

**Pacific Pocket Mouse**  
*(Perognathus longimembris pacificus)*

**5-Year Review:  
Summary and Evaluation**



Photograph of the Pacific pocket mouse (*Perognathus longimembris pacificus*). Photo credit USFWS.

**U.S. Fish and Wildlife Service  
Carlsbad Fish and Wildlife Office  
Carlsbad, California**

**April 1, 2010**

**5-YEAR REVIEW**  
**Pacific Pocket Mouse**  
*(Perognathus longimembris pacificus)*

**I. GENERAL INFORMATION**

**Purpose of 5-Year Reviews:**

The U.S. Fish and Wildlife Service (Service) is required by section 4(c)(2) of the Endangered Species Act (Act) to conduct a status review of each listed species at least once every 5 years. The purpose of a 5-year review is to evaluate whether or not the species' status has changed since it was listed (or since the most recent 5-year review). Based on the 5-year review, we recommend whether the species should be removed from the list of endangered and threatened species, be changed in status from endangered to threatened, or be changed in status from threatened to endangered. Our original listing of a species as endangered or threatened is based on the existence of threats attributable to one or more of the five threat factors described in section 4(a)(1) of the Act, and we must consider these same five factors in any subsequent consideration of reclassification or delisting of a species. In the 5-year review, we consider the best available scientific and commercial data on the species, and focus on new information available since the species was listed or last reviewed. If we recommend a change in listing status based on the results of the 5-year review, we must propose to do so through a separate rule-making process defined in the Act that includes public review and comment.

**Species Overview:**

The Pacific pocket mouse (*Perognathus longimembris pacificus*, "PPM") is one of 16 currently recognized subspecies of the little pocket mouse (*Perognathus longimembris*); a widespread species that is distributed throughout arid regions of the western United States extending into northern part of the Baja California peninsula and west central Sonora, Mexico (Williams et al. 1993, p. 178). The PPM is a small, burrowing rodent that primarily feeds on seeds and is associated with fine grain, sandy substrates in coastal strand, coastal dunes, river alluvium and coastal sage scrub habitats within approximately 4 kilometers (2.5 miles) of the ocean in southern California. Historically, it was documented from near El Segundo in Los Angeles County to the vicinity of the Mexican border in San Diego County. Following 20 years with no reports of the subspecies, we emergency listed the PPM in February of 1994, following the rediscovery of a single population at the Dana Point Headlands in the City of Dana Point. Since its listing, the PPM has been found at three additional sites, all within the bounds of Marine Corps Base Camp Pendleton (Camp Pendleton). All known populations are threatened by habitat fragmentation and small size, and two of the populations are within military training areas. Conservation and management of all remaining suitable habitat, particularly those areas with sandy substrates, is critical to the recovery of the subspecies, because, with the exception of Camp Pendleton and already conserved areas, coastal southern California is nearly completely urbanized.

## **Methodology Used to Complete This Review:**

This review was prepared by the Carlsbad Fish and Wildlife Office (CFWO), following the Region 8 guidance issued in March 2008. We used information from the Recovery Plan, survey information from experts who have been monitoring various localities of this species, and the California Natural Diversity Database (CNDDDB) maintained by the California Department of Fish and Game. The Recovery Plan and personal communications with experts were our primary sources of information used to update the species' status and threats. We received one letter from the public in response to our Federal Notice initiating this 5-year review and information relevant to the taxon being reviewed here is incorporated. This 5-year review contains updated information on the species' biology and threats, and an assessment of that information compared to that known at the time of listing or since the last 5-year review. We focus on current threats to the species that are attributable to the Act's five listing factors. The review synthesizes all this information to evaluate the listing status of the species and provide an indication of its progress towards recovery. Finally, based on this synthesis and the threats identified in the five-factor analysis, we recommend a prioritized list of conservation actions to be completed or initiated within the next 5 years.

## **Contact Information:**

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## **Federal Register (FR) Notice Citation Announcing Initiation of This Review:**

A notice announcing initiation of the 5-year review for this taxon and 57 others, and the opening of a 60-day public comment period was published in the Federal Register on February 14, 2007 (72 FR 7064). One letter was received expressing support for preservation of the noticed species, and listed a broad category of potential threats to them without identifying how any of those threats apply specifically to the PPM. Information from this letter and the threats identified has been taken into consideration during the discussion of threats to the PPM.

## **Listing History:**

### **Original Listing**

**FR Notice:** 59 FR 49752

**Date of Final Listing Rule:** September 29, 1994

**Entity Listed:** Pacific Pocket Mouse (*Perognathus longimembris pacificus*), a mammal subspecies

**Classification:** Endangered

### **Associated Rulemakings:**

The Pacific pocket mouse (*Perognathus longimembris pacificus*, “PPM”) was emergency listed as endangered on February 3, 1994 (59 FR 5306-5310). The emergency listing remained in effect until September 28, 1994. No critical habitat has been designated for this species.

### **Review History:**

No formal status review has been conducted for the PPM since its original listing. Informal status reviews have been conducted and incorporated into biological opinions, habitat conservation plans, and the 1998 recovery plan for this species.

### **Species’ Recovery Priority Number at Start of 5-year Review:**

The recovery priority number for the PPM is 3C according to the Service’s 2009 Recovery Data Call for the CFWO, based on a 1-18 ranking system where 1 is the highest-ranked recovery priority and 18 is the lowest (Service 1983, pp. 43098-43105). This number indicates that the taxon is a subspecies that faces a high degree of threat and has a high potential for recovery. The “C” indicates conflict with construction or other development projects or other forms of economic activity.

### **Recovery Plan or Outline:**

**Name of Plan:** Recovery Plan for the Pacific Pocket Mouse (*Perognathus longimembris pacificus*)

**Date Issued:** September 28, 1998

## **II. REVIEW ANALYSIS**

### **Application of the 1996 Distinct Population Segment (DPS) Policy:**

The Endangered Species Act defines “species” as including any subspecies of fish or wildlife or plants, and any distinct population segment (DPS) of any species of vertebrate wildlife. This definition of species under the Act limits listing as distinct population segments to species of vertebrate fish or wildlife. The 1996 Policy Regarding the Recognition of Distinct Vertebrate Population Segments under the Endangered Species act (Service 1996, pp. 4722-4725) clarifies the interpretation of the phrase “distinct population segment” for the purposes of listing, delisting, and reclassifying species under the Act. The PPM is not listed as a DPS, and there is no new information to suggest that this subspecies should be listed as a DPS.

## Information on the Species and its Status:

### Species Biology and Life History

The PPM is one of 16 currently recognized subspecies of the little pocket mouse (*Perognathus longimembris*; PELO) (Williams et al. 1993, pp. 177-184), and is one of the smallest rodents in North America. Because of its rarity, much of what is known about PPM is inferred from studies of other subspecies. Thus, this status review uses PPM to refer to information that is specifically known for the subspecies, while PELO is used to indicate information that is derived from the study of other subspecies of *P. longimembris*. Body length from nose to tip of tail in PELO ranges from 110-155 mm (Hall 1981, p. 537; Ingles 1965, p. 219) with the ratio of length of tail to head and body usually ranging between 1.03-1.40 (Williams et al. 1993, p. 177). However, body dimensions of PPM appear to fall at the lower end of this range, with PPM considered to be one of the smallest members of the species (Huey 1939, pp. 49-54). Weight is reported to vary between 7-10 grams (Jameson and Peeters 1988, p. 286; Burt and Grossenheider 1976, p. 136), though adult PPM have occasionally been captured on Camp Pendleton weighing as little as 5-6 grams. The body pelage of the PPM is silky (spineless) and predominately brown, pinkish buff or ochraceous buff above and light brown, pale tawny, buff, or whitish below (Hall 1981, p. 537). There are typically two small but conspicuous patches of lighter hairs at the base of the ear (Ingles 1965, p. 219). The tail can be either distinctly or indistinctly bicolored (Hall 1981, p. 537).

Behaviorally, PPM are non-social and like all members of the family Heteromyidae, they are nocturnal granivores with external, fur-lined cheek pouches. Although PPM is a strong seed specialist, its diet may occasionally include insects and green vegetation (Reichman and Price 1993, p. 540; Meserve 1976a, p. 312). Seeds found within the cheek pouches of PPM have come from the following plants: *Heterotheca grandiflora* (telegraph weed), *Hordeum murinum* (barley), *Pluchea sericea* (arrow weed), *Crysothamnus* sp. (rabbitbrush), *Croton californicus* (Croton), *Centaurea melitensis* (tocalote) (von Bloeker 1931a, p. 371), *Lotus prostratus*, *Monanthochloe* sp. (shoregrass), *Franseria* sp. (ragweed, bur-sage), a rush, two species of salt bush, heliotrope, and mustard (Bailey 1939, p. 327). An intensive field study of the dietary preferences of PPM based on fecal analysis found the diet of PPM included arthropods and seeds or green vegetation from *Eriogonum fasciculatum* (California buckwheat), *Lotus scoparius* (California broom), *Rhus integrifolia* (lemonadeberry), *Salvia* sp. (sage), *Erodium* sp. (storksbill), *Cryptantha clevelandii* and grasses (Meserve 1976a, p. 312). However, Meserve (1976a, p. 310) found that PPM “shows strong specialization on grass and forb seeds with relatively less utilization of other foods”. PPM were also found to consume a higher proportion of forb seeds in the spring, and a higher proportion of grass seeds later in the year, which may relate to seasonal food availability (Meserve 1976b, p. 661).

