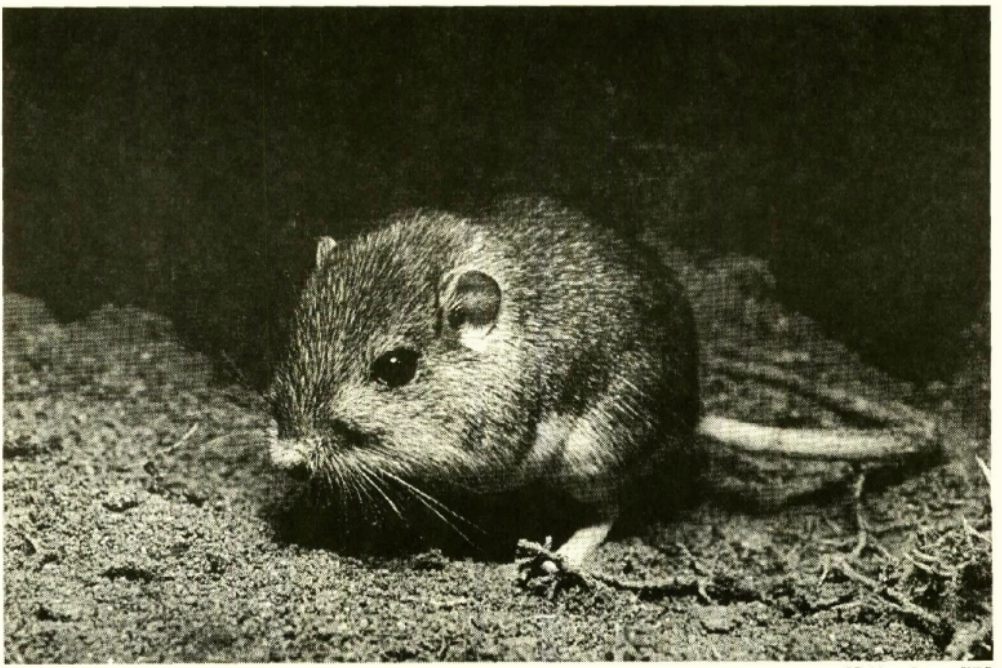
Recovery Plan for the Pacific Pocket Mouse

(Perognathus longimembris pacificus)



Pacific Pocket Mouse

(*Perognathus longimembris pacificus*)

Recovery Plan

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Region 1
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Date: 9/28/98

DISCLAIMER

Recovery plans delineate actions required to recover and/or protect listed species. We (the U.S. Fish and Wildlife Service) publish plans. Sometimes the plans are prepared with the assistance of recovery teams, contractors, State agencies, and other affected and interested parties. Recovery teams serve as independent advisors to us. Plans are reviewed by the public and submitted to additional peer review before they are adopted by us. Objectives of the plan will be attained and any necessary funds made available, subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not obligate other parties to undertake specific tasks and may not represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation, other than us. They represent our official position only after they have been signed by the Regional Director or Director as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

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EXECUTIVE SUMMARY

Current Status: The Pacific pocket mouse (*Perognathus longimembris pacificus*) historically occurred on the immediate coast of southern California from Marina del Rey and El Segundo in Los Angeles County, south to the vicinity of the Mexican border in San Diego County. The subspecies has been recorded up to approximately 4 kilometers (2.5 miles) inland. Rediscovered in 1993 after a 20-year period during which the subspecies was not detected, the subspecies is currently known to occur at the Dana Point Headlands, Orange County, and two locations on the Marine Corps Base, Camp Pendleton in San Diego County. Current occupied habitat for the Pacific pocket mouse is estimated to be less than 400 hectares (1,000 acres) at the three known localities combined.

Habitat Requirements and Limiting Factors: The Pacific pocket mouse has occurred on fine-grain, sandy substrates in open coastal sage scrub, coastal strand, coastal dune, and river alluvium habitats. The extant populations at the three known locales occur within open coastal sage scrub habitats. The subspecies is imminently threatened by habitat destruction and fragmentation, documented depredation by domestic cats, and recreational activities.

Recovery Objective: Delisting, with an interim objective of reclassification to threatened status.

Recovery Criteria: We may consider reclassifying the Pacific pocket mouse to threatened status if and when:

1. Ten populations are independently viable and stable or increasing, and their habitats are secure (free of risk of loss) and fully protected through fee ownership by a resource agency or conservation program, conservation easement, or other means of permanent protection. Populations of Pacific pocket mice shall be considered viable if the appropriate analysis of measured population parameters indicate that each of the 10 populations has a 95 percent or greater chance of surviving for 100 years.

2. Occupied habitat consists of a minimum of 2,000 hectares (4,940 acres) that are secure and fully protected through fee ownership by a resource agency or conservation program, conservation easement, or other means of permanent protection.

3. All Pacific pocket mouse populations are managed through a program to maintain genetic diversity for future generations.

4. All Pacific pocket mouse populations and essential habitat are managed so that current and potential threats (e.g., predation and disease) are eliminated or minimized to the extent that each population is not at risk of extirpation. Essential habitat is defined to mean both suitable and potential habitat that is necessary for the full recovery of the subspecies.

We may consider delisting the Pacific pocket mouse if and when:

1. All actions necessary for reclassification to threatened have been implemented.

2. Any necessary protection, restoration and enhancement activities (on all sites that have been determined to be essential to the recovery of the subspecies) are successfully completed.

3. Populations of the Pacific pocket mouse should be representative of the full (existing) genetic variability and historical geographical range of the subspecies and occur in habitats that collectively represent the full range of parameters observed and described in the past or during prescribed, future research and monitoring efforts.

Actions Needed and their costs:

1. Identify and protect all extant populations and essential habitat.	$511,000
2. Prepare and implement management plans.	2,900,000

3. Enhance and expand occupied and potential habitat.	698,000
4. Conduct research on life history, ecology, and population biology.	1,053,000
5. Identify and implement measures to create additional populations.	2,096,000
6. Enhance public awareness.	211,000
Total	$7.5 million

These costs exclude land acquisition and other, as yet, undeterminable costs.

Dates of Reclassification: Reclassification to threatened status may occur by the year 2023, assuming full implementation of this plan. Research and other tasks prescribed by this plan are necessary to determine the potential for complete recovery and delisting. Accordingly, the date of delisting is presently uncertain.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

I. Introduction

The Endangered Species Act (Act) calls for preparation of recovery plans for those listed species that are likely to benefit from the effort. A recovery plan must establish, if practicable, recovery goals and objectives, describe site-specific management actions recommended to achieve those goals, and estimate the time and costs required for recovery. A recovery plan presents a set of recommendations.

Species Overview

The Pacific pocket mouse (*Perognathus longimembris pacificus*) is endemic to the coast of southern California from Marina del Rey and El Segundo in Los Angeles County, south to the vicinity of the Mexican border in San Diego County. The subspecies occurred on fine-grain, sandy substrates and inhabited coastal strand, coastal dunes, river alluvium, and coastal sage scrub habitats growing on marine terraces within approximately 4 kilometers (2.5 miles) of the ocean. Currently, the subspecies is found predominantly on sandy substrates within coastal sage scrub habitats.

We (the U.S. Fish and Wildlife Service) emergency listed the Pacific pocket mouse in February 1994 (59 *FR* 5306) following the rediscovery of a single population at the Dana Point Headlands in 1993. Upon expiration of the emergency rule, we federally listed the subspecies as endangered on September 29, 1994, in accordance with the Endangered Species Act (59 *FR* 49752). We gave the subspecies a recovery priority number of 3C which means it is facing a high degree of threat, including conflicts with development projects, yet has a high recovery potential. The California Department of Fish and Game also designated the Pacific pocket mouse as a "Species of Special Concern".

In 1995, Pacific pocket mice were discovered in two general locations on the Marine Corps Base, Camp Pendleton, in San Diego County. Current occupied habitat for the Pacific pocket mouse is estimated to total less than 400 hectares (1,000 acres) at all sites combined. None of the nine historic locales (Erickson

1994, Erickson 1998) are permanently protected and all have been damaged or are threatened by habitat destruction or fragmentation, human-caused fire, or other disturbances. Populations at six of the historic localities apparently have been extirpated.

This recovery plan summarizes the taxonomy of the Pacific pocket mouse, its historic and current distribution, known features of habitat and life history, and the current threats to the subspecies. The present status of conservation efforts on behalf of this subspecies is also described. In Part II of this plan, recommendations are made for a long-term program to affect the recovery of the subspecies.

Description

All members of the family Heteromyidae are nocturnal granivores with external, fur-lined cheek pouches. The body pelage of the little pocket mouse (*Perognathus longimembris*) is silky. The little pocket mouse shows wide geographic variation in pelage color (Hall 1981). The dorsal pelage is predominately brown, pinkish buff or ochraceous buff. The ventral pelage is whitish. There are typically two small patches of lighter hairs at the base of the ear. The tail can be either distinctly or indistinctly bicolored. The Pacific pocket mouse is among the smallest subspecies of little pocket mice, ranging up to 131 millimeters (5.2 inches) in length from nose to tip of tail (Hall 1981). Little pocket mice weigh 7 to 9 grams (0.25 to 0.33 ounces).

Taxonomy

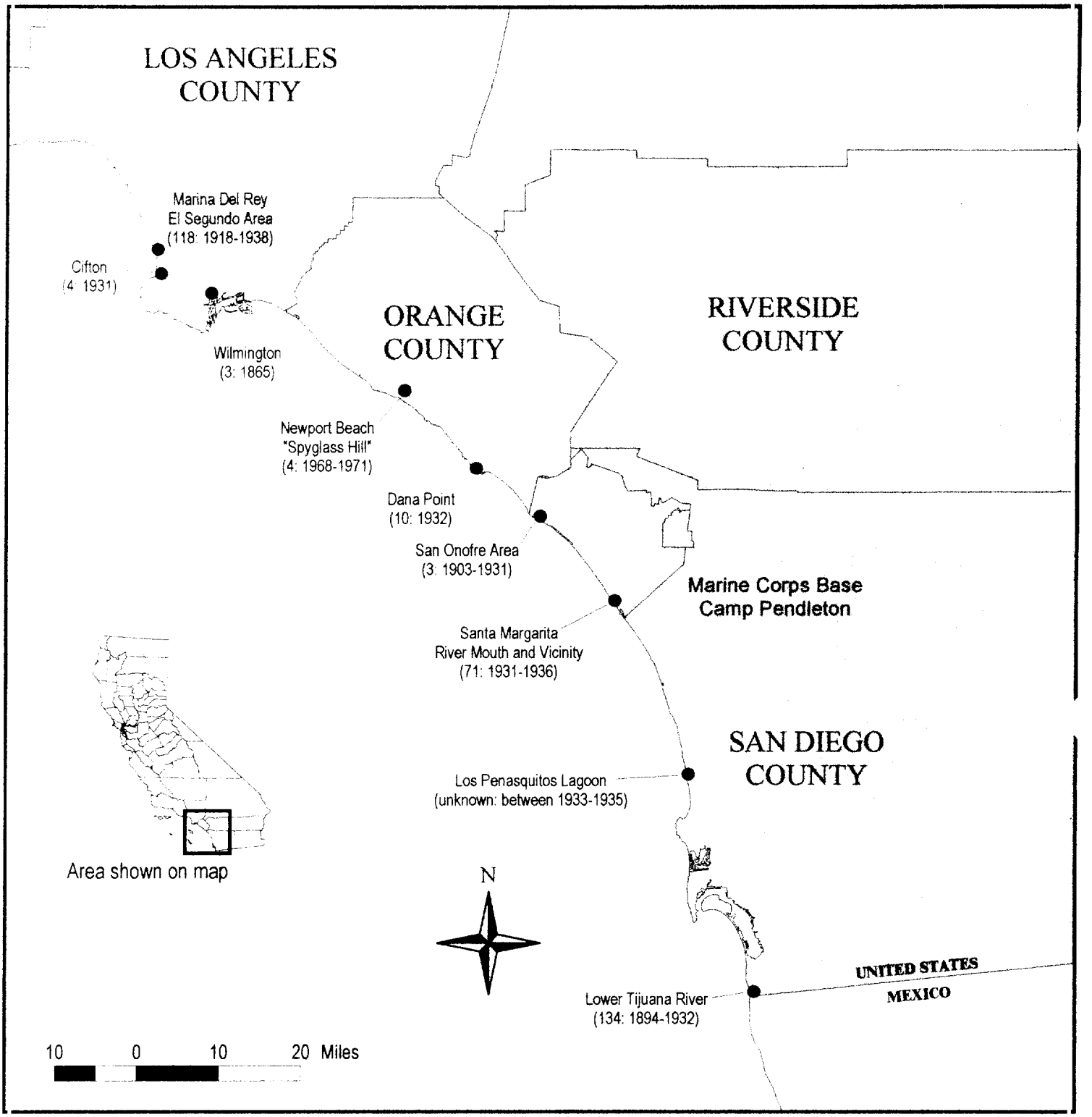
The Pacific pocket mouse (*Perognathus longimembris pacificus*) is 1 of 19 recognized subspecies of the little pocket mouse (*Perognathus longimembris)* (Hall 1981). This subspecies is the smallest member of the family Heteromyidae, which consists of spiny pocket mice (*Heteromys* and *Liomys*), pocket mice (*Perognathus* and *Chaetodipus*), kangaroo rats (*Dipodomys*), and kangaroo mice (*Microdipodops*).

The Pacific pocket mouse was originally described by Mearns (1898) as a distinct species, *Perognathus pacificus*, based on the type specimen that was collected on the shore of the Pacific Ocean at "Mexican Boundary Monument 258" in San Diego County, California. Although von Bloeker (1931a,b) initially recognized the Pacific pocket mouse as a distinct species, he subsequently concluded *P. pacificus* represented two subspecies of the little pocket mouse, *P. longimembris pacificus* and *P. l. cantwelli* (von Bloeker 1932). Subsequent to a biometric analysis of 331 specimens of the little pocket mouse, Huey (1939a) recognized *P. l. pacificus* inclusive of the two subspecies described by von Bloeker (1932). Hall (1981) and Williams *et al.* (1993) continued to rely on that treatment.

Historic and Current Range

The Pacific pocket mouse is endemic to the immediate coast of southern California from Marina del Rey and El Segundo in Los Angeles County, south to the vicinity of the Mexican border in San Diego County (Hall 1981; Williams *et al.* 1986; Erickson 1993). The subspecies has not been recorded outside of California (Williams *et al.* 1993; Erickson 1993) and has not been reliably reported more than 4 kilometers (2.5 miles) from the ocean. Erickson (1993) noted further that the Pacific pocket mouse has not been reliably recorded above 180 meters (600 feet) in elevation, but Spencer (1997) noted that elevation and distance from the coast are correlated values and doubted that elevation was relevant.

Range-wide survey data to date and all other relevant information indicate that the Pacific pocket mouse was and is a patchily distributed subspecies that has been described as never common or rare on carefully studied plots or, at best, historically and locally "...abundant on sandy bottoms near the coast of San Diego County..." (Bailey 1939). The available data indicate that the historical distribution of the Pacific pocket mouse was much more extensive prior to the large-scale development of the coastal lowlands of southern California. Between 1894 and 1972, the Pacific pocket mouse was recorded from 9 general locales and 30 specific localities from Los Angeles County south to the Mexican border in San Diego County (Figure 1) (Erickson 1998). Prior to the recent discovery or



Source: Adapted from Erickson, 1993; Erickson 1994.

Legend
(134: 1894-1932)
Years collected
Individuals in
museum collection

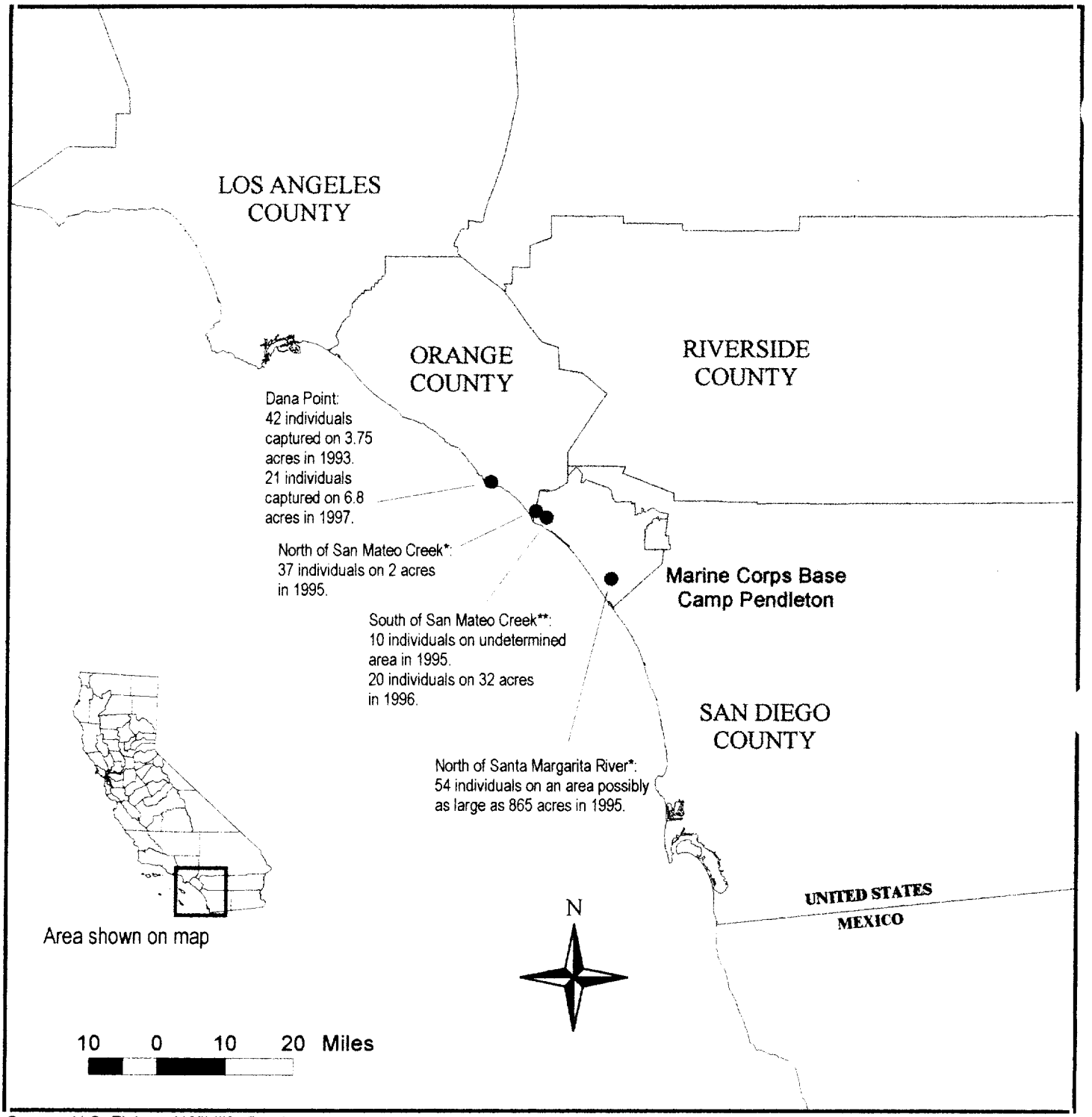
Figure 1. Historic localities, based on museum records.

rediscovery of the extant populations at the three known locales (Figure 2), approximately 80 percent of all Pacific pocket mouse records were from 1931 or 1932 (Erickson 1993).