Brown and Lieberman (1973, pp. 790-791) found that in desert environments, PELO were highly specialized and selected seeds averaging 1.4 mm (0.06 in) in size. They also found that rodents generally consumed seeds proportional to their body size, and suggested that similar-sized co-occurring rodents (such as the western harvest mouse (*Reithrodontomys megalotus*)) may compete for the same seeds. Others have not observed a pattern of dietary preferences on the

basis of seed size in Heteromyids (Stamp and Ohmart 1978, p. 700; Reichman and Price 1993, p. 557), and argue that patterns in seed size selection are likely correlated with seed availability in preferred microhabitats. Based on a comparison of habitat and resource utilization, Meserve (1976b, p. 658) found relatively little niche overlap between PPM and *R. megalotis*.

For an animal of its size, PELO is exceptionally long-lived (Brown and Harney 1993, p. 622; Edmonds and Fertig 1972, p. 301; French et al. 1967, p. 537). Individual PELO held in captivity have lived in excess of 7 years (Bailey 1939, p. 328; Egoscue et al. 1970, p. 623; Edmonds and Fertig 1972, p. 301), and French et al. (1967, p. 537) reported on 25 PELO that survived from 3 to 5 years in the wild. During PPM population monitoring, several individuals have been observed to survive at least 2 years and 7 months in the wild (Service 2008a, Raw data, on file CFWO).

Adaptations that are likely to be associated with the longevity of PELO are its semi-fossorial habit and residence in burrows during periods of inactivity, its seed-caching behavior, and its physiological capacity to enter torpor. PELO are among the smallest mammals known to hibernate/aestivate (Bartholomew and Cade 1957, p. 68), and PPM generally remains dormant below ground from September/October to March/April (Kenagy 1973, p. 1204; Kenagy and Bartholomew 1985, p. 377; Meserve 1976b, p. 651; O'Farrell 1974, p. 812). Periods of dormancy appear to vary with environmental conditions and food availability (Kenagy 1973, p. 1212; Kenagy and Bartholomew 1985, p. 377; Service 2008a, pp. 23-24; Shier 2008a, p. 16; French et al. 1967, p. 543). In 2003, PPM was readily detectable on population monitoring grids in mid-September, a time when peak animal abundance was found (Service 2008a, p. 25). At the same location in 2004, peak abundance was found in July and very few animals were captured during September, suggesting a majority of animals had already entered dormancy by September of that year (Service 2008a, p. 27). During detailed behavioral observations of PPM at a single site in 2006, Shier (2007b, p. 9) found nearly all adult males had begun aestivation prior to July 11, and nearly all animals (adults and subadults) entered aestivation by July 27 of that year. In 2007, across several sites in close proximity to one another, Shier (2008a, p. 16) observed variability in the onset of dormancy, with all PPM at one site entering dormancy by June 18, all animals at another site entering dormancy by July 15, and a majority of animals at another site entering dormancy by the beginning of August. At this latter site, several individuals remained active into September, which may have been prompted by supplementary seed being provided to animals on a nightly basis in traps (Shier 2008a, p. 16). Early entry of animals into dormancy in 2007 may have been prompted by low precipitation that caused low plant and seed production during that year (Shier 2008a, p. 16)

In contrast to other hibernators that accumulate fat reserves, PELO feed on seed caches stored in their burrows (Price et al. 2000, p. 97; Kenagy 1973, p. 1213; Bartholomew and Cade 1957, p. 68). Thus, cessation of above-ground foraging activity is not obligatorily dependent on torpor, though both may occur simultaneously in cold temperatures (French 1977, p. 37). Facultative use of torpor confers significant metabolic energy savings during periods of environmental stress (Bartholomew and Cade 1957, p. 70; French 1976, p. 187; Chew and Butterworth 1964, pp. 211-212). In laboratory trials, PELO adjusted the amount of time they spent in torpor to food availability (Bartholomew and Cade 1957, p. 69; French 1976, p. 191). Because torpor slows metabolic processes, it is likely to delay cellular senescence (Hayden and Lindberg 1976, p.

270). Overall, the ability to remain below ground through the use of stored food and/or torpor appears to improve survivorship (Chew and Butterworth 1964, p. 224; French et al. 1967, pp. 544-545; Service 2008a, p. 74), likely due to a combination of reduced exposure to factors causing mortality when animals are above ground, and active and reduced metabolic energy demands when resources are scarce (Hayden and Lindberg 1976, p. 270).

Periods of inactivity, either through exploitation of seed caches or use of torpor, may have neither a strictly daily or seasonal pattern. Emergence from hibernation in spring generally correlates with availability of forb and grass seeds (Meserve 1976a, p. 316) but can vary among years (Kenagy 1973, p. 1204) and may relate to the vertical temperature gradient in the soil profile (French 1977, p. 37). Based on laboratory studies, French (1977, p. 40) reported that emergence from hibernation is a gradual process whereby animals initially emerge for short periods divided by periods of torpor, then individuals gradually increase their time above ground over several weeks. In a desert subspecies of PELO, Kenagy and Bartholomew (1985, p. 377) found that as in other hibernating species, males emerged approximately 2 weeks earlier than females in the Spring, a pattern that is associated with reproductive timing and the selective pressure for males to gain access to females that are not already impregnated (French 1977, p. 42). Consistent with the findings of Kenagy and Bartholomew (1985, p. 377), during the first night of PPM trapping in April of 2004 at one monitoring location, the Service (2008a, p. 66) captured 48 males and a single female. However, this pattern of males emerging prior to females has not been observed at other times (Service 2008a, p. 66; Shier 2008a, p. 16). This may be associated with interannual variability in behavior that relates to resources or abundance of conspecifics (Service 2008a, p. 66), or the timing of survey initiation.

The timing of onset of dormancy can also vary widely (French et al. 1967, p. 543; Service 2008a, p. 25; Shier 2008a, p. 16), but generally follows a pattern of adult males entering dormancy first, then adult females, then juveniles (French 1977, p. 42). Because there often appears to be near equal numbers of male and female PPM in a population (Service 2008a, pp. 34-37), and there is support for behavioral differences between the sexes (Service 2008a, pp. 31-32), caution must be exercised when making inferences about PPM population sex ratios based on short term trapping studies

While animals surviving for more than 5 years in the wild are likely to represent the maximum end of the longevity curve, mean individual survivorship of PPM appears to be lower. A demographic study of PPM from 2003 through 2006, estimated distinct monthly survivorship rates during summer and winter months, that generally corresponded with periods of above ground activity and inactivity, respectively (Service 2008a, p. 74). Mean monthly summer survivorship on two population monitoring grids was estimated at  $81 \pm 5\%$  (Mean  $\pm$  Standard Error) and  $75 \pm 5\%$ , and monthly winter survivorship was estimated at  $92 \pm 3\%$  and  $91 \pm 2\%$ , respectively. On one of the two grids, support was found for lower overwinter survivorship during the winter of 2004-2005 ( $66 \pm 4\%$ ), which was likely associated with near record rainfall during that winter and spring, causing lower survivorship at that location. If one assumes that each survivorship rate applies for 6 months of the year, then for the grid with better overall survivorship this would result in a mean annual survivorship rate of around 17%. This is consistent with the observation of just a few individuals being detected on the monitoring grids for more than 2 years.

Kenagy (1973, p. 1212) reported overwinter survivorship of 82 %, 56 %, and 36 %, over 3 consecutive years, which he correlated with population size and resource availability for PELO in Owens Valley, California. Larger population sizes and greater survivorship were positively associated with rainfall and annual plant seed availability. Conversely, French et al. (1967, pp. 544-545) suggested there is a correlation between longevity of PELO and seasonal adversity, with animals seeming to survive longer during poor environmental conditions. French et al. (1967, pp. 544-545) hypothesize that during years of good resource availability animals remain active a greater proportion of the time, thus exposing themselves to higher risks of mortality. French et al. (1967, p. 541) also observed an almost complete lack of reproduction in the population during a year of low plant production. If there is a cost in terms of reduced survivorship associated with reproduction, as is often suggested by reproductive theory, the ability of PELO to forego reproduction during years of poor plant production should improve their prospects for survival (Conley et al. 1977, pp. 208-209).

These factors suggest that PPM may be capable of shifting demographic strategies depending on resource availability. Under periods of high rainfall and plant production PPM are likely to exhibit maximum reproduction and relatively low survival rates, while minimum reproduction and maximum survival rates would be expected during times of drought and poor primary production (Conley et al. 1977, pp. 208-209). Thus, in addition to seasonal variability in the age structure of a PPM population that is associated with overwinter dormancy and recruitment of young during spring and summer, there may often be annual variability in the age structure of the population, with the overwinter population being comprised of an increasing proportion of older animals following years of low reproduction (French et al. 1974, pp. 54-58).