There are three historic localities for the subspecies in Los Angeles County: Marina del Rey/El Segundo, Wilmington, and Clifton. There have been no records of Pacific pocket mice from Los Angeles County since 1938 (Erickson 1993; Brylski 1993). The Pacific pocket mouse has been confirmed at two locales in Orange County: the San Joaquin Hills and Dana Point. The only known extant Pacific pocket mouse population in Orange County occurs on the Dana Point Headlands, a historic Pacific pocket mouse locality that was discovered in the 1930's. The Pacific pocket mouse was known historically at four localities in San Diego County: San Onofre, the vicinity of the Santa Margarita River Estuary, Penasquitos Lagoon, and the lower Tijuana River Valley (Erickson 1994, Erickson 1998). Figure 1 depicts the historic localities where individuals were collected for museum research, or, in the case of "Spyglass Hill" in Newport Beach, where research was conducted on rodent community ecology (Meserve 1972; M'Closkey 1972).

In 1993, presence/absence surveys resulted in the capture of 25 to 36 individual Pacific pocket mice at Dana Point Headlands, spread over approximately 1.4 hectares (3.5 acres) of occupied habitat (Brylski 1993). Twenty-one individual Pacific pocket mice were captured at Dana Point Headlands in 1997 on approximately 2.8 hectares (6.8 acres) of occupied habitat (U.S. Fish and Wildlife Service 1998).

Two locations with extant Pacific pocket mouse populations were discovered (or rediscovered) in 1995 on the Marine Corps Base, Camp Pendleton in the vicinity of two historic locales. One location consists of two separate small pockets of animals detected immediately north and south of San Mateo Creek. The northerly site, which has been designated by Camp Pendleton as the San Mateo-North Site ("SMN"), is approximately 1.4 kilometers (0.9 mile) from the coast. The southerly site, which has been designated as the San Mateo-South Site ("SMS"), is approximately 2.1 kilometers (1.3 miles) from the coast. Presence/absence



Source: U.S. Fish and Wildlife Service
Brylski (1993, unpublished data)

* Minimum number of individuals known to occur at time of survey.

** North and South San Mateo Creek, map represent a single population.

Figure 2. Locations of known populations

surveys have been performed in much of this area as well as preliminary work aimed at determining if the two San Mateo groups are connected or distinct (MBA and LSA 1996; MBA 1997; OGDEN 1997). Twenty individual Pacific pocket mice were captured in 1996 at the San Mateo South site on approximately 13 hectares (32 acres) of occupied habitat; 37 individuals were captured in 1995 at the San Mateo North site on approximately 6.5 hectares (16 acres) of occupied habitat (OGDEN 1997). These surveys were designed to determine only the presence or absence of the Pacific pocket mouse in specific areas and did not employ the more intensive methods necessary to determine population numbers or demographics (OGDEN 1997).

Studies to definitively determine the relationship between these two groups (e.g., degree of exchange of genetic material) are not yet conclusive and will take more time and effort to complete than any of the studies conducted to date, especially if standard live trapping techniques are employed (M. Pavelka, pers. comm. 1998). Any movement occurring between these two groups probably is naturally sporadic and infrequent -- something limited surveys would not likely detect. Some impediments to movement now exist, including a roadway, cultivated agricultural lands, and San Mateo Creek wash. Consistent occupation of the San Mateo Creek wash or a "connecting corridor" is unlikely to occur under current conditions as Pacific pocket mice are not likely strong colonizers and probably could not maintain a presence in areas subject to periodic overwash/flooding or other continual disturbances (i.e., agriculture) (M. Pavelka, pers. comm. 1998). Nevertheless, periodic movement between groups across the wash may occur in the long term. As a result, linkage between these groups may prove necessary to maintain genetic integrity, allow for habitat dynamics and ecosystem function, and provide for recolonization should one group become extirpated.

The second, separate Camp Pendleton locale with an extant population occurs on a marine terrace north of the Santa Margarita River in an area that is designated by Camp Pendleton as training area Oscar-1. The extent of occupied habitat in the Oscar-1 training area ranged from approximately 2.5 to 4 kilometers (1.6 to 2.5 miles) from the coast in 1996 (U.S. Fish and Wildlife Service, unpublished data). Fifty-four individual Pacific pocket mice were captured in 1995 at the Oscar-1

site, estimated to possibly be as large as 350 hectares (865 acres) of occupied habitat (OGDEN 1997). Surveys of the coastal area between the two known locales with extant populations on Camp Pendleton have almost been completed and no additional populations have been found (Buck 1997). Although supporting data are presently lacking, both Camp Pendleton locales with extant populations could be part of a metapopulation operating in the long term with populations occupying a dynamic mosaic of habitats. Even though the Pacific pocket mouse appears to be extirpated from suitable patches today, it does not necessarily mean that these populations do not function as a metapopulation. Given the temporal mosaic of suitable and unsuitable patches throughout this subspecies range, it appears more likely that they functioned as a classic metapopulation (A. Davenport, pers. comm. 1998). The locations and relative sizes of the extant populations at the three known locales are depicted in Figure 2.

Fewer than 150 individual mice (when recaptures are considered) were live-captured at these sites from 1993 to 1997. Numerous recent surveys within the historic range of the subspecies have failed to detect additional extant populations (U.S. Fish and Wildlife Service 1994c; U.S. Fish and Wildlife Service, unpublished data; OGDEN 1997, SAPPHOS 1997). Given the small numbers of known populations, the small area known to be currently occupied, and total individual animals captured to date, the Pacific pocket mouse remains highly endangered and vulnerable to extinction.

Habitat Description

Pacific pocket mice occur on fine-grain, sandy or gravelly substrates in the immediate vicinity of the Pacific Ocean (Mearns 1898; von Bloeker 1931a, b; Grinnell 1933; Bailey 1939). Although individual Pacific pocket mice have been collected or observed in several plant communities, the subspecies has narrow habitat requirements and typically occurs on sandy soils. The Pacific pocket mouse was known to inhabit coastal strand, coastal dunes, river alluvium, and coastal sage scrub growing on marine terraces (Grinnell 1933; Meserve 1972; Erickson 1993), however, recent survey efforts have found the subspecies in sandy substrates within coastal sage scrub.

Specific habitat descriptions for various localities are as follows:

(1) Spyglass Hill, San Joaquin Hills, Orange County: The habitat occupied by the population of *P.l. pacificus* studied by Meserve (1976b) comprised open sand (26.1 percent), perennial shrubs (59.9 percent), grasses (11.6 percent), and forbs (2.4 percent).

(2) Tijuana River Valley, San Diego County: There are three accounts of the area. Mearns (1898) noted that the type specimen was captured on "...a flat, often submerged by high ocean tides, at the mouth of the Tijuana River, where it appears to be abundant." Recounting his discovery of a population, von Bloeker (1931a, b) recorded the following: "The mistake was made of trying to trap for *P. pacificus* on the ocean shore in the immediate vicinity of Monument No. 258." Instead, he found them in a neighboring field: "This field gave the appearance from the road of being covered by a dense growth of weeds and brush. However, after I entered the field, small open spaces of alluvial river-bottom sand were encountered that make an ideal situation for pocket mice. Two series of pocket mice were taken from three separate fields in the bed of the Tijuana River near its mouth. In two of the fields, fox-tail, or barleyweed (*Hordeum murinum*), salt grass (*Distichilis spicata*), ice plant (*Mesembryanthemum crystallinum*), star thistle (*Centaurea melitensis*), and telegraph weed (*Heterotheca grandiflora*) were the predominating plants. In the other field, arrow-weed (*Pluchea sericea*), telegraph weed, salt grass, ice plant, and *Croton californicus* were the predominating plants." Bailey (1939) described the Pacific pocket mouse as "abundant on sandy bottoms near the coast".

(3) Oceanside, San Diego County: The Pacific pocket mouse was formerly found "...among the sand dunes along the shore near Oceanside" where the animals were apparently abundant over their restricted habitat. Burrows were noted "under the edges of creeping vegetation". "None was discovered in the high hard clay soil back of the beaches". The burrows were simple and ended in a small cavity or nest chamber a foot or so below the surface (Bailey 1939).

(4) Dana Point Headlands, Orange County: Pacific pocket mice at this locale were detected in open coastal sage scrub dominated by *Artemisia californica*, with fine, sandy soil with bare sandy areas (Brylski 1993). Exposed sandy soil covered 13 percent of the surface area in occupied habitat (Brylski, unpublished data).

The Pacific pocket mice found in the Oscar-1 area on Camp Pendleton currently occur in non-coastal sage scrub habitats, including non-native grasslands and disturbed areas dominated by filaree (*Erodium* sp.). Anecdotal evidence suggests that the areas of dense grasslands are not occupied (to a level of being detectable during surveys), but the small coastal sage scrub, bare ground, and low density non-native grassland patches within the more dense grasslands are occupied. It is unclear whether the mice occupy the dense grasslands in low numbers, use them only for movement to/from the smaller patches of suitable habitat, or only move across those areas following burn events (which are quite frequent within Oscar-1) when the vegetation is less prohibitive to movements. The Pacific pocket mouse also exploits the friable (easily crumbled) soils in berms created during road maintenance in this area. It appears that the occurrence of the Pacific pocket mouse is closely associated with loose or friable soils that permit burrowing (M. Pavelka, pers. comm. 1998).

Life History/Ecology

Table 1 summarizes basic information on the natural history of the Pacific pocket mouse and other *P. longimembris* subspecies. Few studies have been conducted on the ecology and life history of the Pacific pocket mouse. However, the attributes of the little pocket mouse (*P. longimembris*) and the available data that pertain to the Pacific pocket mouse suggest that the subspecies is facultatively or partially fossorial, relatively sedentary, primarily granivorous, and able to become torpid, estivate, or hibernate in response to adverse environmental conditions (Bailey 1939; Kenagy 1973).

Little pocket mice are among the smallest mammals known to hibernate. They hibernate in winter (O'Farrell 1974), typically from September to April. In

contrast to other hibernators that accumulate fat reserves for hibernation, little pocket mice feed on seed caches stored in their burrows. Individuals become torpid when deprived of food for 24 to 36 hours. During hibernation, the body temperature of pocket mice is slightly above that of, and varies directly with, ambient temperature (Bartholomew and Cade 1957). Periods of dormancy have neither a daily or strictly seasonal pattern. In captivity, dormant individuals may show some activity each day within their burrows. Emergence from hibernation in spring (typically in March) correlates with availability of forb and grass seeds (Meserve 1976b).

Relatively little is known of the breeding biology of Pacific pocket mice. Meserve (1972) noted that pregnant and lactating females have been found from April through June with immatures noted from June through September. Brylski (1993) observed lactating females in July of 1993 on the Dana Point Headlands and noted that two litters were produced. One or more of the juveniles in the Dana Point Headlands population were considered to have limited reproductive capabilities (Brylski 1993).

Table 1. Summary of the Natural History of *Perognathus longimembris*

Food Habits

P. longimembris pacificus: Pacific pocket mice prefer seeds and stems of grasses and some forbs (Meserve 1976a); arthropods and larva are eaten somewhat (von Bloeker 1931; Meserve 1972; Meserve 1976a). Bailey (1939) recorded seeds of the following species from the pouches of collected specimens: "*Lotus prostratus*, two species of salt bush, heliotrope, mustard, *Monanthochloe*, *Franseria*, a rush..." From the pouches of collected specimens, von Bloeker (*in* Bailey 1939) recorded the seeds of *Heterotheca grandiflora*, *Chrysothamnus*, *Centaurea melitensis*, *Croton californicus*, *Pluchea sericea*, and *Hordeum murinum*. *P.l. pacificus* was observed to drink water regularly in captivity (Bailey 1939).

Other *P. longimembris*: *P.l. longimembris* typically forage in and adjacent to clumps of vegetation (Brown and Lieberman 1973).

Activity

P. longimembris pacificus: apparently hibernates in winter and generally remains in underground burrows from November to February (Meserve 1972).

Other *P. longimembris*: Kenagy (1973) observed that little pocket mice may stay in their burrows continuously for up to 5 months in winter, alternating between periods of dormancy and feeding on stored seeds. Periods of dormancy apparently may be induced by, or correlated with, food shortage (Kenagy 1973). In the Owens Valley, the activity of *P.l. longimembris* differed in three consecutive winters, ranging from 0 to 5 months of inactivity (Kenagy 1976). In 1969-70, the year of greatest survival (82 percent) and the largest population number (27) for this group, they were active all winter. Precipitation in the season prior to the 1969-1970 winter was three times normal, and plants produced a prolific crop of seeds. This population was active foraging above ground during a different winter following poor seed production, although it is not clear that all individuals were active. Less fit individuals and young of the year may be forced into winter activity due to low food stores. In the same study, males were observed in the spring before females. Winters are less severe in the range of Pacific pocket mouse than of other subspecies, which may explain (and predict) some differences in activity patterns (Spencer 1997).

Table 1. Summary of the Natural History of *Perognathus longimembris*

(Continued)

Density and Movements

P. longimembris pacificus: Thirty-six animals were captured in approximately 1.4 hectares (3.5 acres) of occupied habitat on the Dana Point Headlands in 1993 (Brylski 1993). Ogden (1997) reported a movement (by recapture) of about 22 meters. Most other recaptures are at the first capture location (Spencer 1997). Twenty individual Pacific pocket mice were captured in 1996 at the San Mateo South site on approximately 13 hectares (32 acres) of occupied habitat; 37 individuals were captured in 1995 at the San Mateo North site on approximately 6.5 hectares (16 acres) of occupied habitat (OGDEN 1997).

Other *P. longimembris*: Little pocket mice are often the most abundant rodent in arid habitats. Hall (1946) estimated a population density in Nevada to be as high as 990 individuals/hectare (400 individuals/acre). Home ranges ranged in size from 0.12 to 0.56 hectares (0.30 to 1.4 acres) and populations ranged in density from 1 to 5.5 individuals per hectare (0.4 to 2.2 individuals per acre) in Joshua Tree National Monument, California (Chew and Butterworth 1964). In Nevada, home ranges of males averaged 0.3 to 1.9 hectares (0.7 to 4.7 acres) and home ranges of females averaged 0.5 to 3.1 hectares (1.2 to 7.6 acres). One studied population density fluctuated from 1 to 5.4 individuals per hectare (0.4 to 2.2 individuals per acre).

Little pocket mice have ranged up to 305 meters (1,000 feet) from their burrows in a 24-hour period (Burt and Grossenheider 1976). In the Owens Valley, California, Kenagy (1973) observed movements of less than 50 meters (165 feet).

Population densities of *P. flavus* fluctuate widely: in one Arizona study area, animals were absent for years and yet later were the most abundant species. Average range of movement was 62.5 meters (205 feet) (Chew and Chew 1970) and the average dispersal distance during a lifetime was 202 meters (660 feet) (Brown and Zeng 1989). Home ranges have been reported at 0.11 hectares (0.27 acres) in Arizona and 0.24 to 0.63 hectares (0.6 to 1.6 acres) in New Mexico; males' home ranges are larger than those of females.

Table 1. Summary of the natural history of *Perognathus longimembris*

(Continued)

Reproduction

P. longimembris pacificus: Breeds from April through July. A minority of juveniles may breed within a month of weaning.

Other *P. longimembris*: The species as a whole breeds from January to August, with a peak from March to May. Reproduction is keyed to the availability of green vegetation. Nests are constructed in the burrow with roots, leaves, and other organic materials. Gestation is approximately 22 to 23 days, although extremes of 21 to 31 days were recorded by Hayden *et al.* (1966). Young of the year are capable of breeding in the same season they are born.

Longevity

P. longimembris pacificus: Two *P.l. pacificus* lived about 4 and 6 years in captivity (Bailey 1939). A *P.l. bangsi* trapped as an adult lived 3.5 years in captivity; when it died it was probably more than 4 years old (Behrends 1997).

Other *P. longimembris*: Within a population of *P. longimembris* studied at Joshua Tree (apparently *P. l. bangsi*), 30 percent of the marked individuals survived from one spring to the next (Chew and Butterworth 1964).

Behavior

P. longimembris pacificus: Observations by Bailey (1939) and Meserve (1972) on captive animals indicate this subspecies, like other heteromyids, is aggressively solitary.

Table 1. Summary of the natural history of
Perognathus longimembris

(Continued)

Age Structure and Sex Ratio

P. longimembris pacificus:
Age Structure: At the Dana Point Headlands and San Mateo Creek populations, 61 percent and 75 percent of the captures, respectively, were young of the year (juveniles and subadults). Both studies were conducted during July and August. Despite a potential trap bias (juveniles may be more trappable than adults), the age structure of these populations after reproduction is dominated by juveniles.

Sex Ratio: At the Dana Point Headlands, the sex ratio was 1.1 to 1 (♂♂:♀♀). At the San Mateo Creek population, the sex ratio was 0.8 to 1.

Other *P. longimembris*: No data found.

Predation

P. longimembris pacificus: House cats are known predators on the Dana Point Headlands population.

Other *P. longimembris*: Little pocket mice are preyed upon by owls, loggerhead shrikes, foxes, snakes, and feral cats.

Population Viability

Population viability is the capacity of a population to persist over time and is influenced by both deterministic and stochastic factors. Deterministic factors lead to long-term population trends and may include such things as the amount of suitable habitat, predation rates, reproduction rates, etc. Stochastic factors are random or unpredictable events which may cause an instantaneous extinction, or more commonly, reduce a population to the point where it enters one of several "extinction vortices" or positive feedback loops of biological and environmental interactions that have further negative impacts on a population, possibly leading to its extinction (Gilpin and Soule' 1986). Efforts to manage a species or its habitat can alter the deterministic factors but it may be much more difficult to ameliorate or minimize the stochastic ones.

Generally, small populations are more vulnerable than large ones (Pimm 1991, Noss and Cooperrider 1994). Noss and Cooperrider (1994) identified four major factors which predispose small populations to extinction:

- Environmental variation and natural catastrophes. Unusually harsh weather, fires or other unpredictable environmental phenomena.

- Demographic stochasticity. Chance variation in age and sex ratios or other population parameters.

- Genetic deterioration. Small isolated populations are prone to inbreeding depression and genetic drift or random changes in gene frequencies.

- Metapopulation dynamics. Many species are distributed as systems of local populations linked by occasional dispersal that wards against demographic or genetic deterioration.

Reasons for Listing: Decline and Current Threats

Although suitable Pacific pocket mouse habitat apparently remains in San Onofre and contiguous coastal areas of the Marine Corps Base, Camp Pendleton, San Joaquin Hills, Palos Verdes Peninsula, El Segundo Dunes, and at scattered localities elsewhere in the historic range of the subspecies, this habitat is becoming increasingly scarce and likely will continue to be destroyed, disturbed or otherwise adversely affected by human activities. Williams (1986) concluded that habitat losses resulting from off-road vehicle activities, highways, and urbanization likely were extensive. Erickson (1993) observed that industrial and agricultural development likely were additional factors contributing to the decline of the subspecies. Studies of the effects of habitat fragmentation and depredation on small mammal populations suggest further reasons for the decline of the Pacific pocket mouse. All such major threats directly or indirectly implicated in the decline of the Pacific pocket mouse are individually discussed below.

Habitat Destruction

The conversion of native habitats resulting from urban, suburban, and agricultural development apparently is the leading cause of the large-scale destruction of Pacific pocket mouse habitat. A recent, comprehensive review of the Pacific pocket mouse (Erickson 1993) included considerations of the fate of confirmed (historically-occupied) Pacific pocket mouse habitat. Other, more recent data, pertinent research, and analyses have been integrated into the following account.

The large majority of native habitats within the historic range of the Pacific pocket mouse in coastal Los Angeles, Orange, and San Diego counties have been converted to urban, suburban, and agricultural uses (U.S. Fish and Wildlife Service 1993). Less than 400 hectares (1,000 acres) or 1 percent of approximately 11,340 hectares (28,000 acres) within 3.2 kilometers (2 miles) of the coast in Los Angeles County apparently are undeveloped (U.S. Fish and Wildlife Service, unpublished data, 1993). In Orange County, about 17,600 hectares (43,500 acres), or 81 percent of approximately 21,600 hectares (53,500 acres) within 3.2 kilometers (2 miles) of the coast, have been developed (U.S. Fish and Wildlife

Service, unpublished data, 1993). Land uses in coastal San Diego County are reportedly similar. Oberbauer and Vanderwier (1991) reported that 72 percent of the original coastal sage scrub, 94 percent of native grasslands, 88 percent of coastal mixed chaparral, 88 percent of coastal salt marsh, 100 percent of coastal strand, and 92 percent of maritime sage scrub habitats in San Diego County had been converted to urban and agricultural uses by 1988.

Although the historic distribution of the coastal sage scrub element of Pacific pocket mouse habitat was undoubtedly patchy to some degree, this condition evidently has been greatly exacerbated by urban and agricultural development. All of the published literature on the status of coastal sage scrub vegetation in California supports the conclusion that this plant community is one of the most depleted habitat types in the United States (U.S. Fish and Wildlife Service 1993). In a broader context, the California floristic province, which is recognized as a separate evolutionary center by botanists, is identified by Wilson (1992) as one of the recognized world "hot spots", which are defined to be "...habitats with many species found nowhere else and in greatest danger of extinction from human activity." The California floristic province is the only designated "hot spot" in North America and Mexico (Wilson 1992).

The available information further suggests that the quantity of potential Pacific pocket mouse river alluvium substrate has significantly declined since the subspecies was last recorded in numbers in the 1930's. With few exceptions (such as the Santa Margarita River), essentially all of the rivers and creeks within the historic range of the Pacific pocket mouse are now partially or completely channelized. In many cases (e.g., Los Angeles River, San Gabriel River, Santa Ana River), stream and sediment flows are regulated or inhibited by dams, reservoirs or other water conservation or impoundment facilities (Erickson 1993).

Although described as locally abundant in the Tijuana River Valley environs in south westernmost San Diego County by Mearns (1898) and Bailey (1939), the Pacific pocket mouse has not been detected at that locale since 1932 despite recent, repeated attempts to locate an extant population (Taylor and Tiszler 1991; U.S. Fish and Wildlife Service 1994a,c; U.S. Fish and Wildlife Service 1995a,b;

Montgomery 1995). And, although small populations have been discovered further north in San Diego County in upland areas near the Santa Margarita River and near San Mateo Creek, recent, intense survey efforts at the historically occupied vicinity of the Santa Margarita River mouth similarly did not result in any Pacific pocket mouse detections (OGDEN 1997; Salata 1981; U.S. Fish and Wildlife Service 1994c; Zembal 1984). During the 1930's when Pacific pocket mice were detected at the mouth of the Santa Margarita River, the Marine Corps Base, Camp Pendleton did not exist. The southern half of the Santa Margarita River Estuary was destroyed in the early 1940's during the establishment of Camp Pendleton and the related construction of a boat basin and harbor facilities. In addition, the adjacent Oceanside area has been extensively developed since the Pacific pocket mouse was last recorded there in the 1930's.

Within Orange County, the Pacific pocket mouse has been confirmed at two locales: the San Joaquin Hills and Dana Point. Development of the "Spyglass Hill" area in the San Joaquin Hills began in 1972 and has resulted in the destruction of the site where the Pacific pocket mouse and a number of other small rodent species were studied for a 3-year period (P. Meserve, pers. comm., 1994; R. M'Closkey, pers. comm., 1994; R. MacMillan, pers. comm., 1994; M'Closkey 1972; Meserve 1972). Prior to the rediscovery of the Pacific pocket mouse in 1993 on the Dana Point Headlands (Brylski 1993), the last record of the subspecies was from "Spyglass Hill" in the San Joaquin Hills in 1971 (Erickson 1993). June to October trapping efforts totaling 6,411 trap nights in the San Joaquin Hills and adjacent Laguna Canyon in 1993 resulted in no detections of the Pacific pocket mouse (Erickson, pers. comm., 1993).

The Pacific pocket mouse has persisted on the Dana Point Headlands in southern, coastal Orange County. Given the data and analysis presented by Brylski (1993), it is apparent that from 25 to 36 Pacific pocket mice occupied approximately 1.4 hectares (3.5 acres) of habitat within a coastal sage scrub community at that locale in 1993. This population was located on land under consideration for development (e.g., City of Dana Point, *in litt.*, 1994; EDAW 1994). An April 28, 1998, approval by the Dana Point City Council supported a development proposal on the 49 hectare (122 acre) site with 28 hectares (70 acres) of the site designated

as open space. The Dana Point Headlands population is within this open space area, but the open space is currently slated to remain private property with undetermined conservation protection.

Within Los Angeles County, the Pacific pocket mouse historically was detected in three areas: Marina del Rey/El Segundo/Hyperion, Wilmington, and Clifton. Two of the three historic locales for the Pacific pocket mouse (Clifton and Wilmington) in Los Angeles County have been developed (Erickson 1993). We are currently unaware of potential Pacific pocket mice habitat at these two locales; none was disclosed or revealed as a result of our request for information (U.S. Fish and Wildlife Service 1994c). The third historic locale (Marina del Rey/El Segundo/Hyperion) apparently has been substantially altered since the subspecies was last detected there (Erickson 1993; P. Brylski, *in litt.*, 1993). The Hyperion area, which formerly contained relatively large expanses of coastal strand and wetland habitats, has been extensively developed. Although potential habitat remains at the El Segundo Dunes, the available information suggests that it is unlikely that the Pacific pocket mouse presently occurs there (P. Brylski, *in litt.*, 1993). The El Segundo Dunes within the Los Angeles Department of Airports property were extensively trapped in 1997 with negative results (SAPPHOS 1997, B. James, pers. comm. 1998). This trapping was performed in conjunction with environmental baseline studies for the Los Angeles International Airport 2015 Expansion Master Plan Project. There have been no records of the Pacific pocket mouse in Los Angeles County since 1938 (Erickson 1993; Brylski, *in litt.*, 1993; B. James, pers. comm. 1998). Given the available information at the time, Williams (1986) concluded that it was probable that all populations north of the San Joaquin Hills in Orange County were extinct.

Habitat Fragmentation and Degradation

Habitat fragmentation is thought to reduce habitat quality and increase local extirpation of native wildlife (e.g., Terborgh and Winter 1980; Wilcox 1980; Ehrlich and Ehrlich 1981; Wilson 1992; Bolger *et al.* in press; Soule' *et al.* 1992). Based on studies of native bird, rodent, and flowering plant species persistence in chaparral and coastal sage scrub habitat remnants in coastal San Diego County,

California, Soule' *et al.* (1992) concluded that "[t]he effects of fragmentation in a scrub habitat in California on 3 taxa (plants, birds, and rodents) are concordant. Extinctions within the habitat remnants occur quickly and the sequence of species disappearances of birds and rodents is predictable based on population density in undisturbed habitat." Terborgh and Winter (1980) observed previously that "[r]arity proves to be the best index of vulnerability."

Bolger *et al.* (*in press*) concluded that "[f]ragments support fewer species [of native rodents] than equivalently sized plots in large plots of unfragmented chaparral indicating that local extinctions have occurred following insularization." Given a composite of the available data on the local status and distribution of select species within the study area in coastal San Diego County, Soule' *et al.* (1992) remarked that it was possible to assess with reasonable accuracy the date that a particular habitat remnant became isolated.

Soule' *et al.* (1992) further noted that "...urban barriers including highways, streets, and structures, impose a very high degree of isolation." Similarly, Ehrlich and Ehrlich (1981) observed that "smaller animals may also suffer fragmentation of their populations by highways, railways, canals, etc., changing population structures and making the remaining populations smaller and more subject to random extinction. One study has indicated that a four-lane divided highway may be a barrier to the movement of small forest mammals equivalent to a river twice as wide (Ehrlich and Ehrlich 1981). Although not a forest animal, the Pacific pocket mouse must now be considered rare by any standard and therefore vulnerable to the effects of continuing habitat destruction and fragmentation (see Terborgh and Winter 1980).

Population persistence and expansion should be maintained by precluding actions which result in physical barriers to movement, habitat fragmentation, or an increase in edge effects. All ecosystem components of Pacific pocket mouse habitat should be maintained or reestablished, including predator-prey relationships, retention of pollinators, linkages with other habitats necessary for ecosystem functioning, maintenance of corridors between potential populations,

and protection of habitat currently unoccupied due to successional cycling of the vegetation community.

Wildfires due to anthropogenic ignitions have contributed to the loss, degradation, and fragmentation of coastal sage scrub vegetation in southern California (U.S. Fish and Wildlife Service 1993). Most of these human-caused fires occur during the fall in conjunction with Santa Ana wind conditions. Natural fires most often likely occurred during the late spring and early summer (May to June) in conjunction with occasional late season lightning storms (R. Minnich, pers. comm. 1989). Lightning (an ignition source) more rarely strikes the coast than the foothill-mountain region and prehistoric fires probably burned from the foothills to the coast infrequently (R. Minnich, pers. comm. 1989). Natural fires near the coast (generally consisting of coastal sage scrub) likely occurred episodically and less frequently than in the foothills (more often composed of chaparral). Coastal sage scrub is a fire adapted plant community (Beyers and Wirtz 1996), but unlike for chaparral, little biological justification exists for maintaining high fire frequency in coastal sage scrub (Zedler 1996). Coastal sage scrub does not appear to have high senescence risks (the chance that long intervals without fire will result in population decline or local extinction) as compared to immaturity risks (the chance that populations will be harmed by recurrence of fire when insufficient time has elapsed for regrowth or build up of seed reserves) (Zedler 1996). An increased fire frequency may favor invasion of exotics in coastal sage scrub (Zedler 1996).

The seasonality, size, intensity, and frequency of fire in coastal southern California has likely changed drastically in the last century (R. Minnich, pers. comm. 1989). Most of coastal southern California's remaining natural areas are likely subject to less frequent, aseasonal, and comparatively larger/hotter wildfires than occurred prehistorically. Camp Pendleton habitats likely suffer from an increased fire frequency, with many fires occurring aseasonally. Although it is true that the largest areas of relatively unfragmented coastal sage scrub vegetation remain on the Marine Corps Base, Camp Pendleton, over 6,070 hectares (15,000 acres) of native vegetation, much of it coastal sage scrub, have burned on the Base during 3 recent years as a result of fires started incidental to military training

activities. Two of these fires consumed over 2,630 hectares (6,500 acres) of coastal sage scrub vegetation. High fire frequencies and the lag period associated with recovery of the vegetation may significantly reduce the viability of affected habitats throughout much of the current and historic ranges of the Pacific pocket mouse.

Some habitats that would otherwise generally remain sub-optimal for Pacific pocket mouse may be repeatedly manipulated such that they will support the taxon in the short term. Other habitat areas that would typically (and likely historically did) support optimal habitat may be made occupiable by removal of some perturbing influence (such as reduction of exotic species cover). A portion of the Oscar-1 population of Pacific pocket mice on Camp Pendleton currently occurs in areas that have burned recently, either by wildfire or controlled burning, including some areas that have been burned annually for several years (Buck 1997). The Pacific pocket mice found in the Oscar-1 area on Camp Pendleton currently occur in non-coastal sage scrub habitats, including non-native grasslands, and disturbed areas dominated by filaree (*Erodium* sp.). Anecdotal evidence suggests that the areas of dense grasslands are not occupied (to a level of being detectable during surveys), but the small coastal sage scrub, bare ground, and low density non-native grassland patches within the more dense grasslands are occupied (M. Pavelka, pers. comm. 1998).

Little is known of the relation between fire and Pacific pocket mouse habitat. Fire of unknown frequency, intensity, and season may intermittently create or sustain Pacific pocket mouse habitat mosaics. Two of the three locales with extant populations of the Pacific pocket mouse occur solely in open coastal sage scrub habitats and are absent from adjacent patches of dense coastal sage scrub. Disturbance to the dense shrub canopy, as a result of disturbances such as fire, may improve habitat for the subspecies. In the short term, fire in the proper season and intensity could temporarily reduce shrub canopy coverage that may be too dense to provide optimum habitat for the Pacific pocket mouse (e.g., over much of the Dana Point Headlands and San Mateo sites). By contrast, fire could potentially eliminate occupied habitat for the Pacific pocket mouse and may also result in development of a denser (and unacceptable) understory of non-native

annual grasses and sprouts of native shrubs. Previously, it was reported that increased fire frequency may contribute to the type conversion of coastal sage scrub to annual grassland habitats (U.S. Fish and Wildlife Service 1993). Currently, minimal data are available to evaluate the overall effects of fire on Pacific pocket mice or their habitat. We conclude that current fire prevention measures and unnaturally high fire frequencies resulting from anthropogenic ignitions may directly or indirectly impact the Pacific pocket mouse. It will be necessary to evaluate the role of fire prevention and management practices to develop measures that are consistent with the long-term maintenance of Pacific pocket mouse habitats.

The vegetation of the marine terraces from Dana Point to southern Camp Pendleton today is heavily influenced by annual grasses and other non-native species, partly in response to exotic plant introductions and agricultural use of these lands during the late nineteenth and early twentieth centuries (as well as the fire regime changes noted above). Such dense exotic vegetation, in concert with relatively hard soils, probably precludes occupation by the Pacific pocket mouse, whereas relatively low densities of animals may have historically occurred in the same areas in association with the original, more open, native vegetation.

Historic agricultural uses appears to have had lasting, adverse effects on Pacific pocket mouse habitat function. Results of surveys on Camp Pendleton illustrated a potentially strong negative relationship between known Pacific pocket mouse distribution on Base and areas that have been farmed in the past (OGDEN 1997). No Pacific pocket mouse captures occured within these former agricultural areas, which include many sites that otherwise appear suitable (OGDEN 1997). One of the largest blocks of high potential habitat that has not been farmed supports the largest population on Base (Oscar-1); the other population on Base seems likewise restricted to unfarmed portions of the high potential soils in the San Mateo area (OGDEN 1997). Unfortunately, it appears that no extant population is adjacent to an agricultural area that has gone fallow, which would help confirm this potential relationship.

As a consequence of a recent survey, we (U.S. Fish and Wildlife Service 1994a) reported that selected habitats and lands in a historically occupied Pacific pocket mouse locality apparently have been adversely affected by pedestrian and horse traffic, artificial lighting, and the presence of non-native rodent species. All factors considered, heteromyid rodents, including the Pacific pocket mouse, may be more susceptible to the adverse effects of the human presence than cricetid rodents (R. MacMillan, pers. comm., 1994).

Artificial night-time lighting may cause problems for nocturnal rodents such as the Pacific pocket mouse through potential modification of predation rates, obscuring of lunar cycles, and/or causing direct habitat avoidance. Artificial lighting has the potential to increase the efficiency of predators and could have a negative effect on the Pacific pocket mouse (M. Pavelka, pers. comm. 1998). Illumination of foraging habitat by artificial light during Pacific pocket mouse surface activity periods likely makes detection by predators easier, potentially increasing the predation rate by owls, coyotes, fox, house cats, etc. Artificially lit habitat areas may also be directly avoided by Pacific pocket mouse for unknown behavioral reasons. Artificially lit but otherwise apparently suitable habitat was avoided by Heteromyid rodents (evidenced by absence of burrows), while adjacent unlit habitat areas were occupied, in a survey performed on Fallbrook Naval Weapons Station (A. Davenport, pers. comm. 1998).

Exotic Argentine ants are invading coastal sage scrub areas near Pacific pocket mouse habitats. These ants could have adverse direct or indirect effects on Pacific pocket mouse populations (R. Fisher, pers. comm. 1997). Argentine ants are known to exclude most native ant species upon invasion in coastal southern California habitats (R. Fisher, pers. comm. 1998). Ants are a major ecosystem component of most terrestrial ecosystems (Wilson 1992). Argentine ants could adversely affect Pacific pocket mouse individuals (such as nestling mortality) and burrow sites directly. They could also affect seed producing plants, or could disrupt key ecosystem functions, including those typically carried out by native ants. Invasion of these ants may be expedited by development and associated irrigation.

In summary, habitats within the historic range of the Pacific pocket mouse have been highly fragmented or degraded by highways, roads, structures, lighting, foot traffic, other human activities, and the proliferation of non-native plant and animal species. Fragmented and degraded habitats support smaller populations, which are more susceptible to random extinction events.