In desert environments, reproduction in PELO is highly correlated with rainfall and seed availability (Beatley 1969, p. 721; French et al. 1974, p. 45; Kenagy and Bartholomew 1985, p. 371), and PELO can be prone to great population fluctuations (French et al. 1974, p. 45; Service 2008a, p. 40; Flake and Jorgensen 1969, pp. 146-149; Spencer et al 2001, p. iii). PPM may breed only once in the spring between the months of April and June, though occasionally they have been observed to extend the breeding season and produce two or more litters in a year (French et al. 1967, p. 538; Service 2008a, p. 29; Shier 2008a, p. 24).

Based on studies of a similar sized species of *Perognathus* in the Great Basin, O'Farrell et al. (1975, p. 24) observed that individual components of the population had brief periods of activity above ground on an annual basis. Once they commenced above ground activities, individual Great Basin pocket mice (*P. parvus*) were trappable for an average of 60 days during years of adequate food supplies and an average of 90 days during years that food was scarce. During productive years, trapping late in the year primarily captured subadults produced from late litters, while adults captured earlier in the year had already ceased surface activity (O'Farrell et al. 1975, p. 25). In laboratory trials, French (1977, p. 42) observed that PELO stopped foraging even when food was always made available to them, suggesting that mice may enter dormancy once reproduction is completed and sufficient food stores are accumulated. This pattern of brief periods of above-ground activity among components of the population is consistent with the results of PPM population monitoring efforts; over-winter adults are typically only observed in the spring and early summer, while young of the year tend to remain active into late summer

(Service 2008a, pp. 25-27). This temporal isolation of age groups may minimize competitive interactions between juveniles and dominant adults that have established home ranges and burrow systems (O'Farrell et al. 1975, pp. 26-27).

Gestation of PELO typically lasts 23 days, and young are weaned after 30 days (Hayden et al. 1966, p. 420). PELO become sexually mature at 41 days of age and can breed in their natal year during favorable conditions (Hayden et al. 1966, p. 416; Service 2008a, pp. 28-29). The Service (2008a, pp. 28-29) documented pregnant PPM in April and as late as mid-September, with many of the later pregnancies occurring in young of the year.

PELO produce between four to six offspring per litter if conditions are suitable (Cramer and Chapman 1990, p. 364; Hayden et al. 1966, p. 417; Kenagy and Bartholomew 1985, p. 386). In another species of *Perognathus* with similar reproductive characteristics to PELO, French et al. (1974, p. 61) found mean litter sizes to vary from 5.1 for females less than 1 year old to 6.0 for animals 3 years of age, but comparisons did not reveal significant differences in litter size among age groups. This suggests populations dominated by older individuals maintain high reproductive potential. Conversely, in years of poor resource availability (*e.g.*, drought) PPM may delay breeding or forego breeding altogether, resulting in little to no recruitment to the population (Beatley 1969, p. 721; French et al. 1967, p. 538; Kenagy and Bartholomew 1985, p. 390).

Overall, large litter sizes, the ability of adults to breed more than once in a year, the ability of young to reproduce during their natal year, and the ability of older animals to continue to reproduce give PPM the ability to rapidly recruit individuals into the population under favorable conditions (Beatley 1969, p. 722; Conley et al. 1977, p. 197; French et al. 1974, p. 45; Service 2008a, p. 38). Using simulations, Conley et al. (1977, p. 197) showed that an idealized desert rodent that is reproductively inactive for six months of the year can achieve four-fold population increases within one year with 90 percent of adults and no young reproducing, or with 50 percent of adults and 50 percent of young of the year reproducing. Assuming a greater proportion of adults will breed when young of the year are reproducing, even greater population increases are possible. Using just the number of unique individuals captured, a demographic study of PPM at Camp Pendleton documented an 8.9 -fold increase in PPM abundance between May and September of 2003, with formal population estimates suggesting an even higher rate of population increase occurred on the population monitoring grid (Service 2008a, pp. 38-40). However, population irruptions of this magnitude appear to be infrequent, and relatively stable low population densities of PPM appear to be more typical (See tables of survey results for PPM at extant sites below; Meserve 1976b, p. 651).

Efforts to characterize the home range size or movements of PPM have primarily relied on live-trapping studies to reveal animal movements (Dodd et al. 1998, pp. 9-11; Dodd et al. 1999, p. 12; Dodd and Montgomery 2001, pp. 22-23; Service 2008a, pp. 49-57; Brehme and Fisher 2009, p. 35). Live trapping studies are suboptimal for characterizing an animal's movements or range, since passive sampling methods limit the number of locations and observations that are possible for each individual; measured distances and home ranges are an artifact of trap spacing, configuration, and duration of study; and traps themselves may influence animal behavior (Hayne 1950, pp. 26-39; Allred and Beck 1963, p. 199; Thompson 1982a, p. 1303; Gurnell and

Gipps 1989, p. 241; Service 2008a, p. 52). Low sample sizes common to many PPM trapping efforts and movement data that is not normally distributed (a consideration of importance for statistical comparisons) also compromise the ability to draw strong conclusions from various movement studies. Despite these limitations, a large amount of variability in the movement patterns of PPM has been observed, with qualitative and non-parametric statistical comparisons suggesting that PPM movement varies in response to sex, time of year, age, site conditions, and population density.

The best data for characterizing PPM movement patterns has been collected on Camp Pendleton where four consecutive years of population monitoring was performed on two 1.38 hectare (3.4 acre) monitoring grids (Service 2008a, pp. i-94). For animals captured two or more times within the grids, the observed maximum distance between capture records (the observed range length, "ORL") ranged from 0 meters (for animals always recaptured in the same trap), to 145.3 meters for animals captured at opposite ends of the monitoring grids. Though PPM are capable of longer distance movements over short time intervals (Dodd et al. 1999, p. 12), movements off the monitoring grids precluded such measurements.

Because analysis of PPM movement data reveals that PPM movement estimates are positively correlated with the number of captures per individual, the Service calculated short term movement estimates from animals captured 8 or more times over 4 to 10 nights of consecutive trapping (Service 2008a, p. 53). Combining data from both monitoring grids, males ranged over a significantly larger area than females with mean ORLs of 19.1 and 12.1 meters, respectively ( $U=2883$ ,  $p<0.001$ ). Because this data was not normally distributed, the 95<sup>th</sup> percentile of PPM movements provides an alternative indication of PPM space use over the study interval, with the 95<sup>th</sup> percentile values for males and females being 34.5 and 28.3 meters, respectively.

To characterize PPM spatial utilization over longer time intervals, the Service (2008a, p. 54) calculated ORLs from the largest distance measured between trapping locations recorded among separate trapping bouts performed from 1.5 to 7 months apart over a 4 year monitoring period. Over this time interval, significant differences were again found among the sexes ( $U=18819$ ,  $p<0.001$ ), and mean ORL values increased to 29.3 and 17.9 m for males and females, respectively. The 95<sup>th</sup> percentiles of PPM movements increased even more substantially over the longer time span to 90.5 and 65.7 m for males and females, respectively.

Within the scale of the Service's (2008a, pp. i-94) monitoring grids, permanent relocations of adults from one part of the grid to another were revealed by tabulating recapture sequences for individual animals (Service 2008a, raw data on file CFWO). This phenomenon has been observed for other *Perognathus* species (Maza et al. 1973, p. 405). Shifts in activity may be made in response to localized resource over-utilization, provide a means of avoiding competition with parents, offspring, conspecifics or other species, or may simply represent the discovery of better habitat conditions during an exploratory excursion. While such shifts suggest that an accurate depiction of an animal's use area may require an examination of the temporal sequence of capture locations (Maza et al. 1973, pp. 409-410), it also reveals that PPM occasionally disperse and change their utilization of space over time.

When comparing movement estimates calculated for individual 4-10 night trapping bouts performed between April and September, the Service (2008a, pp. 50-51) found qualitative differences among bouts, with the largest movement estimates generally coinciding with April trapping bouts, when the population was primarily comprised of adults engaged in breeding activity, and September bouts, when the trappable population was generally comprised of subadults just prior to their entry into dormancy. On one of two population monitoring grids, the Service (2008a, pp. 56-57) also found an inverse relationship between PPM abundance and movement distance.

Using similarly derived movement estimates, the larger movement distances corresponding to low population densities at Camp Pendleton are consistent with movement distances observed at the Dana Point Headlands, where low PPM densities have been found (Dodd et al. 1998, p. 12). An inverse relationship between population density and movement has been noted elsewhere in pocket mice and kangaroo rats (Chew and Butterworth 1964, p. 203; Maza et al. 1973, p. 405; O'Farrell et al. 1975, p. 1), but it is unclear whether decreased movement is a response to increased social interactions at higher population densities or greater local resource availability that correlates with higher population densities (French et al. 1974, p. 70).

Despite occasional exploratory forays and shifts in use areas over time, there has been very little study of the immigration/emigration and dispersal capabilities of PELO. Flake and Jorgensen (1969, pp.143-149) removed all the PELO from a 6.3-ha (15.6-ac) area and measured the colonization rate of the trapped-out area. They found during the first year of their removals that adult PELO rapidly colonized the trapped-out area, with the highest rates of invasion (3.6 animals/day) immediately following animal removals. They suggest that the initial invaders were likely to be animals with home ranges along the border of the study site that responded to the removal of animals with which their home ranges overlapped. In each year of their study they observed a decrease in the mean age of invaders over time that coincided with the appearance of young in the surrounding population. Overall, they were unable to detect significant differences in the ratio of invading males and females from the surrounding population or in the mean age of invaders, leading them to conclude that invasion rates varied widely and were mainly influenced by the structure and density of the surrounding population (Flake and Jorgensen 1969, pp. 148-149).