Depredation

Feral or domestic cats are one of the existing threats to the population of Pacific pocket mice at the Dana Point Headlands. Feral and domestic cats are known to be efficient predators of rodents (e.g., Hubbs 1951; George 1974). Pearson (1964) concluded that the removal of 4,200 mice from a 14-hectare (35-acre) test plot was accomplished largely by 6 cats over 8 months. For the Anastasia Island field mouse (*Peromyscus polionotus phasma*), a reduction in feral cats was followed by an immediate and sustained increase in mouse population density (Frank 1993). Phil Brylski examined one dead specimen of Pacific pocket mouse taken from the mouth of a house cat (P. Bryski, pers. comm. 1998).

Other non-native species, including the red fox (*Vulpes vulpes*), are also potential predators of the Pacific pocket mouse. The explosive proliferation of non-native populations of red foxes in coastal southern California is well documented (e.g., Lewis *et al.* 1993). Given the relative abundance of the red fox in coastal southern California (Lewis *et al.* 1993) and the fact that the diet of red foxes invariably include mice (Ingles 1965; Jameson and Peeters 1988; Burkett and Lewis 1992; Lewis *et al.* 1993), red foxes could substantially impact populations of Pacific pocket mice where they are sympatric.

Conservation Efforts: Research

Research on the life history and ecology of the Pacific pocket mouse has been limited (see previous section on life history and ecology). It should be noted that much of the information concerning the Pacific pocket mouse was collected incidental to more general rodent studies or is derived from other subspecies that

may not apply to the Pacific pocket mouse (e.g., daily and seasonal activity patterns, home ranges, diet, etc.) (Behrends 1997).

Conservation Efforts: Management and Protection

The only known extant populations of the Pacific pocket mouse occur on two areas on the Marine Corps Base, Camp Pendleton and on a small parcel of land on private property at the Dana Point Headlands. To date, recovery activities to achieve the protection and conservation of the Pacific pocket mouse have been recent and limited in scope. Future efforts will, by necessity, include habitat protection and species management accomplished through the cooperation of Federal, State, and local agencies; species experts; landowners; and other interested citizens.

Federal Actions

Section 7(a) of the Act, as amended, requires Federal agencies to evaluate their actions with respect to any species that is proposed or listed as endangered or threatened and with respect to its critical habitat, if any is designated. Regulations implementing this interagency cooperation provision of the Act are codified at 50 CFR Part 402. If a species is listed, section 7(a)(2) requires Federal agencies to ensure that activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of such a species or to destroy or adversely modify its critical habitat. If a Federal action may affect a listed species or its critical habitat, the responsible Federal agency must enter into formal consultation with us (the Service) in accordance with the regulations at 50 CFR 402. Federal agencies that authorize, fund, or carry out activities that may affect the Pacific pocket mouse include the Service; Department of the Navy; Marine Corps Base, Camp Pendleton; the Army Corps of Engineers; and Federal Highways Administration. These agencies, which are all individually charged to utilize their resources to further the purposes of the Endangered Species Act, are individually treated below:

1) U.S. Fish and Wildlife Service: Since the designation of the subspecies as a candidate for listing in 1985, we have attempted to conserve the subspecies by seeking the support and cooperation of other government agencies and the interested public to achieve that goal. In an open letter dated May 7, 1992 to local planning agencies and concerned parties within the historic range of the subspecies, we solicited relevant information and comments pertaining to the status, distribution, and the possible listing of the Pacific pocket mouse and eight coastal plant species. Prior to listing the subspecies, we coordinated with local jurisdictions on specific projects in the range of the Pacific pocket mouse and asked for focused surveys for the subspecies and the avoidance of impacts to potential habitats. Also prior to listing, we contacted the Marine Corps Base, Camp Pendleton natural resource office personnel regarding the precarious status of the Pacific pocket mouse and asked for their assessment of the status and distribution of the subspecies within their jurisdiction.

Since the subspecies was listed, we, in accordance with our responsibilities under the National Environmental Policy Act and Endangered Species Act, have continued to ask for focused Pacific pocket mouse surveys in appropriate habitats throughout the historic range of the subspecies. We have also conducted two such surveys on our own (National Wildlife Refuge) lands. We have authorized, in partnership with the California Department of Fish and Game, projects in accordance with section 6 of the Endangered Species Act that provide for the identification and delineation of potential habitat and, hopefully, additional extant populations. We are also undertaking studies on Camp Pendleton to gather information on habitat affinities and demographics of the Pacific pocket mouse, and have performed presence/absence surveys on our Refuge lands in the Tijuana Estuary area. In addition, we have issued recovery permits in accordance with section 10(a)(1)(A) of the Endangered Species Act that allow for appropriate and prudent Pacific pocket mouse surveys and management.

2) The Department of the Navy (Navy): The Navy is charged with protecting trust resources on multiple areas of land containing potential Pacific pocket mouse habitat. Biologists with the Navy's Environmental Planning and Natural Resource Management Division (Southwest Division) have coordinated and conducted five

focused surveys for the Pacific pocket mouse on Federal lands. Because no Pacific pocket mice have been detected during the course of these surveys, it is likely that none will be directly affected by impending projects.

3) Marine Corps Base, Camp Pendleton: Camp Pendleton has authorized, coordinated, and funded multiple surveys for the Pacific pocket mouse in recent years. Focused surveys for the Pacific pocket mouse were conducted in appropriate habitats along the coastal portion (within 3 miles of the shoreline) of Camp Pendleton during 1994, 1995, 1996, and 1997. Presence/absence surveys for the Pacific pocket mouse are scheduled to be completed in 1998 (Buck 1997); these surveys cover a majority of the potential habitat on base.

For purposes of continued military training and land management activities, the level of survey effort is considered sufficient to conclude absence of the Pacific pocket mouse on those training areas where no Pacific pocket mice were found by this or previous studies. However, construction projects in areas typical of Pacific pocket mouse habitat may still require specific trapping surveys, according to our (Service) protocols (Ogden 1997).

Survey efforts authorized by Camp Pendleton in 1995 led to the discovery of two of the three locales with known extant populations of the Pacific pocket mouse. The Base also developed a habitat evaluation model (Spencer 1997). Camp Pendleton is funding some additional surveys on the Base, with trapping in 1998 on Edson Range Impact Area and in the Stuart Mesa area (Spencer 1997). The Base has noted that they would authorize the translocation of animals from the Base to off-base locales for purposes of establishing new populations. Camp Pendleton personnel are additionally preparing a management plan for Base upland habitats and have begun the process of identifying potential habitats by developing a model that relies on data pertaining to soils, vegetation, elevation, and distance from the coast.

4) U.S. Army Corps of Engineers: The U.S. Army Corps of Engineers (Corps) regulates and permits the discharge of fill into wetlands and waters of the United States in accordance with various provisions of section 404 of the Clean Water

Act. Because the Pacific pocket mouse could occur in areas that are designated as wetlands or waters of the United States, the Corps may regulate some projects that could affect the subspecies. For the International Wastewater Treatment Plant Project in the Tijuana River Valley, the Corps funded surveys for the Pacific pocket mouse within the action area of the project. Like any Federal agency, the Corps is required to consult with us in accordance with section 7 of the Endangered Species Act if their discretionary authority to issue permits "may affect" federally listed species, including the Pacific pocket mouse. Avoidance or compensation measures are generally integrated into projects that may affect listed species.

5) Federal Highways Administration: The Federal Highways Administration has required and authorized focused surveys for Pacific pocket mice in conjunction with the proposed Foothill (South) Transportation Corridor project. It is expected that the Federal Highways Administration will continue with informal consultation (ongoing as of April 1998) and will initiate formal consultation with us in accordance with the regulations at 50 CFR 402 if the project may adversely affect the Pacific pocket mouse population(s) near San Mateo Creek. At the present time, the project applicant, the Transportation Corridor Agencies, apparently is redesigning the proposed project to avoid direct impacts to the local Pacific pocket mouse occupied habitat as it was defined in the last survey effort. The applicant's proposed preferred alternative currently parallels San Mateo Creek. One alternative alignment for the proposed project avoids San Mateo Creek drainage altogether by connecting with Interstate-5 farther to the north. We are evaluating a number of alternatives in coordination with the Federal Highways Administration.

State and Local Actions

California Department of Fish and Game (Department): Because the Pacific pocket mouse is not a State-listed threatened or endangered species, it is not presently protected in accordance with the California Endangered Species Act (CESA). However, the Department formally supported the listing of this

subspecies (K. Berg, California Department of Fish and Game, *in litt.*, 1992) and recognizes the Pacific pocket mouse as a Species of Special Concern.

The California Environmental Quality Act (CEQA), enacted in 1970, provides for the disclosure and mitigation of project impacts to State-designated rare animals and plants in accordance with the CEQA environmental review process conducted by the Department. The rediscovery of the Pacific pocket mouse in 1993 was a result of the Department's formal request for a focused survey for this subspecies on the Dana Point Headlands.

The Department is also responsible for enforcing various codes established to protect native California plants and animals. In this capacity, the Department could issue citations for the unauthorized capture of Pacific pocket mice. As such, authorization to trap and collect the Pacific pocket mouse is excluded from standard collecting and trapping permits.

Most recently, the Department, at the request of the State of California Resources Agency, initiated a Natural Community Conservation Planning (NCCP) program in an attempt to conserve the coastal California gnatcatcher (*Polioptila californica californica*), that species' coastal sage scrub habitat, and other sensitive plant and animal species therein. The NCCP planning effort has developed to the point where a minimum of 30 cities, 2 counties, 35 landowners, and 3 land management agencies have formally committed to develop or to assist in the development of conservation plans that (based on process guidelines finalized by the California Resources Agency on September 1, 1992) meet the standards for allowing incidental take of a federally listed species under section 10 of the Endangered Species Act and are in compliance with the 4(d) rule established for the coastal California gnatcatcher. Landowner/land management agency enrollments, which allow for the destruction of 5 percent of the remaining coastal sage scrub, encompass about 18,200 hectares (45,000 acres) of coastal sage scrub habitat.

Conservation needs of the Pacific pocket mouse or the subspecies' potential habitat are being addressed by several plans being developed under the NCCP program. At the present time, however, the Pacific pocket mouse is not the

primary focus of any NCCP and few subregional plans or individual plans have been completed or implemented that provide for specific protection of the subspecies, with the exception of the approved Central/Coastal NCCP plan in Orange County. This plan has identified potential Pacific pocket mouse habitat within the proposed conservation (reserve) area.

California State Parks (State Parks): A branch of The Resources Agency, State of California, this agency leases land from the Marine Corps Base, Camp Pendleton that contains a significant portion of the north Camp Pendleton Pacific pocket mouse population. State Parks is responsible for managing these lands as well as other park property in southern California that apparently contains suitable Pacific pocket mouse habitat. One of State Parks' land management mandates is the conservation of sensitive species and their habitats. The agency also participates fully in NCCP planning and conservation efforts.

City of Dana Point: The City of Dana Point (City) has expressed an interest in the conservation of the Pacific pocket mouse population and other sensitive animals and plants within their jurisdiction. In this regard, the City suggested the potential need for conservation measures above and beyond those in the Orange County Central/Coastal NCCP plan. On April 28, 1998, the Dana Point City Council unanimously supported a development proposal that calls for 185 homes and 28 hectares (70 acres) of open space on the 49-hectare (122-acre) Dana Point Headlands parcel. Apparently most of this 28 hectare open space, which includes the Dana Point Headland Pacific pocket mouse population, would be privately owned. It is undetermined what retention of this habitat area as private property general open space means for the short- and long-term conservation of the Pacific pocket mouse at this location.

II. Recovery

Recovery Strategy

The recovery strategy for the Pacific pocket mouse consists of two components. The first is to stabilize the existing populations by protecting currently occupied habitat. In addition to providing protection to the known populations, the first component also entails searching for additional populations, and providing protection to any that are found. The second component involves establishing additional populations through: 1) natural colonization/recolonization into nearby and adjacent habitats, coupled with habitat management in these areas, and 2) translocation and/or the release of captive-bred individuals.

The success of translocations into continental (as opposed to island) habitats is poor (Soule' 1996). In the case of the Pacific pocket mouse, the number of individuals available for translocation are likely to be small, making success more tentative (Soule' 1996). Extant populations of Pacific pocket mice currently may not be large enough to support a captive breeding program; a substantial number of individuals probably will be needed to establish a successful breeding program (Behrends 1997). Releases of wild-caught animals are usually more successful than releases of captive bred animals, and introductions of widespread species are more successful than introductions of species with limited ranges (Soule' 1996, Pimm 1991).

Because establishing additional populations is experimental and, to date, has met with limited success with other species, we intend to work with a closely related surrogate species to refine captive breeding and release techniques. If translocation is successful with a surrogate species, we would pursue such techniques with the Pacific pocket mouse. However, prior to the implementation of a translocation or captive breeding program for the Pacific pocket mouse, suitable unoccupied habitat must be identified and research must be conducted on the protocols for both the translocation and captive breeding of *P. longimembris*. The narrative outline to follow and Appendix 2 delineate protocols for captive breeding and translocation techniques and activities.

The immediate recovery goal is to avert the extinction of the Pacific pocket mouse by focusing on short-term strategies to improve the subspecies' prospects for survival. Foremost among these are the immediate protection and restoration of existing populations and the habitat of the subspecies. Considering the extremely small population size of the Pacific pocket mouse (fewer than 150 individual animals were detected from 1993 to 1997) and the fragmentation and depletion of the coastal strand, river alluvium, and coastal sage scrub habitats upon which the subspecies depends, further losses of occupied or potential habitat would seriously reduce the probability of the persistence of the subspecies. Given the small sizes of the populations at the three known extant locales, the apparent sedentary nature of the subspecies (Meserve 1972), and the severe fragmentation and diminution of the subspecies' habitat, the Pacific pocket mouse is highly susceptible to extinction as a result of environmental or demographic factors alone (see Mace and Lande 1991).

Unless, or until sufficient, additional viable populations are discovered and/or established and protected, it is imperative that existing populations be protected and expanded through active management. Loss or degradation of any of the populations at the three known extant locales could irretrievably diminish the likelihood of the subspecies' survival. All known extant populations are essential, including the Dana Point Headlands population (Boggs 1997, Buck 1997, Price 1997, Silver 1997, Silver and Drumm 1996, Soule' 1996). Concurrent with the initial priority of protection, conservation, and appropriate management of existing populations, recovery should focus on the identification of potential habitat and creation of additional habitat and viable populations. Although the fundamentals of population biology and conservation biology (e.g., Mace and Lande 1991) strongly suggest that additional (or larger) populations of the Pacific pocket mouse are critical to reduce the risks of stochastic extinction, the biology and life history of the Pacific pocket mouse currently is not sufficiently well known to permit conclusive assessments of viable population size and the amount and configuration of essential habitat. "Essential" habitat is defined hereby to be those areas necessary for the recovery of the subspecies.

Accordingly, this recovery plan should be reviewed within 3 years of becoming final and every 5 years thereafter. However, this document should be immediately reviewed if, at any time, new data and analyses pertaining to the subspecies' natural history, population/metapopulation dynamics, viable population sizes, and management measures reveal that the subspecies is not responding, or is likely not to respond, to the recovery measures prescribed herein.

Recovery Objectives and Delisting Criteria

The ultimate objective of this recovery plan is to protect and maintain sufficient populations and habitat of the Pacific pocket mouse to allow the removal of this subspecies from the List of Endangered and Threatened Wildlife in accordance with the Endangered Species Act. The recovery of the Pacific pocket mouse will involve a two-stage process, beginning with reclassification of the subspecies from endangered to threatened status.

Recovery of the Pacific pocket mouse will likely take approximately 25 years (until the year 2023). We may consider reclassifying the Pacific pocket mouse to threatened status if and when:

1. Ten populations are independently viable and stable or increasing and their habitats are secure (free from risk of loss) and fully protected through fee ownership by a resource agency or conservation program, conservation easement, or other means of permanent protection. Populations of Pacific pocket mice shall be considered viable if the appropriate analysis of measured population parameters indicate that each population has a 95 percent or greater chance of surviving for 100 years.

2. Occupied habitat consists of a minimum of 2,000 hectares (4,940 acres) that are secure and fully protected through fee ownership by a resource agency or conservation program, conservation easement, or other means of permanent protection.

3. All Pacific pocket mouse populations are managed through a program to maintain genetic diversity for future generations.

4. All Pacific pocket mouse populations and essential habitat are managed so that current and potential threats (e.g., predation and disease) are eliminated or minimized to the extent that each population is not at risk of extirpation. Essential habitat is defined to mean that habitat necessary for the full recovery of the subspecies.

We may consider delisting the Pacific pocket mouse if and when:

1. All actions necessary for reclassification to threatened have been implemented.

2. Any necessary protection, restoration, and enhancement activities (on all sites that have been determined to be essential to the recovery of the subspecies) are successfully completed.

3. Populations of the Pacific pocket mouse are representative of the full (existing) genetic variability and historical geographical range of the subspecies and occur in habitats that collectively represent the full range of parameters observed and described in the past or during prescribed, future research, and monitoring efforts.

In order to delist the subspecies, we must also determine that the following five factors no longer continue to adversely affect the survival and recovery of the subspecies: (1) the present or threatened modification, or curtailment, of the subspecies' habitat or range; (2) overutilization for commercial, recreational, scientific, or educational purposes; (3) disease and predation; (4) inadequacy of existing regulatory mechanisms; and (5) other human-made or natural factors affecting the continued existence of the subspecies (50 CFR 424.11). A final decision relating to the delisting of the subspecies would be made only after a thorough review of all relevant information, including prescribed research.

Narrative Outline for Recovery Actions

1 Identify and protect all extant populations and essential habitat.

Pacific pocket mouse populations occur at three sites: the Dana Point Headlands in Orange County and San Mateo Creek (northern Camp Pendleton) and Oscar-1 (southern Camp Pendleton) in San Diego County. Fewer than 150 individuals (with recaptures considered) have been live-captured at these sites (OGDEN 1997, U.S. Fish and Wildlife Service 1998). The historic range of the Pacific pocket mouse has been adversely affected by urban and suburban development and the demand for further coastal development within its range can be expected to continue indefinitely. Consequently, achieving the objectives of the recovery plan requires that the identification, selection, and protection of essential habitats and populations be done expeditiously.

1.1 Protect and secure extant populations.

The recovery criteria indicate that 10 viable populations are required. Loss or degradation of any of the populations at the three known extant locales could irretrievably diminish the likelihood of the subspecies' survival. All extant populations are essential. These populations should be protected and secured from significant potential impacts. This should include dedicating the biological resource open space that has been secured for the area occupied by the Dana Point Headlands population to conservation of the Pacific pocket mouse population on site in perpetuity.

1.2 Undertake surveys to locate unknown populations.

Learning whether additional populations exist is critical to achieving the objectives of the recovery plan to the extent it influences the nature and intensity of management efforts on populations. The location of additional populations may make

intensive management efforts to establish additional populations less imperative.

Efforts to locate any additional populations are occurring through two avenues: *a*) through the environmental review process of proposed development projects required under the California Environmental Quality Act (CEQA), the National Environmental Policy Act (NEPA), and the Endangered Species Act, and *b*) through special studies undertaken by various State, Federal, and local agencies, such as the Service, the Marine Corps Base, Camp Pendleton, and the California Department of Parks and Recreation. The Service and the California Department of Fish and Game should communicate survey methods and data reporting requirements to the appropriate agencies, jurisdictions, and individuals, and advise them on when and where surveys are needed.

Surveys should be performed in Baja California, Mexico to determine possible occupation. Current aerial photos and satellite imagery of this area should be obtained, as well as any available soils and vegetation data/maps. Historic sampling of much of this area did occur and these records should be researched for clues to potential locations. Coordination between U.S. and Mexican authorities and experts should occur. Cooperative and systematic searches by U.S. and Mexican mammalogists should be performed in Baja California Norte in coastal locales between the U.S./Mexico border and the city of El Rosario.

1.3 Continue to refine a standardized survey approach.

We have developed a standardized survey approach to help ensure that the results of surveys are reliable, and correctly indicate presence or absence of the Pacific pocket mouse. The standardized survey approach should continue to be tested and refined because:

- Like most small mammal populations, populations of the Pacific pocket mouse are expected to show dramatic fluctuations in numbers. Survey results in one area should not be applied to other, even adjacent, areas. The survey protocol should be sensitive enough to detect the subspecies when numbers are naturally low.

- The Pacific pocket mouse may persist in unlikely places, and all populations are important to the conservation of this subspecies. Small populations in isolated locales may: *a*) be important in maintaining the genetic and ecological diversity of the subspecies, *b*) persist in the long term if carefully managed, and *c*) provide animals for translocation or the possible establishment of captive breeding populations.

1.4 Identify prospective habitat and population sites.

Reconnaissance surveys are needed to identify potential habitat that is either occupied by the subspecies or can serve as a host site for translocation efforts. Because of the subspecies' reliance on sandy soils, such efforts should begin with a range-wide analysis of soils and identify those similar to those that support existing populations. Regional planning efforts identify and protect potential and prospective habitat areas.

Potential habitat should be identified based on soils maps, foot surveys of the site, and live-trapping surveys. Detailed analysis of these and other appropriate features should be performed to revise and refine the existing habitat evaluation model developed by Camp Pendleton. Potential habitat sites in Los Angeles County include the El Segundo dunes adjacent to Los Angeles International Airport and selected areas of the Palos Verdes Peninsula. Prospective sites in Orange County include (from north

to south) Bolsa Chica (uplands around the wetlands and grasslands to the south), the Central/Coastal Orange County Reserve, San Joaquin Hills, University of California Irvine, Crystal Cove State Park, Dana Point Headlands, and San Clemente State Park. The largest number of sites and acreage of habitat occurs in San Diego County, including San Onofre State Park, the coastal portions of Camp Pendleton, Batiquitos Lagoon, Torrey Pines State Park, Border Fields State Park, and the mouth of the Tijuana River. Surveys should also be performed in and around the following areas: the Naval Radio Receiving Facility (NRRF) on the Silver Strand, Spooner's Mesa, Outlying Landing Field (Tijuana River), Penasquitos Lagoon, San Dieguito Lagoon, San Elijo Lagoon, Aqua Hedionda Lagoon, and Buena Vista Lagoon.

1.5 Identify essential habitats and sites.

Essential habitats required for the recovery of the Pacific pocket mouse should be identified based on studies of population size, extent of potential habitat, dynamics of habitat occupation and/or succession, ecosystem interactions, opportunities for population and habitat management, and the results of research on viable population sizes and metapopulation dynamics (see Section 4). The identification of essential Pacific pocket mouse habitat should begin immediately.

1.6 Evaluate and prioritize protection alternatives for essential habitat.

Multi-species planning efforts are underway within the historic range of the Pacific pocket mouse. Protection options for habitats include fee ownership, voluntary landowner protection plans, deed restrictions, resource management plans, easements and memoranda of agreement. The adequacy of these protection alternatives should be evaluated with respect to the long-term

viability of Pacific pocket mouse populations and habitat at these sites. Regional planning efforts should take into account overall ecosystem functions, self-sustainability, dynamic nature of habitat occupation through time, connectivity and fragmentation, fire and fire abatement effects, and the influence of adjacent land uses.

1.7 Protect essential habitats and sites.

Utilizing the protection alternatives considered and prioritized above, essential habitats and populations should be protected in perpetuity. As development pressure intensifies, areas of potential Pacific pocket mouse habitat will likely become more fragmented and isolated. Conservation and management of these important sites is essential, but we recognize that even the best sites may continue to lose species (loss of diversity) if isolated from other similar habitat patches (Margules *et al.* 1982). Research in relation to island biogeography and extended to the study of nature reserves has shown that fragmented habitats will not support a full range of species (Jones *et al.* 1996; Harris and Gallagher 1989). To maintain their full potential, these ecosystems as a whole must be managed in a way which will support and complement full ecosystem functioning to the extent currently possible. Occupied habitat, potential habitat, and surrounding linkages should be secured and protected so that the ecosystem upon which the Pacific pocket mouse depends is conserved.

2 Prepare and implement habitat management plans.

The conservation and maintenance of existing populations of the Pacific pocket mouse and its habitat, as well as suitable habitat at historical locations, are immediate recovery plan priorities. Protecting and maintaining existing populations includes a range of potential actions and interventions. In the short term, it involves protection against conversion of occupied habitat and various disturbances in and around occupied

habitat that could reasonably be expected to adversely affect the Pacific pocket mouse population. Such disturbances include off-site activities that would fragment Pacific pocket mouse populations, on-site off-highway vehicle use, excessive foot or bicycle traffic, and predation by cats and other predators (particularly exotic predators and artificially high native predator levels). In the long-term, it involves actively managing habitat in some areas, but providing for self-sustaining ecosystem functions wherever possible so as to minimize the risk of extinction and to conserve the ecosystem upon which the Pacific pocket mouse depends.

Management plans should be prepared for each extant population as a means to identify, avoid, minimize, and off-set threats, to protect and enhance existing ecosystems, habitats and populations, and to manage habitat to maximize pocket mouse population viability/size. If additional populations are located, site-specific management goals and objectives should be developed, included in the appropriate management plan, and implemented. Conservation of the ecosystem upon which the Pacific pocket mouse depends should be the long-term goal of all management plans. All research described below should be coordinated and combined as appropriate.

2.1 Monitor population trends and identify potential threats and management needs.

Limited population data are currently available for the populations at the three known extant locales: Dana Point Headlands; San Mateo Creek (north and south sites); and Oscar-1 in southern Camp Pendleton. Annual, long term monitoring of these populations based on capture/recapture studies is essential. Studies designed to monitor existing populations will need to be carefully designed to yield useful data because of the small population sizes and limited number of populations (Behrends 1997). Statistically determining significant factors that affect population viability will be difficult. Monitoring proposals should be peer reviewed by

qualified biostatisticians or scientists to ensure that proposed studies clearly define research methods and analytical techniques, including statistical analyses that will be employed (Behrends 1997). Although the most significant current threats to the Pacific pocket mouse are habitat destruction, fragmentation, and depredation, all potential threats should be monitored on a continuing basis. Potential threats include invasion by exotic plant and animal species, disease, recreational activities, and changes in habitat (e.g., vegetation densities, edaphic factors, meso-predator population increases). Once potential and real threats are identified, appropriate corrective measures should be incorporated into management plans for each site.

2.2 Develop habitat and species management plans.

Management plans that direct management of the subspecies and its habitat should be prepared for each known population. The management plans must provide site and population-specific details and should concisely describe the actions to be taken, building on the menu of actions listed below. The habitat and species management plan should be ecosystem oriented and place site-specific efforts in the context of various regional planning efforts such as the NCCP. The plans should provide details of avoidance, minimization, and mitigation measures needed, including issues of habitat avoidance, indirect effects, adjacent land use, edge effects, fire, predator retention, fragmentation, wildlife movement corridors, exotic species, habitat secession and cycling, restoration needs, self-sustainability, and preservation of long-term ecosystem functioning. All recommendations should focus on key problems, not indicators or symptoms, and be long-term if possible. Management plans should be amended whenever necessary to incorporate new information and to implement field proven techniques.

2.2.1 Develop an adaptive management plan for Federal lands on the Marine Corps Base, Camp Pendleton.

Two of the three locales with known extant populations of the Pacific pocket mouse are found on the Marine Corps Base, Camp Pendleton, where training exercises result in various forms of landscape disturbance. Certain forms and magnitudes of disturbance may be beneficial for the Pacific pocket mouse. Many forms of disturbance are likely destructive to Pacific pocket mouse habitat and resident populations. The Base and Service staff should co-develop management and enhancement strategies and impact avoidance measures for incorporation into the Base-wide upland species and habitat management plan now in preparation. This plan should incorporate monitoring, research, and management needs for all potential Pacific pocket mouse sites on the Base. Fire management plans and other existing management plans on the Base should be reviewed, and updated if necessary to include provisions for avoiding and minimizing impacts to the Pacific pocket mouse. This management plan should incorporate the Marine Corps and Service responsibilities under section 7(a) of the Act and the military mission of the Base.

2.2.2 Develop and implement adaptive management plans for other locales as necessary.

Management plans should also be prepared for populations and habitats outside of Camp Pendleton. Management plans in these areas can be a requirement of the permitting process for proposed development projects. In the case of public lands (e.g., State, County, or city park lands or other public open spaces), they can be prepared as separate management plans or incorporated into resource management or multi-species planning efforts.

2.5 Protect Pacific pocket mouse habitat from fire and fire abatement measures at occupied sites.

The Dana Point Headlands and San Mateo Creek populations are located on the perimeter of residential areas, where human-caused accidental fires are possible. The Oscar-1 population is located within a Marine Corps Base, Camp Pendleton training area, where repeated human-caused fires are possible. Habitat adjoining this population recently burned. Until the effects of various fire and fuel abatement regimes are known, Pacific pocket mice and their habitat should be protected from fires or fuel abatement practices that could impact occupied habitats and individuals. Potential but unoccupied habitat should be protected from fuel abatement measures.

2.6 Fence Pacific pocket mouse habitat where necessary.

Two Pacific pocket mouse populations are adjacent to residential areas, where urban and recreational uses (including unexpected changes in the pattern and intensity) could have adverse impacts. Documented impacts have occurred in Pacific pocket mouse habitat from activities of residents adjacent to occupied habitat (M. Pavelka, pers. comm. 1997). For example, one Pacific pocket mouse population has recently been subjected to vegetation clearing and ground disturbance for creation of a bicycle motocross track (J. Avery, pers. obs.). Potential impacts include, but are not limited to, vegetation clearing/ground manipulation, fire, fuel abatement, dumping/littering, bicycle/off-road vehicle use, pets, exotic plant and animal introduction, trail creation, and vegetation trampling. As yet undiscovered populations may also exist near residential areas, and would likely benefit from fencing that separates residential zones from potential habitat. Fencing may only have limited usefulness in reducing some of the impacts noted above. The type of fencing used needs to be considered carefully

to ensure that important predator-prey relationships are maintained (Behrends 1997), including maintaining coyote presence. For example, perching predators such as great horned owls should not be encouraged by such fencing (Price 1997). This can be accomplished by using large enough buffers to distance potential perches from occupied habitat, or fence design that minimizes perching benefits. Signage on fencing may be appropriate.

2.7 Control depredation by house and feral cats and other exotic predators as needed.

Because of their relative locations, at least two of the three locales with extant Pacific pocket mouse populations (Dana Point Headlands and north Camp Pendleton/San Mateo Creek) are at significant risk due to predation by house and feral cats. An ongoing program that results in the removal of house and feral cats from these locations (and maintains viable presence of coyotes and other native predators) is needed. Camp Pendleton should continue to discourage house cat ownership on Base. Supplemental feeding of any wild animals, including feral cats, should be discouraged Basewide. Local residents in proximity to the populations should be provided educational outreach material on Pacific pocket mouse habitat/coastal sage scrub ecology and the influence of non-native animals and land use practices (e.g., outdoor feeding of animals, trash placement, etc.) that modify predator numbers and other ecosystem functions. Activities that are compatible with native ecosystem functions should be outlined and encouraged. Using ecosystem management, predator management programs should be developed or existing ones modified to keep all native predators extant at viable/natural levels and to eliminate exotic predators/competitors in the long term. A healthy coyote population on Camp Pendleton may help control the feral house cat populations there (Spencer 1997). Predator-prey relationships of the Pacific pocket mouse need to be

maintained. Adjacent land uses practices that contribute to self-sustaining and relatively natural population levels of native animals should be encouraged.

2.8 Control exotic plants.

Two known Pacific pocket mouse populations occur in coastal sage scrub communities that have been invaded by aggressive exotic grasses and forbs. Other escaped exotic species such as hottentot fig (*Carpobrotus edulis*) have invaded portions of the Dana Point Headlands site, which is also vulnerable to invasion by crystal ice plant (*Mesembryanthemum crystallinum*). Pacific pocket mice currently do not occur in portions of the site invaded by these plants. These invasive plants should be removed from potential habitat and from sites targeted for translocation efforts. As coastal sage scrub is invaded by non-native taxa, particularly annual grasses, sites on sandy soils along the coastal terraces and slopes acquire an understory that may be too dense to provide useable habitat. Other negative effects are likely. The invasion of exotic plant species should be monitored and effects/control evaluated further.

2.9 Monitor the success of management efforts.

The effectiveness of management plans and efforts should be evaluated regularly. Evaluation criteria should include population stability and trends, area of occupied habitat, adult fecundity, and other factors for individual sites.

3 Enhance and expand Pacific pocket mouse habitat.

Management of Pacific pocket mouse habitat has not yet been attempted, and there is limited information on techniques that can be used to create, restore, enhance, or expand Pacific pocket mouse habitats. The regulatory

agencies should prepare, or direct the preparation of, a habitat management plan component that provides for optimization of Pacific pocket mouse habitat at managed sites. Techniques that could be employed include revegetation (with or without salvaged materials such as topsoil) and selective habitat enhancement, including experimenting with fire. Small degraded areas incapable of supporting Pacific pocket mouse populations or other listed species may serve as sources for plants (seeds and transplants) or substrate materials (particularly sandy topsoil) for restoration/enhancement efforts. Plant and substrate materials should be salvaged from all development projects where appropriate. Emphasis should be placed on self-sustaining, long-term, natural habitat optimization techniques. Simple, low-tech, and easy methods should be tried first with movement to more complex and high-tech methods if simple methods do not work (Behrends 1997).

3.1 Select target sites for actions that enhance or expand pocket mouse habitat.

The habitat at known population localities is surrounded by plant communities that are candidates for selective vegetation manipulations to expand suitable habitat and pocket mouse populations. Other actions that enhance or expand pocket mouse habitat may be recommended at other sites. The sites for these actions should be identified and prioritized for their importance to achieving the objectives of the recovery plan.

3.2 Undertake habitat manipulations near or adjacent to occupied habitat to expand available habitat and increase population numbers.

Opportunities to promote expansion of Pacific pocket mouse populations likely exist where occupied habitat is surrounded by dense cover of *Artemisia* scrubs and in sandy areas devoid of vegetation (or dominated by certain exotic plant species). Where

existing vegetation is dense, removal of individual shrubs or groups of shrubs could create additional habitat that may be colonized by dispersers from nearby or adjoining occupied habitat. Where sandy areas are devoid of vegetation, or where it is dominated by exotic species (e.g., *Mesembryanthemum crystallinum* or European grasses) and not utilized by the Pacific pocket mouse, exotics control and revegetation with appropriate native species (including reintroduction of soil microflora where necessary) could also create/enhance habitat to support populations of the Pacific pocket mouse. Manipulated vegetation would likely require on-going management efforts. For example, hand clearing or coverage reduction may result in rapid regrowth following root sprouting by sage scrub species. Consequently, thinning to prevent closed canopy conditions from rapidly reoccurring may be required.

Another approach to reduce vegetative cover would be the use of a herbicide containing relatively benign glyphosates, which could be applied to sprouts when Pacific pocket mice are underground. Experiments could be undertaken away from, and possibly adjacent to, occupied sites to ascertain the effectiveness of this strategy to keep areas between shrubs open, or to reduce understory grasses. A principal concern of these efforts would be to ensure that adequate seed sources that provide food for the Pacific pocket mouse are maintained in occupied habitat. Compacted areas such as abandoned roads would likely be more attractive to the Pacific pocket mouse if they were decompacted and covered with several centimeters of sand. Sand should preferably come from the same general locality if removable without harm to native habitats (e.g., removed from areas already legally disturbed by construction).

Techniques that are more self-sustaining/long-term and ecosystem oriented should be experimentally sought. A reduction in overall

plant cover and understory could be obtained through reduction in soil fertility or "anti-fertilization", which can be accomplished by adding organic matter (e.g., wood chips) to the soil matrix (T. St. John, pers. comm. 1996) or by adding coarse inorganic material (e.g., sand washed of fine materials). Conversely, care should be taken when experimenting with soil properties, as soil texture and structure (e.g., crusts) may be as essential to the Pacific pocket mouse as optimum plant cover (Spencer 1997). Allopathic plant effects or artificial changes in soil chemistry could also be utilized to reduce plant cover. If senescent coastal sage scrub is unoccupied by the Pacific pocket mouse, then earlier seral stages may be more attractive. Earlier seral stages could be created by fire (discussed below) or other methods. A mosaic of potential habitat types and ages could be created outside of occupied habitat in this manner.

Some habitats that would otherwise generally remain sub-optimal for the Pacific pocket mouse may be repeatedly manipulated such that they will support the taxon. Other habitat areas that would typically (and likely historically did) support optimal habitat may be made occupiable by removal of some perturbing influence (such as exotic species). The latter has the greater potential for long-term success.

The Pacific pocket mice found in the Oscar-1 area on Camp Pendleton currently occur in non-coastal sage scrub habitats, including non-native grasslands, and disturbed areas dominated by filaree (*Erodium* sp.). Anecdotal evidence suggests that the areas of dense grasslands are not occupied (to a level of being detectable during surveys), but the small coastal sage scrub, bare ground, and low density non-native grassland patches within the more dense grasslands are occupied. Where appropriate, habitat manipulations that convert adjacent exotic grassland areas back to coastal sage scrub should be attempted, particularly those actions that promote

essentially self-sustaining and long-term habitat trends. Pacific pocket mice also exploit the friable soils in berms created during road maintance in this area. We (the Service) do not advocate creation of additional berms, but protection of these existing berms could be important (M. Pavelka, pers. comm. 1998).