Allred and Beck (1963, pp. 190-200) studied small mammal dispersal using trapping grids and trapping webs with traps spaced at 22.8 m (75.0 ft) intervals. For the few PELO captured in more than one trap station, they recorded maximum dispersal distances of 229 m (751.3 ft) and 235 m (771.0 ft) for a male and female, respectively, over about 1 month intervals. Average range of movement was 71 m (232.9 ft) for males and 57 m (187.0 ft) for females, but relatively few animals were recaptured at stations other than where they were first caught, suggesting the trap spacing exceeded the average range of movement of most mice (Allred and Beck 1963, pp. 198-199).

Summarizing, PPM exhibit substantial individual variability in movement with some individuals appearing to remain relatively sedentary and others making long distance excursions of 150 meters or more; sometimes coinciding with a shift in use area. Males consistently are observed to have larger home ranges than females, with additional variability in movement over time and

space possibly relating to breeding status, the age composition of the population, population density and/or site conditions. Based on data collected at Camp Pendleton and assuming a circular home range with a diameter equal to an animal's maximum observed movement distance, over a 4-10 night interval mean maximum male PPM movements are likely to fall within 0.03 hectare (0.07 acre) and 95 percent of maximum male PPM movements are likely to fall within 0.09 hectare (0.23 acre). Using the same assumptions, over a time interval closer to an animal's lifetime, mean maximum male PPM movements are likely to fall within 0.07 hectare (0.17 acre) and 95 percent of maximum male PPM movements are likely to fall within 0.64 hectare (1.59 acre). However, these movement patterns are characteristic of habitat that is nearly continuously occupied by PPM. Animal removal experiments combined with a PPM's capacity to make longer distance forays suggest PPM may be able to quickly colonize unoccupied suitable habitat adjoining areas of occupancy; with the rate of invasion likely to depend on the density of the surrounding population (Flake and Jorgensen 1969, pp. 148-149).

The direct causes of PPM mortality are poorly known but, similar to desert subspecies, PPM are likely to be prey for a large suite of vertebrate predators including snakes, owls, foxes, weasels, raccoons, coyotes, bobcat, feral and/or domestic cats, and possibly lizards (French et al. 1967, pp. 546-547; Kotler 1985, pp. 824-828; Ogden 1997, p. 36; Pietruszka et al. 1981, pp. 249-250; Price and Brown 1983, pp. 121-124; Service 1998, p. 15). Feral and domestic cats have the ability to deplete a rodent population very quickly (Pearson 1964, p. 180) and may pose a particular predatory threat to PPM populations adjacent to residential developments where cat owners, by providing food, boost cat populations far beyond carrying capacity (Crooks and Soule 1999, p. 565). At the time of listing, a resident living adjacent to the Dana Point Headlands population reported that domestic cats had repeatedly brought in "tiny gray mice" from the adjoining habitat, with one of the retrieved specimens confirmed to be a PPM (Service 1994b, p. 49762)

During population monitoring, dead PPM have been encountered in traps where they were found with other PPM or had been mobbed by ants (Miller, 2004, pers. obs.; Miller, 2006, pers. obs.). Heteromyids are known to be very intolerant of one another, and it is suspected that deaths within traps with two animals resulted from one animal winning out over the other during hostile interactions. Under natural conditions, it is likely that avoidance behavior or the ability of animals to flee from one another minimizes fatal encounters between individuals. However, observations of injured animals and a greater tendency to observe double captures of animals during the breeding season suggest that animals fight over access to mates. With regards to animals found mobbed by ants, it is not clear if ants were able to opportunistically kill animals confined in traps or if the individuals were first subdued by other factors (*e.g.*, exposure). Thus, ants are a potential predator of PPM, but it is unclear how important they are to population dynamics under natural conditions.

Most captured PPM have not shown evidence of disease or heavy parasite loads (Montgomery 2003, p. 32; Ogden 1997, p. 36; Miller, 2008, pers. obs.), although this has not been specifically studied. At the Dana Point PPM population, co-occurring desert woodrats (*Neotoma lepida*) have been observed with severe skin infections, possibly of fungal origin, but it is not known whether there is a risk of transmission to PPM outside of possible exposure from trapping studies (Montgomery 2003, p. 32). PPM at Camp Pendleton are also occasionally observed with

yellow-orange mites around their tail and genitals, and at least one individual has been observed with mange (Miller, 2008, pers. obs.). If disease or parasites are a significant factor in PPM mortality, then larger more dispersed populations would be evolutionarily favored. Trapping records suggest PPM occur in relatively concentrated and contiguous populations, thereby suggesting that disease and parasites could be a significant factor during episodic events. However, no such events have been documented, and the importance of exposure of PPM to skin fungus from population monitoring or chronic low levels of infestation by mites is unknown.

Within the fire-adapted coastal sage scrub community, fire may represent an occasional source of mortality for PPM. Fires, even grass fires, can cause mortality of mice due to heat or suffocation (Howard et al. 1959, p. 231). Fires typically raise surface soil temps to 95-720°C (203-1,328°F) and below surface temps, down to 3-4 cm (1.2-1.6 in) below ground, to 50-80°C (122-176°F). The actual temperature and duration are dependent on fuel distribution and moisture content (DeBano et al. 1998, p. 84). In an experiment to test the effects of fire on rodents, Howard et al. (1959, p. 231) reported that some rodents died due to suffocation, while all others died when surrounding temperatures reached 59-60°C (138-140°F). Because PELO have been known to use burrows only 1 cm (0.39 in) below the surface, and the physiological capacity of heteromyid rodents to withstand temperatures above thermoneutrality is not great (Kenagy 1973, pp. 1210-1211; Chew et al. 1967, pp. 497-499), it is likely that fire could result in the direct mortality of PPM inhabiting an area.

### Spatial Distribution and Abundance

The PPM 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, pp. 538-539; Williams 1986, pp. 27-28; Erickson 1993, unpaginated). The subspecies has not been recorded outside of California and has not been reliably reported more than 4 kilometers (2.5 miles) from the ocean (Service 1998, p. 3).

Range-wide surveys and all other relevant information indicate that the PPM remains a patchily-distributed species that was never more than locally common (Bailey 1939, p. 326; Service 1998, p. 3). Between 1894 and 1972, the PPM was confirmed from 8 general locales encompassing 29 sites including: Marina del Rey/El Segundo (one locale), Clifton and Wilmington in Los Angeles County; Newport Beach (“Spyglass Hill”) and Dana Point in Orange County; and the San Onofre area, the vicinity of the Santa Margarita Estuary, and the Lower Tijuana River valley in San Diego County (59 FR 49752; Service 1998, p. 3). Two additional reports from San Diego County at Lux Canyon near the San Elijo lagoon, and from the vicinity of Los Penasquitos lagoon, are unconfirmed (Germano 1997, p. 3; Erickson 1993, unpaginated)

Although the PPM was likely once more extensively distributed across this range, much of the habitat that may have supported the subspecies has been lost in association with large scale development of the coastal lowlands of southern California. Five of the eight areas historically known to harbor PPM have been developed or significantly degraded through human activity (59 FR 49752; Erickson 1993, unpaginated). There are no records of PPM from Los Angeles County since 1938, and the Clifton and Wilmington locales have been developed (Erickson 1993, unpaginated). Habitat in the Hyperion area of Marina del Rey/El Segundo has been lost to urban

development (59 FR 49759). In the vicinity of the Marina del Rey/El Segundo locale, the El Segundo dunes contain the best remaining habitat but a portion of the dunes formerly supported a residential development, and this area has reportedly been trapped extensively without success (Germano 1997, p. 31; Erickson 1993, unpaginated). Within Orange County, the “Spyglass Hill” location and surrounding area was developed in 1972 (Erickson 1993, unpaginated). Habitat surrounding the type locality for the subspecies near the Mexico border in San Diego County has been degraded by illegal border crossings and patrol, agriculture and other human activities, and recent trapping surveys have failed to detect PPM at this locale (59 FR 49769; Germano 1997, p. 12).

A Geographic Information System (GIS) study that modeled remaining potentially suitable PPM habitat based on soil and vegetation parameters identified the San Joaquin Hills in Orange County, and Camp Pendleton in San Diego County, as having the largest remaining contiguous blocks of natural habitat within the subspecies historical range (Spencer et al. 2000, p. 7). Smaller areas with remaining potentially suitable habitat include the vicinity of Aliso Canyon in Orange County, and in San Diego County, the Lawrence Canyon/Benet Canyon/ Tuley Canyon area in northern Oceanside, Torrey Pines State Park, Point Loma, and habitat fragments adjoining the San Elijo and San Dieguito lagoons (Spencer et al. 2000, p. 7).

Between 1972 and 1993 there were no records of PPM until the subspecies was rediscovered at the Dana Point Headlands in Orange County. This was the only known extant population of the subspecies at the time of its listing in 1994 (59 FR 49752). Shortly thereafter, PPM was discovered at three additional locations, all within the boundaries of Marine Corps Base Camp Pendleton in San Diego County (MBA and LSA 1997, pp. 8-9; Ogden 1997, p. 2; Service 1999a, p. 1). Despite at least 82 survey efforts that have been performed within its historical range since the time of listing (2009 CFWO Survey Report Data Base), no additional locations for PPM have been identified.

All four of the recently documented locations of PPM were known when the Recovery Plan was written (Service 1998, pp. i-112). Because the northernmost two locations on Camp Pendleton, known as San Mateo North and San Mateo South, are found on either side of San Mateo Creek, the Recovery Plan (Service 1998, pp. 5-6) describes them as contributing to a single PPM “locale.” For ease of discussion, San Mateo North and San Mateo South are herein discussed separately and referred to as two populations. The third location of PPM discovered on Camp Pendleton occurs on a coastal terrace north of the Santa Margarita River, in an area that is designated by the Marine Corps as the Oscar-1 and Edson Range training areas. This document refers to this population as the Santa Margarita population, but elsewhere this population has been referred to as the Oscar-1 population or the Oscar-1/Edson Range population.

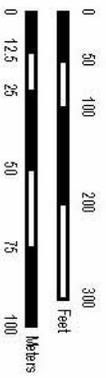
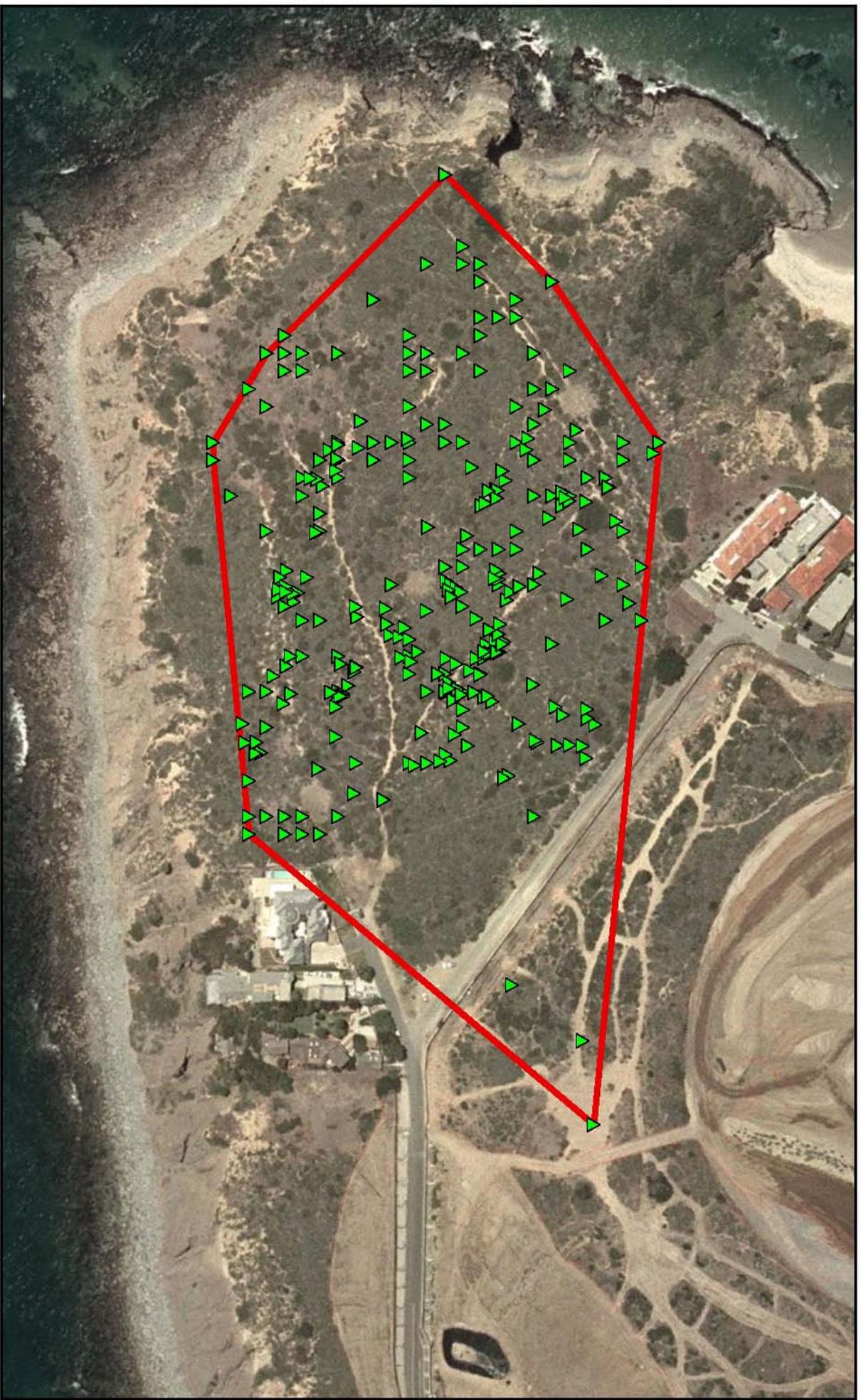
#### *Dana Point Headlands*

The Dana Point Headlands site is a remnant coastal bluff top habitat fragment that overlooks Dana Point Harbor and the Pacific Ocean and is otherwise surrounded by urban development (Figure 1). The PPM habitat at Dana Point is predominated by coastal sage scrub vegetation growing within loamy sand soils. The PPM was discovered at this location in association with



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*Figure 1: Dana Point Preserve PPM Locations and Minimum Convex Polygon*



- Legend**
-  PPM Capture Locations
  -  Minimum Convex Polygon

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GIS CONTACT: EDWIN TURNER  
BIOLOGY CONTACT: WILL MILLER  
MAP DATE: 03/05/10  
DATA SOURCE: PIMS  
IMAGE SOURCE: CALBED 2008  
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the environmental review of a proposed residential and commercial development on the property, which is the last undeveloped coastal front property in the City of Dana Point.

Using presence/absence survey techniques, Brylski (1993, p. 5) captured 25 to 36 individual PPM within about 1.52 ha (3.75 ac) of habitat on the 48.0-ha (121-ac) site proposed for development. Portions of the 48-ha site were formerly developed with a nursery and a mobile home park. In addition to the area where PPM was found, Brylski identified another 16.8 ha (41.43 ac) of the Headlands site as suitable for PPM. The discovery of this population and the pending development proposal prompted the emergency listing of the species in February of 1994 (59 FR 5306).

In July of 1996, the Orange County Central and Coastal Subregions Natural Community Conservation Plan/Habitat Conservation Plan (NCCP/HCP) conditionally approved take of PPM on the Dana Point Headlands property in association with its development. However, removal of habitat on 8.9 ha (22 ac) of the property, including the area where PPM was discovered was delayed for 8-years by the NCCP/HCP to afford the Service time to study the resident PPM population and decide whether the Temporary Preserve is essential for conservation of the subspecies. Should such a determination have been made, the Service was granted an option to purchase the Temporary Preserve. Approximately 3.2 ha (8 ac) of the Temporary Preserve is oceanward of the bluff edge, so slightly more than a third of the Temporary Preserve is near vertical and likely unsuitable for PPM.

In 2000, the landowners of the Dana Point Headlands proposed to permanently conserve the 8.9-ha Temporary Preserve as part of a revised development proposal for the 48-ha Dana Point Headlands site. This development proposal was approved by the City of Dana Point in February of 2005, and involves residential and commercial development on about 29-ha (71-ac) of the 48-ha (121-ac) site. Grading for the developed portion of the property was initiated in the spring of 2005 and development is ongoing.

Prior to initiation of development, the former Temporary Preserve was placed under a conservation easement and sold to the Center for Natural Lands Management (CNLM) as part of a larger 11.9-ha (29.4 ac) conservation area now known as the Dana Point Preserve. The 3 ha (7.4 ac) portion of the Dana Point Preserve that falls outside the former Temporary Preserve includes a former residential street, Marguerita Avenue, and habitat inland of the street that was separated from the Temporary Preserve. Most of Marguerita Avenue has recently been abandoned and is being restored to coastal sage scrub vegetation, bringing preserved habitat on both sides of the street into more effective contact for mice.

Additional habitat conserved by the City of Dana Point within the overall 48-ha Dana Point Headlands site includes a 4.7-ha (11.5-ac) Hilltop Park that abuts the inland border of the Dana Point Preserve, and two discontinuous parcels that include the 2.8-ha (6.9 ac) Harbor Point Park, and the 1.5 ha (3.7 ac) South Strand Biological Open Space. Of the conserved areas, the Dana Point Preserve has the greatest and only demonstrated potential to support PPM.

Associated with acquisition of the Dana Point Preserve, the philanthropic Harry and Grace Steele Foundation provided endowment funding to CNLM to manage the preserve in its natural

condition for the ongoing benefit of the public. A condition of the development approval and the endowment is that a hiking trail be constructed within the Preserve and be made available for controlled public access. In April of 2007 the trail was constructed, and in December of 2009 access to the trail was granted to the public. Public access trails and viewing points have also been developed and opened to the public within the City owned open space.