3.3 Adaptively manage Pacific pocket mouse habitat and populations.

Conservation of Pacific pocket mouse populations depends largely on the adequate and adaptive management of populations and their habitat. Two of the most important issues to be addressed at each site are how to increase habitat utilization and viability, and remove obstacles (particularly artificial ones) to population expansion and dispersal between populations.

Preparation of interim management plans should promote management of Pacific pocket mouse habitats that is flexible and quickly responds to needs as they arise. Interim plans should be prepared first for known populations, then for other populations as they are discovered. The urgency of the need for interim management plans (and updated versions thereof) will be influenced by the current status and distribution of populations; relative opportunities for habitat or population expansions; and ongoing threats, including development proposals and depredation.

Management plans, methods for monitoring and determining population viability and threats, and criteria of monitoring the success of management plan actions will be updated on an as-needed basis. If substantial changes are recommended, they should be incorporated into updated management plans. Management plans should seek long-term solutions that promote self-sustainability and full ecosystem functionality, thus minimizing the need for, and potential problems of, active management.

The San Mateo population(s) at Camp Pendleton is subject to natural and artificial impediments to periodic movement between currently occupied habitat areas. Most of these impediments are temporary, dynamic, or relatively easy to improve. Artificial barriers such as roadways, agriculture, and flood damage reduction efforts may need to be removed, modified, or enhanced so that connectivity between the San Mateo north and south groups is improved. Natural upland habitats, particularly coastal sage scrub, in this portion of the San Mateo Creek watershed, should be restored and/or enhanced to improve habitat linkage, facilitate movement between the two sites by Pacific pocket mice, allow for population/habitat dynamics, and improve ecosystem integrity. San Mateo Creek wash should be restored and maintained in a natural state; this includes restoration of native floodplain vegetation and maintenance of the wash area free of roads, lighting, exotic vegetation, and linear structures (such as walls, rip-rap, etc.). Provisions for native animal (Pacific pocket mouse, snakes, coyote, fox, bobcat, mountain lion, etc.) movement should be included within any artificial structures remaining in the area, such as a series of bridges along Christianitos Road. All future actions in this area should improve ecosystem function and habitat linkage/connectivity.

3.4 Undertake habitat manipulations at sites targeted as host sites for reintroduction efforts.

Habitat manipulation may also be undertaken at sites targeted to receive translocated individuals. Such sites will contain suitable or nearly suitable habitat for the Pacific pocket mouse, and are likely to require some manipulation to optimize the habitat for the subspecies. Such habitat manipulations will need to be completed prior to any translocation efforts at a given locality.

3.5 Evaluate and monitor the success of habitat restoration efforts.

Successes and deficiencies in the restoration efforts should be identified, reported, and corrected. Appropriate corrective measures should be taken if restoration efforts do not produce results consistent with the objectives and needs identified by relevant research. Monitoring and restoration efforts may be necessary for at least 10 years if difficulties are encountered in maintaining high function and value habitats.

4 Conduct research on the life history, ecology, and population biology of the Pacific pocket mouse.

Data should be collected and analyzed pertaining to the genetic variability (see Appendix 1), population dynamics, life histories, ecological requirements, and viable population sizes of the listed subspecies. Such information should be used to guide recovery actions and to construct mathematical models that help in predicting the likelihood of the persistence of the subspecies over time. Care should be taken to not over-extend the population viablity analysis approach by relying solely on such mathmatical models to predict persistence over time (Spencer 1997). Population viability anylasis is a powerful tool of modern demographic modeling, but it must be used with caution (Price 1997). Population viability analysis is most useful for comparing the relative merits of alternative preserve configuration or plans, and the relative effects of various parameters and model assumptions or predicted metapopulation survivorship (Spencer 1997).

Historic, potential, and occupied habitats should be mapped on GIS, along with soils, fire history, vegetation, and senstive species data. All associated GIS digital data from Camp Pendleton, cities, counties, and other associated agencies with potential habitat should be delivered to us by 1999, with updates provided as they develop. All research should be

coordinated and combined as appropriate and possible to increase effeciency and reduce costs.

4.1 Collect basic information on the natural history of the Pacific pocket mouse, particularly habitat relations and diet.

This Pacific pocket mouse is known from few populations and has not received adequate historic research in the field to allow a clear understanding of many aspects of the subspecies' habits and life history. These data should be collected as they are important to the development of sound strategies pertaining to the habitat manipulation and ecosystem enhancement.

Because heteromyid rodents are a relatively ecologically uniform group, information pertaining to one species can often be applied to others with only minimal additional data collection to verify that the Pacific pocket mouse adheres to patterns typical for the family (Price 1997). Using existing information in this way could reduce redundancy and the cost of implementing this task. We should encourage additional communication with active heteromyid rodent researchers who could assist in compiling relevant existing information and help determine how it can be used.

4.2 Research on potential and known predator ecology.

Research on predator ecology within Pacific pocket mouse habitats should be performed (Bloom 1997). Radio telemetry studies of likely predators including the three most abundant snake species (pacific rattlesnake, gopher, king), barn owls, great horned owls, coyotes, fox, and bobcats should be completed. Other nocturnal predators should also be considered, including house cats. House cats may prey differentially on other species of mice (e.g. *Mus musculus*) which may indirectly effect Pacific pocket mouse

populations (Spencer 1997). The main goal of this research is to determine the abundance of predators within Pacific pocket mouse areas, and the level of predation of each species. If removal of "surplus" dispersing juvenile Pacific pocket mice for translocation is considered, knowledge of predation levels may be influential in decisions on how many animals to be moved in a particular year (Bloom 1997). Predator ecology and movement information would also be beneficial when considering the potential for successful release of Pacific pocket mice into unoccupied sites (Bloom 1997).

4.3 Evaluate Argentine ant invasions into existing and potential habitat.

Exotic Argentine ants are invading coastal sage scrub areas near Pacific pocket mouse habitats. These ants could have adverse direct or indirect effects on Pacific pocket mouse populations and other native species, including replacement of native ant species (R. Fisher, pers. comm. 1997, Chris Nagano, pers. comm. 1998). Potential ecosystem effects include, but are not limited to, Pacific pocket mouse nestling mortality, insect population shifts, and modification of seedling survival rates. Invasion of these ants may be expedited by urban or agricultural development, possibly as a result of supplemental water being made available. Argentine ant invasions should be monitored and overall ecosystem effects evaluated. Ant control methods, including biological control and land use changes, should be developed if necessary.

4.4 Evaluate the role of fire and fire management.

Currently, very little data are available to evaluate the overall effects of fire on Pacific pocket mice or their habitat. Research is needed to develop a long-term fire management, fuel management, and/or fuel abatement program that would protect the animals and

their habitat. If the prescribed research reveals that certain fire and fuel abatement measures are warranted or preferred, such measures should be implemented.

The design and implementation of warranted or preferred fire suppression and management and fuel abatement activities, including controlled burns, fuel thinning, crushing, mowing, clearing, and fire suppression efforts, should be coordinated among all regulatory and fire management agencies and landowners to ensure the development of site-specific Pacific pocket mouse management plans that specify optimum habitat management practices. The potential role of fire in managing or disturbing habitat of the Pacific pocket mouse is poorly known. This question should be addressed for each locality with occupied habitat. Any information obtained on fire effects should be incorporated into the individual management plans.

Some areas of unoccupied potential habitat should be treated with a controlled burn and evaluated in a scientifically-based experimental approach with the goal of determining the positive and negative effects of fire. Ecosystem effects of fire should be evaluated rangewide as opportunities present themselves by wildfire. Existing fire history data (including GIS digital data) should be delivered to us, and necessary GIS maps should be created and maintained for all potential Pacific pocket mouse habitat. The role of fire in its positive and negative influence on the invasion or persistence of various exotic plant species should be evaluated. The potential advantages and disadvantages of fire as a management tool should be addressed.

4.5 Evaluate the effects of artificial night-time lighting.

Artificial night-time lighting may cause problems for nocturnal rodents such as the Pacific pocket mouse through potential

modification of predation rates, obscuring of lunar cycles, and/or causing direct habitat avoidance. Artificial lighting/light pollution and its influence on Heteromyid rodents (particularly those taxa closely related to the Pacific pocket mouse) and overall ecosystem functioning, should be evaluated. Predator-prey relationships in illuminated and unilluminated coastal sage scrub should be researched, with the goal of attaining empirical data on effects. Secondary and tertiary effects should be examined. Illumination of habitat by artificial light and activity patterns/densities of owls, coyotes, foxes, bobcats, house cats, snakes, and rodents should be correlated with lunar cycles and other appropriate habitat attributes. All experimentation with potential for adverse effects should take place in areas unoccupied by the Pacific pocket mouse.

4.6 Evaluate the role of past agricultural uses on habitat function.

The effects of historic agricultural practices on habitat function should be evaluated in areas that have been passively or actively restored to a moderate level of coastal sage scrub functioning. Preliminary evidence suggests that areas previously tilled do not support the Pacific pocket mouse, although they seem to be appropriate habitat otherwise (open, sandy coastal sage scrub adjacent to existing Pacific pocket mouse populations) (Spencer 1997, OGDEN 1997). Soil characteristics, soil microfauna/microflora, plant structure, plant diversity (including exotics), insect diversity, and seed production should be characterized and compared in occupied habitat and former agricultural areas that otherwise appear suitable. Care should be taken to not misidentify relationships and coincidences.

4.7 Develop biological control methods for exotic plant species.

Current management of non-native vegetation requires a considerable commitment to thoroughly remove or kill all above-

and below-ground parts of the target species and follow-up in subsequent years to control any exotics outbreaks. Eradication of most exotic species currently requires a combination of mechanical and chemical control.

The development of biological control of non-native plant species through U.S. Department of Agriculture (USDA), international, and/or university programs should be initiated. Biocontrol programs for some plant pest species have already been developed, including the use of six insect species to control yellow-star thistle (*Centaurea* sp.), an exotic from southern Europe (Randall 1994) and the release of European beetles in New York State for biological control of purple loosestrife (*Lythrum* sp.), an invasive exotic from Europe (U.S. Fish and Wildlife Service 1997). The USDA is currently proposing release of *Tamarix*-specific leaf beetles and mealybugs in nine areas throughout the southwestern U.S. (USDA 1997). The USDA and the International Institute of Biological Control headquartered in Switzerland reportedly have staff and facilities to perform the international research needed to perform the type of work required for biological control of invasive exotic plant species in the range of the Pacific pocket mouse (Dr. Bernd Blossey, Professor of Biology, Cornell University, pers. comm. 1997). Biological control programs hold the promise of long-term, self-sustaining, and very wide-ranging control of invasive plant species with relatively limited costs or use of chemicals, but are not without the biological risks associated with releasing additional exotic species (Mlot 1997, Beardsley 1997, Perlman 1997).

4.8 Conduct research to understand viable population sizes and metapopulation dynamics, and construct appropriate mathematical models to guide management efforts.

To predict the likelihood of survival, information on the number of offspring produced, the life span, and the mating habits of this subspecies should be collected and evaluated. It is sometimes possible to estimate a populations' chance of survival, based upon a number of assumptions. However, more reliable estimates are only possible after conducting appropriate studies. The following studies should be carefully coordinated to produce the most usable results.

4.8.1 Determine the reproductive potential of the subspecies using Leslie matrix models.

The survival or extinction of a population, or of an endangered species, are chance events (Dennis and Scott 1991) for which probability estimates can be obtained. The Leslie matrix model requires estimates of age specific survival and fecundity, rough estimates for which should be used in preliminary analyses while the population studies needed to obtain more reliable estimates are conducted.

4.8.2 Determine habitat area requirements and dispersal distances.

After completing the research prescribed above, a realistic estimate of the acreage of habitat required to support a population of the Pacific pocket mouse should be calculated. This habitat acreage will likely be different for each population and in part depend on the habitat quality and degree to which populations fluctuate naturally.

Currently, virtually nothing is known about dispersal characteristics of the Pacific pocket mouse such as the timing, magnitude, and distance of dispersal, and whether particular habitat or landscape features are preferred. These data should be collected for the Pacific pocket mouse. To obtain these data, radio tracking may be, if logistically feasible, the best methodology available. If radio-tracking is used, emphasis should be to telemeter a large number of juveniles/subadults in the late summer to maximize the potential to track dispersers (Spencer 1997). Otherwise, live-trapping studies could be conducted at varying distances from the source population of marked individuals. A standard trapping grid without drift fences should be utilized due to the potential for interference with home ranges, foraging and social interactions, and the possibility of the fences attracting predators to Pacific pocket mice (Behrends 1997).

4.9 Conduct research on conservation genetics of the Pacific pocket mouse.

An understanding of the genetics of the known populations of the Pacific pocket mouse using modern molecular techniques is needed. The goals of this task are to describe genetic variation in naturally occurring populations of *Perognathus longimembris pacificus*; assess whether any of the disjunct populations show evidence of reduction in genetic variation; describe any genetic subgroups within the Pacific pocket mouse; and integrate the results into conservation planning efforts for the subspecies.

Populations with unusually low variability may be candidates for interventions to bolster genetic variation through mixing of populations. It may be necessary to concentrate conservation

efforts on "priority" populations. The priority ranking of populations requires an assessment of how genetic variation within the species is apportioned or represented and the development of a strategy for maintaining the greatest amount of genetic variation in the long term. Data on interpopulational patterns of genetic variation should be used to identify genetically unique groups or subgroups.

Part of this study includes an examination of the intrapopulational and interpopulational genetic variation. This information is important in order to identify populations at risk due to consequences of the lack of genetic variation such as loss of adaptive flexibility within changing environments. Protein allozyme and molecular evidence should be used to calculate Wright's Coefficient of Relatedness, quantify amounts of genetic variation within the populations, and estimate historic levels of gene flow among the populations. We (the Service) should encourage standard protocols for tissue collection and encourage permitted trappers to collect and submit samples (Spencer 1997), if safe and appropriate.

4.10 Refine management plans.

Based upon the results of these studies, refine the management plans developed under task 2 above.

4.11 Refine recovery criteria.

The results of the population viability analyses and metapopulation dynamics are needed to further refine these criteria. Fewer than 10 populations may be needed for recovery if they are sufficiently large and highly unlikely to be extirpated. Many more than 10 populations may be required if they are small, unstable, and/or isolated.

5 Identify and implement measures to create additional populations.

Protection of all existing, enhanced, and any newly discovered Pacific pocket mice populations and habitat may be insufficient to ensure recovery of the subspecies. In addition to implementing the habitat management objectives in Task #3, it may be necessary to remove individuals from selected populations for the purpose of establishing a captive breeding population, or introducing wild-bred or captive-bred individuals into suitable but currently unoccupied habitat. Potentially suitable habitat apparently occurs within existing publicly-owned and managed natural areas that are within the subspecies' historic range. Reconnaissance-level surveys are needed to evaluate whether the habitat (substrate and vegetation) within a number of these areas can potentially support Pacific pocket mouse populations.

Most occupied Pacific pocket mouse habitat patches are now small and fragmented. Although there are a limited number of sites with suitable or potentially suitable habitat, the establishment of populations in these areas could contribute to the subspecies recovery by increasing the number of populations and constituent, individual animals.

5.1 Evaluate the feasibility of carrying out a translocation effort for the Pacific pocket mouse.

Nielsen (1988) recommended that a feasibility study should include, in part, considerations of the: (1) reason for translocation; (2) status of the wild population(s) to be translocated; (3) ecology, biology, and ethology of the subspecies; (4) current size and density of the wild population(s); (5) movements and distribution of the subspecies; (6) male:female ratio, (7) annual recruitment; (8) mortality rates and causes; (9) health and condition of the populations; (10) genetic variability and integrity; (11) status of remaining habitat; (12) depredation rates in target areas; (13)

translocation strategy (e.g., time of release, number and sex of animals involved); (14) capture technique and technology; (15) number and location of release sites; and (16) post-release support of translocated animals. Research and management tasks described above should provide enough information to determine the feasibility of attempting to translocate Pacific pocket mouse individuals.

Translocation should be considered after the feasibility tasks above are performed and: (1) surveys indicate that the potential for undiscovered populations is very low, and previously defined conservation and management measures fail to produce sufficient, essential habitat and populations, (2) research reveals that animals may be safely translocated into target habitats, and (3) the donor population can withstand the loss of individuals.

5.2 Develop a translocation protocol for wild-reared and captive-bred individuals.

A protocol for translocation of wild-reared or captive-bred individuals should be prepared that addresses all phases of the translocation effort, including host site selection, habitat manipulation, animal capture and release, and monitoring.

Only sites containing apparently suitable, albeit unoccupied habitat are to be considered for translocation efforts unless genetic studies reveal that the translocation of individuals from another population is necessary to enhance genetic variability of the host population, or otherwise benefit the subspecies.

The protocol should consider: a) suitable times of the year for translocation, b) the number of individuals to be moved and target densities, c) the number and type of artificial burrows and food (seeds and leafy vegetation) to be provided, d) spacing patterns of

individuals and sexes, e) the optimum period of time to maintain animals within artificial burrows to allow them to become accustomed to the unfamiliar surroundings, and f) the genetic makeup of translocated animals (see Appendices 1 and 2).

5.3 Implement a translocation program.

Translocations should be limited to sites that were previously occupied by the Pacific pocket mouse or that contain the appropriate substrates and habitat attributes. Translocations to occupied habitat should be done according to the prescribed protocol.

5.4 Monitor translocated populations.

Translocation efforts are to be accompanied by long-term monitoring of the population. Monitoring can be accomplished through establishment of trapping stations where live-trapping is conducted at least twice each year, once to sample adults upon their emergence from their burrows between late April and May, once between late July and late August to sample adults and their annual offspring.

5.5 Develop a protocol for captive breeding and implement first using a non-listed related species.

The captive breeding protocol should follow Hayden *et al.* (1966) and Daly *et al.* (1984). The protocol should require routine or regular observations of natural estrous cycles in large numbers of captive females in order to determine the most favorable mating time, and pairing receptive females with males under conditions that minimize mortality of individuals. Pairs should be observed for 15 to 20 minutes and immediately separated if violent behavior is observed. If the pair appears to be compatible, they may be left

together from 3 to 4 hours or overnight. After this, the female should be removed to an observation cage. Mated females should be kept in a relatively quiet place, away from daily disturbance, and provided with a refugium (see also Appendix 2).

A protocol for captive breeding additionally should address the following issues:

- Whether captive-breeding efforts should be undertaken in light of the results of other recovery plan actions and trends in population numbers.

- Whether or not suitable or potentially suitable host sites have been identified within the subspecies' historic range.