Since PPM were rediscovered in 1993, 13 small mammal trapping efforts have been performed at the Dana Point Headlands (Table 1). Ten of these trapping efforts were restricted entirely to the boundaries of the 8.9 ha Temporary Preserve area, one effort was performed mostly on portions of the Dana Point Headlands that are now being developed, and the two most recent efforts have been implemented within the former Temporary Preserve and the 3-ha adjoining area that was incorporated as part of the Dana Point Preserve. Goals of the trapping efforts have varied over time along with trapping methods, compromising the ability to directly compare results.

Table 1. Pacific Pocket Mouse (*Perognathus longimembris pacificus*) Survey Efforts at Dana Point Headlands, 1995 to 2007.

Date	Reference	Purpose	Effort (trap nights)	# of PPM Captured
1993: 7/19-8/5	Brylski 1993	Presence/absence	648	25-36
1996: 8/28-9/6	Service 1996a	Presence/absence	815	8
1997: 8/19-8/28	Dodd et al. 1998	Population assessment	2782	21
1998: 7/24-8/4	Dodd et al. 1999	Population assessment	3325	19
1999: 4/28-5/5	Dodd and Montgomery 2001	Vegetation thinning experiment	3710	11
1999: 8/7-8/14	Dodd and Montgomery 2001	Vegetation thinning experiment	3710	4
2000: 5/5-5/11	Dodd and Montgomery 2001	Vegetation thinning experiment	3080	9
2000: 8/2-8/8	Dodd and Montgomery 2001	Vegetation thinning experiment	3080	6
2001: 5/30-6/5	Service 2002a	Population assessment	4835	4
2002: 8/5-8/13	Service 2002b	Population assessment	2916	2
2002: 8/18 -9/1	URS 2002	Survey outside Temporary Preserve Area	3035	None
2007: 4/12-4/20	Service 2007a	Salvage trapping along trail alignment	925	1
2008: 5/2-5/7, 6/6-6/11	Brylski et al. 2009	Proportion area used	3280	30
2009:5/1-5/11	Brylski et al. 2010	Proportion area used	3362	82

Initial efforts implemented within the Temporary Preserve following adoption of the NCCP/HCP expanded the area of presumed occupancy for PPM, but also documented fewer unique individuals than Brylski (Service 1996a, pp. 1-3.). These results, in combination with findings elsewhere, led investigators to hypothesize that much of the coastal sage scrub vegetation on site had become too mature to support PPM.

In 1999, 11 small monitoring grids were established in association with a vegetation thinning experiment that was implemented in January of 2000 (Dodd and Montgomery 2001, pp. i-26) to test whether vegetation thinning enhances habitat for PPM. This experiment involved hand thinning of vegetation in four separate 0.14-ha (0.33-ac) plots overlapping eight of the monitoring grids. Initial trapping results in 2000 following the vegetation thinning suggested that PPM responded positively to the thinned areas, but interpretation of results was compromised by the small number of PPM captured (nine and six individuals, respectively, in the spring and summer of 2000) (Dodd and Montgomery 2001, pp. 19-22). Also, of particular concern was the low level of reproductive activity observed in the population during 2000 (one juvenile detected during summer trapping).

In the spring of 2001, a formal trapping grid employing unbiased trap placements was established over all accessible areas within the Temporary Preserve to obtain a statistically valid population estimate for the site (Service 2002a, pp. 1-14). However, this effort only detected four individuals (two males and two females), which was too small a sample size to employ statistical population estimators. Based on initial results and captures of pregnant females, investigators were concerned that an inadvertent trap death could imperil the population and trapping was terminated.

In 2002, another systematic trapping grid was employed over much of the Temporary Preserve to again attempt an improved population estimate for the site (Service 2002b, pp. 1-7 + Figures). This trapping grid was slightly smaller than the one employed in 2001, but was still expansive and surveyed all areas where PPM had historically been detected, along with adjoining areas of potentially suitable habitat. This effort only detected two adult PPM (one male and one female).

In April of 2007, prior to construction of the hiking trail within the Dana Point Preserve, a salvage trapping effort was implemented to avoid direct injury to PPM whose home ranges might fall within the trail alignment (Service 2007a, pp. 1-2). Because traps were confined to areas within or immediately adjoining the trail alignment, this effort was not designed to provide an accurate assessment of the status of the PPM population. However, it did confirm that PPM persisted on site. One animal was captured and held in temporary captivity until construction of the trail was completed. This animal was then released in the vicinity of its original capture using “soft release” methods (*i.e.*, with the use of an artificial burrow).

In 2008, CNLM initiated a PPM monitoring program in association with its management of the Dana Point Preserve. Given budgetary constraints and the difficulty of making statistical population estimates of PPM at low densities, this program was designed to track the proportion of the Preserve that is used by PPM (Brylski et al. 2009, pp. i-32). All bluff top habitat on the ocean-side of Marguerita Avenue (including the entirety of the former Temporary Preserve and some additional area) was overlain by a grid of contiguous 24-m by 24-m sample cells (see Figure 1). In total 96 cells covering 5.5 ha (13.7 ac) were identified on terrain safe enough to survey within the Dana Point Preserve (*i.e.* not on bluff face), from which a cumulative total of 66 cells (69%) were randomly selected to be surveyed over two five-day trapping intervals. Because there was concern that randomized cell selection could miss detecting PPM despite its presence, several traplines were deployed near historical capture records that fell outside of the

random selected cells. Some selectively placed traplines were also placed on habitat inland of Margarita Avenue.

During the first week of May 2008, a total of 14 unique adult PPM were captured, and animals were captured in 10 of 34 cells sampled (Brylski et al. 2009, p. 10). Statistical analysis of individual PPM capture histories estimates that 15 individuals (lower confidence interval (LCI) = 14, upper confidence interval (UCI) = 22) were actually present within the effective sample area, but the size of this area is uncertain due to observed PPM movements among cells (i.e. 15 individuals may be more than resided in the sample cells, but fewer than occurred within the overall Dana Point Preserve). An alternative analysis of habitat use based on animal captures within the sampled cells estimates that PPM were using around  $32 \pm 9\%$  (LCI=18%, UCI=51%) of the Dana Point Preserve at this time (Brylski et al. 2009, pp. 17-20).

During trapping performed a month later, 16 unique juvenile PPM and one adult previously detected in May were captured in 15 of 32 cells sampled (Brylski et al. 2009, p. 10). Thus, in total 30 unique PPM were detected within the Dana Point Preserve in 2008 with almost no adults being detected in the second trapping session. Again, although the area to extrapolate abundance too is uncertain, statistical analysis suggests a total of 28 individuals (LCI = 20, UCI =52) were present within the June effective sample area. Analysis of cell level capture histories suggests that following the emergence of juveniles,  $67 \pm 17\%$  (LCI=31%, UCI=90%) of the Dana Point Preserve was being used by PPM (Brylski et al. 2009, pp. 17-20). Whether the increase in the proportion of the Preserve being used in June is reflective of population growth or dispersing juveniles searching for suitable habitat is unclear.

In 2009, the same monitoring methods were implemented with the exceptions that: 1) surveys were scheduled over a consecutive 10 day sample period in early May (rather than being spaced apart by one month) to allow data from the two survey panels (34 and 32 cells, respectively) to be combined for a single habitat use estimate; and 2) selectively placed traplines were deployed on the inland side of Marguerita Avenue (Brylski et al. 2010, pp. i-33). In total 80 PPM (78 adult, 2 young of year) were captured within 45 of the 66 cells sampled, and another 2 individuals were captured within habitat inland from Marguerita Avenue. The abundance estimate for the area sampled during the first 5 days of trapping was 70 (LCI=63, UCI=86) and for the area sampled during the second 5 days was 88 ((LCI=58, UCI=163). However, recorded PPM movements indicate there was overlap among the effective sample areas of the two survey panels, so these estimates cannot be combined to generate a single abundance estimate for the site (Brylski et al. 2010, pp. 9-12).

Because this issue was not problematic for the habitat use estimate, combined data from capture histories within the sampled cells suggests that PPM were using around  $74 \pm 6\%$  (LCI=59%, UCI=84%) of the portion of the Dana Point Preserve that includes the former Temporary Preserve on the ocean-side of Marguerita Avenue (Brylski et al. 2010, pp. 9-12). Significantly, captures of two individuals on the inland side of Marguerita Avenue indicate that PPM are utilizing habitat that was presumed unoccupied but has recently been restored and conserved as part of the Dana Point Preserve. The recent abandonment and restoration of Marguerita Avenue may enhance the function of this area for mice by bringing it into more effective contact with adjoining occupied habitat.