- A captive breeding protocol for the Pacific pocket mouse surrogate species. The protocol should contain the essential tasks discussed and prescribed in Appendix 2. Hayden *et al.* (1966) successfully bred *P. longimembris bangsi*; it seems reasonable to assume that the same or similar protocol can be used to successfully breed *P. longimembris pacificus*. Experience at breeding pocket mice should be gained by repeating their experiments with two relatively common taxa, *P. longimembris longimembris* or *P. longimembris bangsi*. Efforts to breed Pacific pocket mice should be undertaken after successful results are obtained working with these surrogate species. The captive breeding facility for the surrogate subspecies should not be located within the range of the Pacific pocket mouse. Although interbreeding of subspecies is common in nature, mixing of genetic lineages as a result of accidental releases of animals should be avoided.

- The minimum effective size of the captive breeding colony. To maximize the opportunity for success of the effort, the breeding colony should start with the largest feasible number of individuals. Hayden *et al.* (1966) used over 200 females in their program, in part because it was known that not all individuals would be reproductively receptive during a given, desired time window. Males will have to be screened for their "sexual interest" (Behrends 1997).

- Genetic analysis. The results of the genetic analysis of existing populations of the Pacific pocket mouse should be evaluated, including the source population(s) for the captive breeding and translocation programs prior to the removal of animals. The genetic analysis should be consistent with the protocol presented in Appendix 1. The purpose of the genetic study is to determine whether there are important genetic differences between populations, whether any populations have reduced genetic variability, and determine the minimum number of individuals needed to capture at least 90 percent of the population's genetic variability. The results of the genetic study would be used to determine whether it is desirable for a captive breeding program to interbreed individuals from two or more localities to increase genetic variability. Small tissue samples should be taken from individual animals for any necessary future studies. As an alternative, there is new technology available using fecal analysis as a far less invasive technique for extracting DNA.

5.6 Implement a captive breeding program for a related species.

The captive breeding program should be consistent with the protocol presented in Appendix 2. In particular:

- Individuals for the captive breeding program should be obtained from populations whose distribution and abundance are well known, and whose population is expected to be able to withstand the removed individuals. Populations with restricted opportunities for recruitment (e.g., populations surrounded by unsuitable habitat), are likely to produce more individuals in average years than are typically recruited into the population. The juvenile production beyond that required to maintain a viable population level could be removed late in the season (i.e., late September, early October) and potentially be used in either translocation or captive breeding programs.

- Individuals should be kept individually in gallon jars or other appropriate containers, containing sand and refuge, and fed a diet of seeds (grass and sunflower) soaked in water soluble vitamins (pet vitamins or equivalent). Freshly cut grasses or lettuce are supplied every other day. The laboratory conditions successfully established by Hayden *et al.* (1966), including temperature, relative humidity, and lighting, should be duplicated or used as a basis for the development of a protocol specifically designed to suit the needs of the Pacific pocket mouse.

- Captive-bred animals are to be released at the host site as soon as feasible. The offspring produced in captivity by Hayden *et al.* (1966) were born from April to July; all individuals would be weaned by early August. Preliminary evidence indicates that young of the year disperse from their natal home range from August to September in search of unoccupied habitat. The release of captive bred animals would attempt to mimic this natural pattern to the extent feasible. To minimize the impact of captivity on the fitness of captive-bred individuals, juveniles should be released in

family groups as soon as is feasible, possibly as early as 4 weeks after birth.

5.7 Implement a captive breeding program for the Pacific pocket mouse.

Captive breeding of Pacific pocket mice for their reintroduction into suitable unoccupied habitat could potentially play a role in recovery under specific conditions, particularly if it becomes infeasible to obtain founding populations by regular, selective removal of individuals from existing populations. Captive breeding could be undertaken if necessary to prevent the likely, imminent extinction of the subspecies or to produce relatively large numbers of individuals that are as genetically diverse as possible for the purpose of translocation. The chain of command and the decision-making process should be clearly established at the beginning of any captive breeding program for the Pacific pocket mouse (Behrends 1997).

6 Enhance public awareness of, and appreciation for, the Pacific pocket mouse recovery program through educational and interpretive programs.

Public awareness of restoration and other recovery efforts will create a positive image of these efforts and help to reduce impacts to protected populations. Interpretive exhibits should be established adjacent to habitats containing Pacific pocket mouse populations. Outreach and education efforts will enhance the public's understanding and appreciation of these rare animals and potentially reduce accidental impacts to the subspecies. Interpretive signs and exhibits should describe and depict sensitive local resources and the involvement and contributions of volunteers; announce the availability of published materials and

information; and advertise the locations and times of interpretive walks and programs. Mailings/flyers to residents living near Pacific pocket mouse habitat should be developed outlining ecosystem and life history details, as well as recommendations for pet care, trash placement, fire and fuel abatement precautions, hiking and bicycle use, etc. Care should be taken to not induce or direct vandalism.

6.1 Federal and State agencies should work with private parties to develop participation plans to implement specific recovery tasks.

The success of Pacific pocket mouse recovery efforts will depend on cooperation among Federal, State, and local agencies, researchers, conservation organizations, the public, and land owners to manage lands containing Pacific pocket mouse habitat for the protection of the subspecies. To further such cooperation, outreach efforts that encourage landowners to conserve Pacific pocket mouse habitat and populations should be undertaken.

The agencies and organizations that can be expected to cooperate in recovery planning efforts are the Service, the Marine Corps Base, Camp Pendleton, Department of the Navy, California Department of Fish and Game, California State Parks, the Nature Reserve of Orange County, the Orange County Environmental Management Agency (through its role as lead agency in the Central and Coastal NCCP program), the Transportation Corridor Agencies, the Dana Point Headlands landowners, and the City of Dana Point (through its jurisdiction over land use planning for the Dana Point Headlands). In addition, the following organizations and agencies may be involved in plan implementation: Department of the Navy, Army Corps of Engineers, Federal Highway Administration, Transportation Corridor Agencies, City of San Clemente, and the Endangered Habitats League. The list of

cooperating agencies will be finalized in the first stage of recovery plan implementation.

6.2 Distribute information on recovery plan actions and results to appropriate agencies, jurisdictions, landowners, land managers, and the interested public.

The support and involvement of local jurisdictions, landowners, the public, and State agencies are important where occupied and suitable habitats occur. Updated information on potential habitats, results of the recovery plan efforts, and suggested mitigation guidelines and protection alternatives should be provided periodically to appropriate city and county planning departments. An important element of this cooperation is to interface with the NCCP effort. In addition, a concerted effort must be made to coordinate recovery activities with interested landowners, land managers, scientists with relevant expertise, and interested citizens and citizens' groups.

6.3 Integrate implementation of the recovery plan with local agencies, including appropriate NCCP lead agencies.

The historic range of the Pacific pocket mouse overlaps with three existing programs being implemented under the NCCP program: the Multiple Species and Multiple Habitat Conservation Plans in San Diego County and the Central and Coastal Conservation Plan in Orange County. The Service and California Department of Fish and Game should work with the appropriate agencies to optimize the opportunity for the NCCP to affect the conservation of the Pacific pocket mouse. Long-term self-sustainability and ecosystem functionality of existing and potentially occupied sites should be considered in land use planning of adjacent areas, as well as the sites themselves.

III. Implementation Schedule

The Implementation Schedule that follows outlines the specified actions and estimated costs for the recovery of the Pacific pocket mouse. It is a guide for meeting the objectives discussed in the "Recovery" section of this plan and depicts task numbers, descriptions, priorities, and durations; responsible agencies; and estimated costs. The implementation schedule utilizes the numbering system from the narrative outline in the Recovery section of this document to identify recovery actions. These actions, when accomplished, should bring about the recovery of the Pacific pocket mouse and the protection of its habitat. Because the monetary needs for all parties involved in recovery are identified, this schedule reflects the total estimated financial requirements for the recovery of the subspecies. All costs related to recovery efforts except those associated with possible perpetual maintenance of optimum habitat and populations, possible regulatory needs beyond the year 2005, possible land acquisition, and possible monitoring of restored sites beyond the year 2005 are estimated and included in the schedule. The potential for these additional costs, which remain to be determined (TBD), are disclosed in the comments section of the implementation schedule.

Priority numbers given in Column 1 of the implementation schedule are defined as follows:

Priority 1 — An action that must be taken to prevent extinction or to prevent the subspecies from declining irreversibly.

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

Priority 3 — All other actions necessary to provide for full recovery of the subspecies.

Acronyms used:

COE	= U.S. Army Corps of Engineers;
CORNELL	= Cornell University;
CSP	= California State Parks;
DFG	= California Department of Fish and Game;
FWS	=U.S. Fish and Wildlife Service;
IIBC	= International Institute of Biological Control;
LAWA	= Los Angeles World Airports;
MCBCP	= Marine Corps Base, Camp Pendleton
NROC	= Nature Reserve of Orange County;
OCEMA	= Orange County Environmental Management Agency;
SWDIV	= Department of the Navy, Southwest Division
TBD	= to be determined;
TCA	= Transportation Corridor Agencies
USDA	= U.S. Department of Agriculture

Table 2. Implementation Schedule for Pacific Pocket Mouse Recovery

Priority #	Task #	Task Description	Task Duration (Years)	Responsible Agencies	Estimated Total Cost ($1,000s)	Costs $1,000s FY 01	FY 02	FY 03	FY 04	FY 05	Comments
1	1.1	Protect and secure extant populations.	5	All	TBD						TBD
1	1.2	Undertake surveys to locate unknown populations	10	FWS DFG MCBCP SWDIV LAWA TCA	400	40	40	40	40	40	Potential additional costs beyond agency costs. TBD
1	1.3	Continue to refine a standardized survey approach	1	FWS	5	5					
1	1.4	Identify prospective habitat and population sites	10	FWS CSP DFG NROC MCBCP SWDIV TCA LAWA	60	10	10	5	5	5	
1	1.5	Identify essential habitats and sites	10	All	20	2	2	2	2	2	

Priority #	Task #	Task Description	Task Duration (Years)	Responsible Agencies	Estimated Total Cost ($1,000s)	Costs $1,000s					Comments
						FY 01	FY 02	FY 03	FY 04	FY 05	
1	1.6	Evaluate and prioritize protection alternatives for essential habitat	10	All	26		5	4	3	2	
1	1.7	Protect essential habitat	25+	All	TBD						Extent of essential habitat and possible costs presently unknown
1	2.1	Monitor population trends and identify potential threats and management needs	25	FWS CSP DFG MCBCP SWDIV	2,000	80	80	80	80	80	
1	2.2.1	Develop and implement adaptive management plan for Camp Pendleton	25	MCBCP	300	20	20	20	20	20	
1	2.2.2	Develop and implement adaptive management plans for other locales	25	FWS DFG LAWA SWDIV CSP TCA	142	22	27	27	26	20	Implementation costs are presently unknown
1	2.3	Protect habitat from fire and fire abatement measures	25	All	TBD						TBD

Priority #	Task #	Task Description	Task Duration (Years)	Responsible Agencies	Estimated Total Cost ($1,000s)	Costs $1,000s FY 01	FY 02	FY 03	FY 04	FY 05	Comments
1	2.4	Fence Pacific pocket mouse habitat where necessary	3	FWS CSP DFG MCBCP SWDIV LAWA	TBD						
1	2.5	Control depredation by cats and other exotic predators	25+	FWS CSP DFG MCBCP SWDIV	252	12	10	10	10	10	Control to be achieved per integrated predator management plans after 2001
2	2.6	Control exotic plants	25	All	140	5	10	10	10	5	Possible, future costs TBD
2	2.7	Monitor success of management efforts	22	FWS CSP DFG MCBCP SWDIV	66				3	3	

Priority #	Task #	Task Description	Task Duration (Years)	Responsible Agencies	Estimated Total Cost ($1,000s)	Costs $1,000s					Comments
						FY 01	FY 02	FY 03	FY 04	FY 05	
2	3.1	Select target sites for actions that enhance or expand habitat	8	FWS CSP DFG MCBCP SWDIV LAWA TCA	13	1	1	1	2	2	
2	3.2	Undertake habitat manipulations to increase population numbers	24	FWS CSP DFG MCBCP SWDIV LAWA	360		15	15	15	15	
2	3.3	Adaptively manage Pacific pocket mouse habitat and populations.	25	All	265		20	20	60	60	
2	3.4	Undertake habitat manipulations for reintroduction efforts	TBD	FWS DFG MCBCP SWDIV LAWA	TBD						Costs and task duration TBD

Priority #	Task #	Task Description	Task Duration (Years)	Responsible Agencies	Estimated Total Cost ($1,000s)	Costs $1,000s					Comments
						FY 01	FY 02	FY 03	FY 04	FY 05	
2	3.5	Evaluate and monitor success of habitat restoration efforts	20	FWS CSP DFG MCBCP SWDIV LAWA	60						
2	4.1	Collect basic information on natural history	3	FWS DFG MCBCP SWDIV	20	10	5	5			
2	4.2	Research predator ecology	4	FWS CSP DFG MCBCP SWDIV	50		20	10	10	10	
2	4.3	Evaluate Argentine ant invasions into existing and potential habitat	5	All	65		15	15	15	10	
2	4.4	Evaluate role of fire and fire management	25	All	104	10	10	11	4	4	Potential additional costs TBD

Priority #	Task #	Task Description	Task Duration (Years)	Responsible Agencies	Estimated Total Cost ($1,000s)	Costs $1,000s					Comments
						FY 01	FY 02	FY 03	FY 04	FY 05	
2	4.5	Evaluate effects of night-time lighting	3	FWS CSP DFG MCBCP SWDIV	45		15	15	15		
2	4.6	Evaluate effects of past agriculture on habitat function	2	FWS CSP DFG MCBCP SWDIV	16			8	8		
2	4.7	Develop biocontrol methods for exotic plant species	15	FWS USDA CORNELL	500		100	100	100	100	Potential additional cost TBD
2	4.8.1	Determine reproductive potential of the subspecies	4	FWS DFG	95	20	30	25	20		
2	4.8.2	Determine habitat area requirements and dispersal distances	4	FWS DFG	85	30	20	20	15		
2	4.9	Conduct research on conservation genetics	3	FWS	45		15	15	15		

Priority #	Task #	Task Description	Task Duration (Years)	Responsible Agencies	Estimated Total Cost ($1,000s)	Costs $1,000s					Comments
						FY 01	FY 02	FY 03	FY 04	FY 05	
2	4.10	Refine management plans	10	FWS CSP DFG MCBCP SWDIV	20					10	
2	4.11	Refine recovery criteria	4+	FWS	8				2		
2	5.1	Evaluate feasibility of carrying out translocation efforts	6	FWS DFG MCBCP SWDIV LAWA	24	8	8	8			
2	5.2	Develop a translocation protocol for wild-reared and captive-bred individuals	1	FWS DFG	6			6			
2	5.3	Implement a translocation program	10	FWS DFG LAWA	750			75	75	75	To be undertaken only if feasible and necessary (as determined by prescribed research); possible future costs TBD

Priority #	Task #	Task Description	Task Duration (Years)	Responsible Agencies	Estimated Total Cost ($1,000s)	Costs $1,000s FY 01	FY 02	FY 03	FY 04	FY 05	Comments
2	5.4	Monitor translocated populations	20	FWS CSP DFG MCBCP SWDIV LAWA TCA	100						
2	5.5	Develop a protocol for captive breeding (if necessary)	4	FWS DFG	16	4	4	4	4		
2	5.6	Implement a captive breeding program for a related species	6	FWS DFG TCA	500						To be done only as a last resort; possible future costs TBD
2	5.7	Implement a captive breeding program for Pacific pocket mouse	20	FWS DFG TCA	700						To be done only as a last resort; possible future costs TBD
2	6.1	Develop participation plans to implement recovery	25	ALL	100	4	4	4	4	4	

Priority #	Task #	Task Description	Task Duration (Years)	Responsible Agencies	Estimated Total Cost ($1,000s)	Costs $1,000s					Comments
						FY 01	FY 02	FY 03	FY 04	FY 05	
2	6.2	Distribute information on recovery plan actions and results	25	ALL	55	4	4	3	2	2	
2	6.3	Integrate implementation of recovery plan with local agencies, including NCCP	8	ALL	56	7	7	7	7	7	

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APPENDIX 1

Genetic Analyses

(Derived and adapted from a draft protocol developed by the Morro Bay Kangaroo Rat Recovery Team)

Recovery criteria must reflect a thorough understanding of the population genetics and population dynamics of the species. Uncertainty within these two areas is currently high. Knowledge concerning genetic variability and population dynamics of Pacific pocket mice may be crucial to implementing actions necessary to prevent the extinction of the subspecies.

The genetic analyses described below should provide for a basic understanding of *P. longimembris* population genetics. The following represents an outline of surveys and tasks necessary to provide the minimum of information necessary, how it could best be collected, and how it can be integrated into the decision-making process. Specific circumstances as well as the state of technology will likely dictate which of the genetic analysis methods described below are necessary and feasible.

Tissue sampling

Tissue samples could be obtained from Pacific pocket mouse captured in the field (whether released at the site of capture or taken into the captive breeding colony). Necessary permits and approval of training for personnel should be provided by the Service and the California Department of Fish and Game. A pie shaped wedge of tissue (chord of 1.5 mm and a radius of 2 mm) cut from the margin of the ear should be collected using standard DNA voucher collection methods. Blood from the infraorbital sinus should be collected if an electrophoretic survey of blood proteins (protein electrophoresis) is the only genetic survey to be attempted and if handling and bleeding is done by a highly experienced collector. These tissues should be stored in the Museum of Vertebrate Zoology (UC Berkeley), in an

American Society of Mammalogist-approved frozen tissue collection, granted that the curators are given full and perpetual permission to administer those tissues.

An alternative to such intrusive tissue sampling was related by Dr. Jerry Boggs (1997):

> Discussions I have had with Dr. David Woodruff of [University of California San Diego] indicate that it is not necessary to damage [Pacific pocket mice] to conduct sampling and typing...Dr. Woodruff indicated that it is possible to establish genotypes through strands of hair (including the root). As few as six (6) strands would be sufficient. These samples should be placed in a paper envelope prior to processing. Animals to be sampled can be marked with a wire transmitter inserted into loose skin (as done with lab mice) and then scanned when trapped subsequently.

Another less invasive alternative is to use fecal analysis as a way to extract DNA from individuals.

Survey of current genetic variation

Population size samples of the Pacific pocket mouse and closely-related species should be surveyed for genetic variation. The specific tests and analyses necessary to accomplish this objective will be determined after consulting studies on other heteromyid species. This data base should be used to estimate: (1) the level of genetic polymorphism in the Pacific pocket mouse relative to other pocket mouse or heteromyid populations; (2) the relative genetic effective population size (N_e) as compared to other heteromyids; (3) the level of gene flow (if any) between Pacific pocket mouse and other related taxa (four) and the comparative systematic relationships and genetic differentiation of *P. longimembris*.

Survey historical mitochondrial DNA variation

Using museum study skins located at the Museum of Vertebrate Zoology (University of California at Berkeley), San Diego Natural History Museum, Santa Barbara Natural History Museum, Los Angeles Natural History Museum, and other

locales (Erickson 1993), pre-bottleneck genetic variability should be evaluated. This evaluation may be used in estimations of: (1) the absolute reduction in genetic variation resulting from the current population reduction and (2) the relative change in the level of inbreeding.

Survey nuclear DNA variation

Using collected skin samples, nuclear DNA should be tested for genetic variation. Nuclear DNA will provide estimates of heterozygosity and possibly estimates of genetic differentiation relative to other closely related populations. As such, it could be an important micro-management tool in captive breeding. In addition, screening nuclear loci (e.g., using single-strand conformational polymorphism, denaturing gradient gel electrophoresis, or related methods) would be less costly and more time efficient than sequencing them. If significant variation is found, DNA sequences should be obtained in order to evaluate the robustness of parameters estimated in studies suggested above. Because nuclear DNA is biparentally inherited, in contrast to strict maternal inheritance of mitochondrial DNA, a survey of nuclear DNA would: (1) validate the results obtained from surveying a single locus (mt DNA) and (2) elucidate any differences in genetic structuring due to life history variation between males and females. Specifically, a survey of nuclear DNA could suggest differences in dispersal strategies and it would permit comparisons of the variance in reproductive success between the sexes. If the survey of nuclear DNA were extended to include samples from museum specimens, then more robust conclusions could be reached regarding historical inbreeding levels as well as the absolute amount of loss in variability due to the current population bottleneck.

Conduct microsatellite DNA analysis

This analysis would provide a measure of population heterozygosity, and may be required to obtain all desired information from genetic assessments. However, techniques will need to be worked out for pocket mice. This approach gives fine scale spatial and temporal information regarding population structure, gene flow, and inbreeding. It is probably a better complement to mitochondrial DNA

assessments than nuclear DNA sequencing would be. However, the technical application of microsatellite DNA analysis is still in the developmental stages, particularly for heteromyids. Because the technical constraints are temporary, microsatellite DNA analysis should be given serious consideration once it becomes routinely applicable. Ear tissue would be appropriate for this form of genetic evaluation.

Survey genetic variation in blood proteins

Genetic variation in blood proteins could be evaluated using standard protein electrophoretic techniques. Blood sample collections should be done only by persons who have demonstrated expertise in this area. This survey provides the least expensive and least sensitive survey of genetic variation. Potentially, estimates could be obtained for some of the parameters estimated in other tasks. However, it is unlikely that this survey would provide a sufficiently fine level of resolution, unless Pacific pocket mice are highly differentiated from other little pocket mice taxa.

APPENDIX 2

Essential Captive Breeding Protocol Elements

(Adapted from a draft protocol developed by the Morro Bay Kangaroo Rat Recovery Team)

If captive breeding should become necessary, the Pacific pocket mouse will require an immediate rapid increase in population size to retain genetic variation and protect remaining populations from continuing decline and/or stochastic catastrophe. Once captive breeding is deemed necessary, efforts must be made to: 1) rapidly increase the total Pacific pocket mouse population size; 2) secure a genetic pool isolated from the potential natural and human induced disasters in the wild; and 3) provide a long-term population and genetic resource for supplementing existing wild populations and/or establishing new wild populations in the future. The interdependent actions outlined here would no longer be necessary if and when successfully reintroduced or translocated Pacific pocket mice populations become viable and self-sustaining.

A Pacific pocket mouse captive breeding protocol should contain, at a minimum, the following tasks and objectives:

Breed surrogate species in captivity to establish captive breeding/management parameters

Because reproduction may occur in only a small fraction of the wild animals brought into captivity, establishment of a self-sustaining captive colony will require the initial acquisition of a large number of animals from the wild. Pacific pocket mouse populations currently may be too small and fragmented to sustain viable numbers in the wild after a "take" to establish a captive colony. Therefore, it is recommended that techniques for captive management and reproduction be developed on a closely related surrogate species first to maximize the probability of success with Pacific pocket mice at a later time.

Establish and maintain a population of at least 50 individuals of the selected surrogate species

Because other heteromyid rodents (i.e., kangaroo rats) do not breed readily in captivity, an initial colony of at least 50 wild-caught animals is thought to be necessary to achieve a reasonable probability of captive reproduction. Although genetic management of the surrogate is not strictly required, techniques should be developed for maximizing founder reproduction, which will be of benefit when and if the captive propagation of Pacific pocket mice begins. Obtaining reproduction from 20 of 50 wild-caught animals (40 percent) would be regarded as a successful achievement.

Maintenance of a captive colony as near to Pacific pocket mouse habitat as possible (but not within the known current range) in California is important for a number of reasons. A colony situated near the natural range of the Pacific pocket mouse and surrogate species greatly simplifies acquisition of animals from the wild and later the exchange of animals between captivity and the wild when reintroduction/translocation efforts begin. It also helps foster the necessary interaction between in situ and ex situ Pacific pocket mouse conservation and research efforts, the application of information obtained on wild populations to captive management (e.g., behavioral and nutritional requirements). Finally, a California location should also enhance interaction with local community groups, businesses, institutions of higher learning, and zoos that could potentially provide critically needed resources and assistance for the conservation program. However, the captive breeding facility for the surrogate subspecies should not be located within the range of the Pacific pocket mouse. Although interbreeding of subspecies is common in nature, mixing of genetic lineages as a result of accidental releases of animals should be avoided.

Conduct focused research on reproductive behavior and physiology at a suitable facility that will ensure the goal of doubling the captive population every 2 years and to determine critical factors necessary for captive breeding of the Pacific pocket mouse and other endangered heteromyid rodents

Considerable time, money, and other resources have been devoted to captive breeding of Morro Bay kangaroo rats during the last decade with mixed results. Although a firm foundation of captive husbandry has been established, consistent progress in captive reproduction has been very limited and is still critically needed. Thus, it cannot be assumed that the captive breeding of Pacific pocket mice is assured. Focused research on reproduction in the surrogate should be continued with the specific objective of doubling the captive population every 2 years. Adequate and predictable funding for captive propagation is essential to ensure full-time animal care and research activities for an initial colony of about 100 animals that hopefully will double every 2 years.

Develop intensive husbandry and breeding techniques that will increase captive carrying capacity to a point where several institutions are participating in the captive breeding program

A rapid and dramatic increase in the number of Pacific pocket mice would be required to produce the captive population and genetic pool necessary to ensure a long-term, self-sustaining captive population. It is unlikely, and even inadvisable that any single institution will be able to accommodate this large number of animals. Therefore, it is recommended that a variety of California institutions be recruited as adjunct breeding/exhibition facilities to increase captive carrying capacity. All recruited institutions should be managed under a single management scheme along the lines of the Species Survival Programs (SSP) of the American Association of Zoological Parks and Aquariums (AAZPA). Accordingly, it would be necessary to develop standardized husbandry and breeding protocols as soon as the need arises.

Develop, implement, and evaluate laboratory techniques to prepare captive animals for reintroduction and/or translocation using surrogate species

Results from experimental reintroductions and translocations of surrogate species should be used to develop techniques that are expected to increase the chance that any captive-born Pacific pocket mice will become successfully established in managed habitats. An experimental approach should be adopted that is integrated

with the captive-breeding program. The type, length, and intensity of training necessary should be investigated to maximize short and long-term success of animals introduced to the wild. Also, social learning effects (adult-juvenile, sibling-sibling) that are important to successful establishment in the wild should be elucidated.

Develop and implement techniques for anti-predator training

Use conditioning techniques on captive animals to establish appropriate anti-predator responses in animals prior to their release into the wild. Evaluate cross-modal and cross-predator transfer of learned behaviors.

Develop and implement techniques for foraging training

Evaluate diet selection and foraging strategies (e.g., harvest rates, micro-habitat choice, foraging-predation interactions) in developing, captive animals. Test food preferences in captive animals and incorporate this information into habitat improvement programs. Information from these experiments also should be incorporated into food supplementation programs that may be undertaken on wild populations.

Develop and implement techniques for social training

Investigate social and competitive interactions in young captive animals and the influence of social interactions on timing of sexual maturity and competence. Determine the role of siblings and parents in modifying early social interactions.

Ascertain the development of survival skills to optimize timing of release

Compare the speed of acquisition and maintenance of relevant behaviors at different developmental stages. Investigate the way in which the development of various skills (e.g., social, foraging, anti-predator) interact.

Develop a captive propagation program for the Pacific pocket mouse that will provide a secure source population for reintroductions. Make provisions to obtain sufficient animals from wild populations to ensure that at least 20 (preferably 100) contributing founders are obtained

The ultimate objective of the captive breeding program is to propagate Pacific pocket mice in captivity in sufficient numbers to provide secure, genetically diverse adjunct captive populations to the wild population(s) to buffer against extinction of the subspecies in the event of catastrophic extinction of the wild population, and to provide animals for future reintroduction efforts. From a genetic standpoint, all animals that can be captured in the wild should be placed in a heavily managed captive breeding program. Time is paramount because all genotypes that cannot be incorporated into a rapidly growing captive population will be effectively extinct. Captive breeding of the target subspecies (Pacific pocket mouse) should proceed as soon as sufficient progress has been demonstrated for the surrogate.

Fund and maintain captive populations large enough to preserve at least 90 percent of genetic variation of the founder population for at least 10 years. A relatively large number of founders for the captive breeding program, preferably 100, is recommended to minimize the loss of genetic variation and achieve sufficient numbers of animals to support a short-term (at least 10 years), growing captive population of at least 500 animals that will be able to supply animals for reintroduction efforts. A cooperative funding effort between Federal, State and other agencies and institutions should be initiated. If determined to be prudent and necessary, Service and other agencies and parties will need to fund a program of sufficient duration to ensure that an expanding captive colony can be maintained intact at a single site for long enough to establish the efficacy of captive breeding under the best available conditions. Supplemental or alternative sources of funding should be sought. Once captive breeding is determined to be necessary, sources of private and Federal funding to support the captive breeding effort should be cultivated immediately. Funding sources or endowments should provide at a minimum of $50,000 per year to create, and then sustain, the captive breeding effort.

Once adequate technologies for captive breeding have been developed, collect additional Pacific pocket mice and establish at least two separate captive populations to achieve the goal of doubling the population every 2 years

Acquisition of animals will require research and management access to privately owned lands that support a population of Pacific pocket mice. A long-term, self-sustained captive colony should be housed in at least two, preferably more, California sites to ensure that a catastrophic event at one institution (e.g., infectious disease, fire, earthquake) will not decimate the entire captive population. A genetic and demographic management plan should be initiated to manage the captive population to minimize inbreeding, ensure parity of founder contributions and affect a stable age distribution in the captive population. Application of rational genetic and demographic management techniques will readily enable identification of "surplus" animals based on their genetic makeup, mean kinship, age, fecundity, etc., so that genetically and demographically sound adjunct captive populations can be established for reproduction, exhibition, and/or education programs at participating institutions.

Pursue a program of research on the captive population that can be of benefit to field conservation efforts

Certain types of information pertinent to conservation and management can be collected more rapidly and cost-effectively in the laboratory than in the field (e.g., behavioral and life history data). A successful breeding colony of Pacific pocket mice will generate considerable data needed to design an integrated *in situ* and *ex situ* management program for the recovery of the subspecies (and, hopefully, other species). It is recommended that a program for the collection of these data be developed immediately after the need arises.

Gather information on life history, behavior, and reproductive biology that will provide information for developing demographic and genetic management techniques for the in situ population and for future reintroduction and translocation efforts

Much of the life history and demographic information necessary for *in situ* and *ex situ* population management modeling can be collected opportunistically by using sound and focused record-keeping practices. However, a data collection paradigm should be devised to ensure that all relevant data are collected during the course of the captive breeding program.

APPENDIX 3

Summary of the Agency and Public Comments on the Draft Pacific Pocket Mouse Recovery Plan

In compliance with our (Service) policy on information standards under the Act (59 *Federal Register* 34270, July 1, 1994), we solicited the expert opinions of four appropriate and independent specialists regarding the Draft Pacific Pocket Mouse Recovery Plan in relation to pertinent scientific or commercial data and issues. Comments were received from one of the reviewers. Additionally, on September 25, 1997, we announced the availability of the Draft Recovery Plan for public review (62 *Federal Register* 186, September 25, 1997). The 60-day public review comment period for Federal agencies, State and local governments, and members of the public ended November 24, 1997. Fifteen letters were received during the comment period, each containing varying numbers of comments.

The number of letters received by affiliation:

Federal agencies	2 letters
State government	0 letters
Academia/professionals	7 letters
Environmental/conservation organizations	2 letter
Local governments	0 letters
Business/Industry	3 letters
Private Citizen	1 letter

Summary of Significant Comments and Service Responses

We reviewed all of the comments received during the comment period. Comments received were varied, some providing recommendations for research/conservation strategies or descriptions and information. Comments were both critical and favorable of the approach taken. Several commenters provided valuable additions and corrections to the Draft Recovery Plan. These are gratefully acknowledged and

incorporated in the appropriate sections of the Final Recovery Plan. Most applicable comments have been addressed in, or incorporated into, the body of the Final Recovery Plan; additional substantive comments and our response to each are summarized as follows:

Comment: One commenter indicated that the Draft Recovery Plan appeared to be biased against fire as a causative agent in habitat alteration.

Response: Succession of habitat for the Pacific pocket mouse as it pertains to its ecology and occupation is little understood. We (the Service) acknowledge that additional research is necessary (and called for in this Final Recovery Plan) to elucidate habitat succession for this species. We revised the Final Recovery Plan to greater reflect the potential short- and long-term benefit and/or harm that can result from fire.

Comment: Two commenters indicated that the Draft Recovery Plan failed to address exotic grasslands as habitat for the Pacific pocket mouse.

Response: Some of the Pacific pocket mice found on Camp Pendleton currently occur in non-coastal sage scrub habitats, including non-native grasslands and disturbed areas. Anecdotal evidence suggests that the areas of dense grasslands are not occupied (to a level of being detectable during surveys), but the small coastal sage scrub, bare ground, and low density non-native grassland patches within the more dense grasslands are occupied. It is unclear whether the mice occupy the dense grasslands in low numbers, use them only for movement to/from the smaller patches of suitable habitat, or only move across those areas following burn events (which are quite frequent within this portion of the Base) when the vegetation is less prohibitive to movements. The Final Recovery Plan reflects this information.

Comment: Several commenters indicated that the Draft Recovery Plan should treat the Dana Point Headlands population as essential to the recovery of the species.

Response: This Final Recovery Plan notes that all known extant populations are essential, including the Dana Point Headlands population.

Comment: One commenter noted that Camp Pendleton has now surveyed most of the coastal zone between the populations known on Base and no new populations have been found. This commenter noted that this new data does not support the theory that ". . . Camp Pendleton populations could be part of larger metapopulation."

Response: Over the long-term (100-years plus), it is expected that habitat suitable for occupation by the Pacific pocket mouse dynamically shifts in space and time in response to fire, drought, and other physical processes. Populations may become established, then extirpated, and then recolonized, in response to these physical or other factors. The two main concentrations of known Pacific pocket mouse occupation on Base are currently rather distant from each other. Historic habitat was likely such that the potential for populations dynamically occupying habitats between the currently occupied areas on Camp Pendleton was at least moderate. Thus, the potential for a series of populations on what is now Camp Pendleton functioning as a metapopulation in the past is moderate. Barring artificial impediments to movement, and/or changes in the physical (or other) processes affecting habitat suitability, continued potential exists for metapopulation dynamics to exist on Base in the future as long as contiguity remains. Historically the Pacific pocket mouse was known from a few, disjunct, locations. Data are unavailable to confirm or deny function as a metapopulation. A current lack of detectable occupation throughout a zone of potential habitat does not eliminate the possibility that a metapopulation dynamic exists or that it could become functional in the future. A reasonable approach to protection of the species is to continue to evaluate and provide for this potential.

Comment: One commenter noted that the Draft Recovery Plan required research on the life history, ecology, and population biology of the Pacific pocket mouse. This commenter questioned listing the species prior to assembling this information.

Response: As another commenter noted, relatively little is known of the life history and biology of the Pacific pocket mouse. We acknowledge that additional research is necessary to elucidate the life history, ecology, and population dynamics of the species. Because the results of these proposed studies are not yet available, we are currently charged with incorporating the best available information into the plan and in that regard have repeatedly consulted with the recognized experts on the species and its habitats. Even though the life history, ecology, and population biology for this species is poorly known, general biological tenets are primarily applicable in the case of listing the Pacific pocket mouse, and in the development of the recovery strategy. The threats to the species are determinable and foreseeable. Given the extent of the documented threats facing the species and its current, known range, we continue to conclude, based on a composite of the best information available, that the species is imperiled and presently requires immediate attention to prevent the extirpation of important populations or actual extinction of the species. Waiting to assemble better information on the biology of the species before listing would only delay necessary protection for the species to a period when even fewer options for protection from extinction would be available.

Comment: Several commenters indicated noted that population viability analysis (PVA) is a useful tool in conservation biology, but that it should not be used as an absolute measure of success or failure of a preserve or recovery plan. One commenter lauded us (the Service) for our apparent willingness to use the tools of modern demographic modeling to help determine how population viability is likely to be affected by alternative management plans .

Response: We agree that PVAs can be misused and they should be used cautiously. Care should be taken to not over-extend the population viability (vulnerability) analysis approach. Population viability analysis is most useful for comparing the relative merits of alternative preserve configuration or plans. This is indicated in the Final Recovery Plan.

Comment: Several commenters indicated that we should treat the Pacific pocket mouse occurrences on either side of San Mateo Creek on Camp Pendleton as separate populations.

Response: We have modified this Final Recovery Plan in its treatment of these occurrences near San Mateo Creek to indicate the best information available. It is unknown if these occurrences historically functioned as separate populations, as a single population, or as a metapopulation. The warranted approach to protecting these occurrences is to maintain and enhance connectivity between them as if they are dependent upon each other for exchange of genetic material and/or utilization of one occurrence to recolonize the other in the case of extirpation. Without specific references or information to challenge existing data, information, or recommendations, we cannot assess the relevance, utility, or relative importance of new information. Because we are charged with revising recovery plans as necessary, we encourage all parties to continue to submit any new information that may bear on the recovery process.

Comment: A couple commenters questioned the practicality of completing the actions that would result in delisting of the Pacific pocket mouse.

Response: We develop recovery plans that delineate reasonable actions required to recover and/or protect listed species. The strategy outlined herein is not likely to be easily fulfilled, but it is attainable and reasonable based on the best information available. We define recovery by the needs of the subject species, including conservation of the ecosystem it depends upon.

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