In conclusion, although recent monitoring efforts suggest that the Dana Point Headlands PPM population is currently at a peak and much of the available habitat is being used by PPM, intensive survey efforts over a number of years have commonly detected very few PPM, suggesting that this population has persisted despite sometimes ebbing to very low numbers. In addition to high vulnerability to demographic and environmental stochasticity, populations of this size are vulnerable to inbreeding depression and loss of genetic diversity (Shaffer 1981, p. 131; Franklin 1980, pp. 135-149). While the Dana Point Preserve is conserved as natural open space in perpetuity, the area of potential occupancy for PPM is only slightly larger than the 5.5 ha (13.7 ac) area monitored for PPM on the ocean-side of Marguerita Avenue. The recent loss of potentially suitable surrounding habitat to residential and commercial development and creation of a public access trail within the Preserve suggests that intensive site management will be needed to offset the impacts of increased habitat fragmentation and human presence. Conservation of PPM at this site will rely on the details of site management over the long term and upon close coordination between CNLM and the Wildlife Agencies in pursuing management and recovery of PPM at the site. The apparent small size of the Dana Point population and the likelihood that it may go through frequent population bottlenecks suggests that population augmentation may occasionally be needed to offset the detrimental genetic effects of small population size.

#### *San Mateo North*

The San Mateo North site is located on a south-facing slope in the northwest corner of Camp Pendleton. PPM habitat at San Mateo North is predominated by mature coastal sage scrub growing within loamy coarse sands and sandy loams (MBA and LSA 1997, p. 17). Although San Mateo North falls within the bounds of the Marine Corps Base it is on land leased by the State of California that is managed as part of San Onofre State Park. The area where PPM have been detected is surrounded by residential development and a golf course to the west; a former agricultural field recolonized by sage scrub vegetation, I-5 and commercial development to the south; Christianitos Road, a State Park campground, San Mateo Creek and fallow agricultural fields to the east; and a combination of chaparral, sage scrub, and riparian vegetation that is traversed by power lines and utility roads to the north (Figure 2). The State Park has a public access trail that traverses the boundary of PPM habitat which receives heavy use from nearby residents walking their dogs. Other unauthorized trails and a makeshift BMX track traverse this area. During 2008, surveyors discovered marijuana plants being grown within this vicinity and several areas of homeless habitation (Brehme, U.S. Geological Survey, 2008, pers. comm.; Miller, 2008, pers. obs.).

San Mateo North is 21 km (13 mi) southeast of the Dana Point Headlands, 2.4 km (1.5 mi) northwest of San Mateo South, and around 23 km (14.3 mi) northwest of the Santa Margarita PPM population. It is isolated from the Dana Point Headlands by urbanization and from the Santa Margarita PPM population by a combination of human development, land-use practices, and unsuitable habitat. Of the extant PPM locations, San Mateo North and San Mateo South are closest to one another with the greatest potential for interchange of individuals. A genetic study found that among the extant populations, San Mateo North and San Mateo South share the greatest number of genetic markers, suggesting these populations were the most recent to be

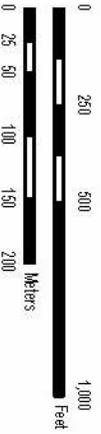


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*Figure 2: San Mateo North PPM Locations and Minimum Convex Polygon*



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CARLSBAD FIELD OFFICE  
GIS CONTACT: EDWIN TURNER  
BIOLOGY CONTACT: WILL MILLER  
MAP DATE: 03/05/10  
DATA SOURCE: FWS  
IMAGE SOURCE: ICLEED 2008  
S:\BeltedSnipe\file\_year\ppm\redssan\_north.joeh\road



- Legend**
-  PPM Capture Locations
  -  Minimum Convex Polygon

historically connected (Swei et al. 2003, p. 508). Presently these sites appear to be effectively isolated from one another and are separated by fallow agricultural fields and associated roads in the San Mateo floodplain, San Mateo Creek, a State Park campground, and Cristianitos Road.

Fourteen surveys targeting PPM have occurred at and around the San Mateo North site since PPM was first detected in 1995 (Table 2). Many of these surveys were directed at defining the boundaries of PPM occupancy at San Mateo North to help minimize impacts to PPM in association with a formerly proposed toll road alignment in this vicinity. Another series of trapping efforts were designed to study whether PPM colonized a 1.4 ha (3.4 ac) area where a prescribed burn was implemented to enhance habitat for PPM. Although the post-burn surveys were designed to estimate PPM density within the burn area, none of the distributional or post burn surveys employed methods to estimate PPM abundance across San Mateo North as a whole. Additionally, several survey efforts performed at this site have been implemented late in the summer when a portion of the population is likely to have already entered dormancy (Service 2008a, pp. 38-40; Shier 2008a, p. 16).

The greatest number of unique PPM documented in a single year at San Mateo North is 33 individuals that were documented in 1995 (MBA and LSA 1997, p. 9). Twenty two individuals were documented the following year (MBA and LSA 1997, p. 12), with fewer than 10 animals documented during each subsequent survey effort. PPM were last captured at San Mateo North in 2003, when 4 individuals were detected (Natural Resource Assessment, Inc. 2003, p. S-1). Although suitable habitat appears to extend beyond the bounds of PPM capture locations, a minimum convex polygon drawn around all historical capture records circumscribes an area of 5.6 ha (13.8 ac).

The most intensive, comprehensive and systematic effort to characterize the San Mateo North PPM population was performed in 2008 by USGS (Brehme and Fisher 2009, pp. i-40). With the exception of Cristianitos Road and areas with impenetrable vegetation or steep slopes, this survey employed a systematic trapping grid that was placed over a 9.7-ha (24-ac) area that included the 5.6 ha minimum convex polygon around historical PPM locations and a 50-m buffer extending beyond that polygon. However, this effort failed to detect any PPM.

In 2009, USGS partnered with University of Washington researchers to test whether dogs trained to detect the scent of PPM scat can be used to survey for PPM. Initial trials indicate that dogs will respond to PPM scat, so survey dogs were brought to San Mateo North to pilot this survey method. Dogs exhibited behavioral responses suggesting the presence of PPM in seven locations, but searches only confirmed the presence of scat at the soil surface at one of those locations (Brehme 2009a, pers. comm.). Because species assays are still in development, it will be some time before the scat can be analyzed to confirm it came from PPM (Brehme 2009a, pers. comm.). Following “hits” by dogs, USGS deployed tracking tubes at the 7 locations to record PPM footprints and, thereby, confirm PPM activity at those locations. The use of tracking tubes is an as yet unproven survey method that is also being tested for application to PPM population monitoring. PPM activity at San Mateo North was not confirmed by the tracking tubes (Brehme 2009b, pers. comm.).

Table 2. Pacific Pocket Mouse (*Perognathus longimembris pacificus*) Survey Efforts at San Mateo North, 1995 to 2003.

Date	Reference	Purpose	Effort (trap nights)	# of PPM Captured
1995: 8/14-8/20	MBA and LSA 1997	Survey to assess distribution	3,836	33
1996: 7/21-9/24	MBA and LSA 1997	Survey to assess distribution	4,783 total, less than half within the known PPM range	22. Some animals could have been counted twice.
1999: 7/18-8/6	MBA 1999	Focused surveys for PPM	6,400 total, about half within the known PPM range	2 captures of likely 1 individual, male
2000: July	Dodd 2000	Genetic sampling	Unreported	8
2001: 6/4-6/9	USDOT 2005	Confirm activity level	2,600	2
2001: 7/10-7/14	Montgomery 2005a	Post Burn / Habitat Improvement Monitoring	1,250	0
2001: 7/2-7/6	USDOT 2005	Confirm activity level	900	1
2002: 7/8-7/12	Montgomery 2005a	Post Burn / Habitat Improvement Monitoring	1,460	0
2003: 7/17-7/21	Montgomery 2005a	Post Burn / Habitat Improvement Monitoring	1,350	0
2003: 9/4-9/14	Natural Resource Assessment, Inc. 2003	Confirmation of presence / define range limits	2,200 total, one third within the known PPM range.	4
2008	Brehme and Fisher 2009	Proportion Area Occupied	4224	0
2009	Brehme 2009a	Test tracking tubes and dog scent detection as survey methods	NA	0 (Dog scent detection at 7 locations)

In summary, although suitable habitat appears to extend beyond the bounds of PPM capture locations, a minimum convex polygon drawn around all historical capture records circumscribes an area of just 5.6 ha (13.8 ac). Additionally a recent intensive survey covering the entire area of historical occupancy and surrounding habitat failed to detect any PPM at this location. While the results of surveys using dogs trained for scent detection provide hope that PPM remain extant at San Mateo North, all indications are that this is the smallest and most vulnerable population to extirpation.

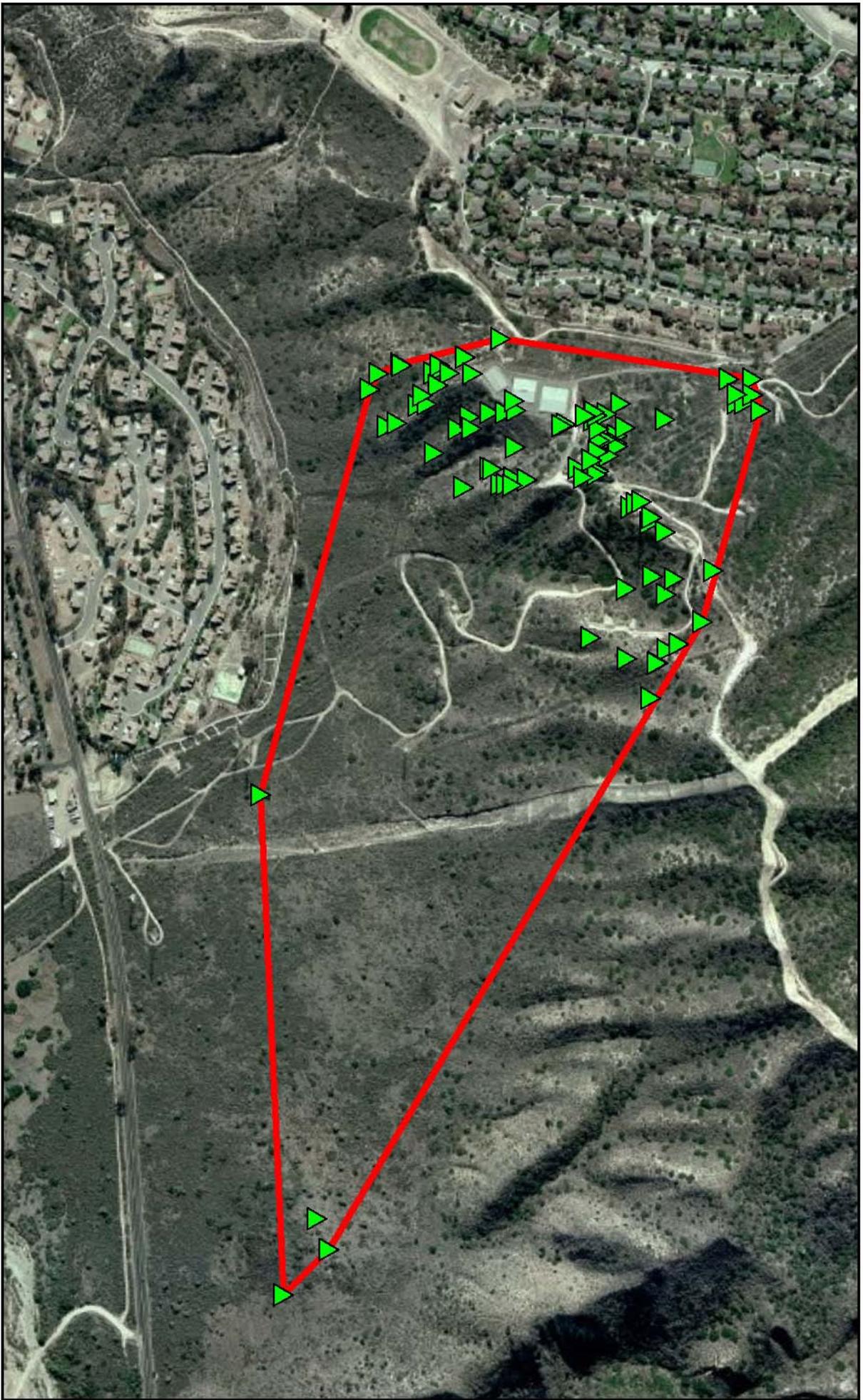
#### *San Mateo South*

The San Mateo South site is located within a military training area on Camp Pendleton approximately 3.2 km (2 mi) from the coastline (see Figure 3). Habitat at this site is characterized by open coastal sage scrub growing in fine sandy loam and loamy coarse sand soils (Ogden 1997, pp. 21-25). San Mateo South is topographically an east-west oriented ridgeline with northerly sloping terrain draining into San Mateo creek, and southerly sloping terrain



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*Figure 3: San Mateo South PPM Locations and Minimum Convex Polygon*



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CARLSBAD FIELD OFFICE  
GS CONTACT: EDWIN TURNER  
BIOLOGY CONTACT: WILL MILLER  
MAP DATE: 10/05/10  
DATA SOURCE: PMS  
IMAGE SOURCE: CALBED 2008  
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draining into San Onofre creek. PPM were first detected at San Mateo South in 1995 (Ogden 1997, p. 4) but its adjacency to San Onofre creek suggests this site may represent a portion of the historical San Onofre PPM occurrence.

The site is bounded on the south by Basilone Road and military housing, to the west by military housing, and to the north by native vegetation and fallow agricultural fields. The eastern boundary of the population is not clearly defined, and there are no obvious changes in soil or vegetation to suggest a definitive limit to habitat suitability in this direction. Within the perimeter of PPM capture locations are several dirt roads, power line structures, a covered water storage facility and fire breaks. Although San Mateo South occurs within an area designated for military training it appears to receive light and infrequent use by troops.

San Mateo South is approximately 2.4 km (1.5 mi) southeast of San Mateo North, and approximately 19.5 km (12 mi) northwest of the Santa Margarita PPM Population. Like San Mateo North, San Mateo South is isolated from the Dana Point Headlands and Santa Margarita PPM populations by distance, urbanization, land use practices and unsuitable habitat. The geographic relationship and potential for interchange of PPM between the two San Mateo populations is discussed above in the section addressing San Mateo North.

Of the four extant PPM populations, the least amount of focused trapping has been implemented at San Mateo South, with none of the efforts designed to specifically estimate population abundance. Nine trapping efforts targeting PPM have occurred at and around the San Mateo South site since the species was first detected in 1995 (Table 3). Of the initial trapping efforts, the greatest number of PPM detected in a single year was 20 individuals which were captured on selectively placed wandering trap-lines in 1996 (Ogden 1997, p. 21). Ogden (1997, p. 21) used combined capture locations from 1995 and 1996 and homogeneity of surrounding habitat to estimate that the San Mateo PPM population occupies an area of around 13 ha (32 ac).

The most comprehensive and systematic trapping for PPM at San Mateo South was implemented by USGS in 2008 in association with development of a Base-wide PPM monitoring methodology (Brehme and Fisher 2009, p. i-40). With the exception of areas of impenetrable vegetation and steep slopes, this effort involved placement of a systematic trapping grid over a 15.3-ha (37.8-ac) area that included an 8.3-ha (20.5-ac) minimum convex polygon surrounding historical PPM locations and a 50-m buffer extending beyond that polygon. A total of 45 unique PPM were captured during this survey effort, about one third of which were captured outside of the formerly delineated minimum convex polygon (Brehme and Fisher 2009, p. 17).

In 2009, PPM were also captured at two locations near San Mateo South but outside the bounds of historical capture records. The first of these was an incidental capture of a single PPM in a reptile survey pitfall array adjoining military housing off of Basilone Road, approximately 400 m southeast of 1995-2008 capture locations (Brehme 2009c, pers. comm.). This reptile pitfall array was installed over 10 years ago for biodiversity monitoring, and was initially operated on an annual basis, then was not operated for a number of years but has been brought back into use over the last few years (Sosa 2009 pers. comm.). This is the first confirmed capture of PPM within the pitfall array. Three PPM were also detected during presence absence surveys about

800-m to the southeast of 1995-2008 capture locations, and about 500-m east of the reptile pitfall array (Vergne 2009, p. 6).

Because habitat that intervenes between the 1995-2008 capture locations and these two locations appears suitable for PPM, it is not clear if these records represent an expansion of the San Mateo South population or a portion of the distribution that previously went undetected due to low population density or limited or no survey coverage of this area. Assuming these capture locations represent a portion of the San Mateo South population, the minimum convex polygon surrounding PPM captures in the San Mateo South vicinity now circumscribes 40.4-hectares (99.8-acres).

Table 3. Pacific Pocket Mouse (*Perognathus longimembris pacificus*) Survey Efforts at San Mateo South, 1995 to 2005.

Date	Investigator	Purpose	Effort (trap nights)	# of PPM Captured
1995: May	Ogden 1995 <sup>1</sup>	Presence/absence	unreported	2
1995: 7/6-10/18	MBA and LSA 1997	Seasonal activity monitoring	735	13
1996: 8/15-9/21	Ogden 1997	Base Wide survey	~2,000	20
1999: 8/2-8/6	MBA 1999	Focused Surveys for PPM	500	6
2003: 7/7	Montgomery 2003	Control trapping for SDGE surveys outside known range	15	1
2003: 8/ 20	Montgomery 2003	Control trapping for SDGE surveys outside known range	12	1
2005: 7/12-14	Montgomery 2005b	Trap and relocation	296	8
2008: 5/5-6/26	Brehme and Fisher 2009	Proportion Area Occupied	2798	45
2009	Brehme 2009c	Incidental capture	n.a.	1
2009	Vergne 2009	Presence Absence	3400	3

In summary, the boundaries of the San Mateo South PPM population remain poorly characterized, with recent capture locations suggesting that this PPM population extends further to the southeast than previously documented. Within the bounds of historically documented occupancy, low population densities have always been documented with fewer than 50 individuals ever having been detected during even the most intensive survey at this location.

### *Santa Margarita*

The southernmost of the PPM populations on Camp Pendleton is located in the Oscar One and Edson Range training areas, which adjoin one another immediately north of the Santa Margarita River. The Santa Margarita population has alternately been referred to as the “Oscar One” or “Oscar One/Edson Range” population, and is distributed over a significantly larger area than any of the other known populations (see Figure 4). As such, this site has the greatest range of habitat conditions with vegetation ranging from areas predominated by coastal sage scrub to sage scrub-

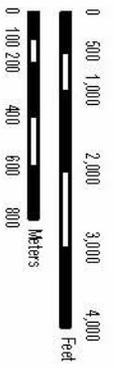
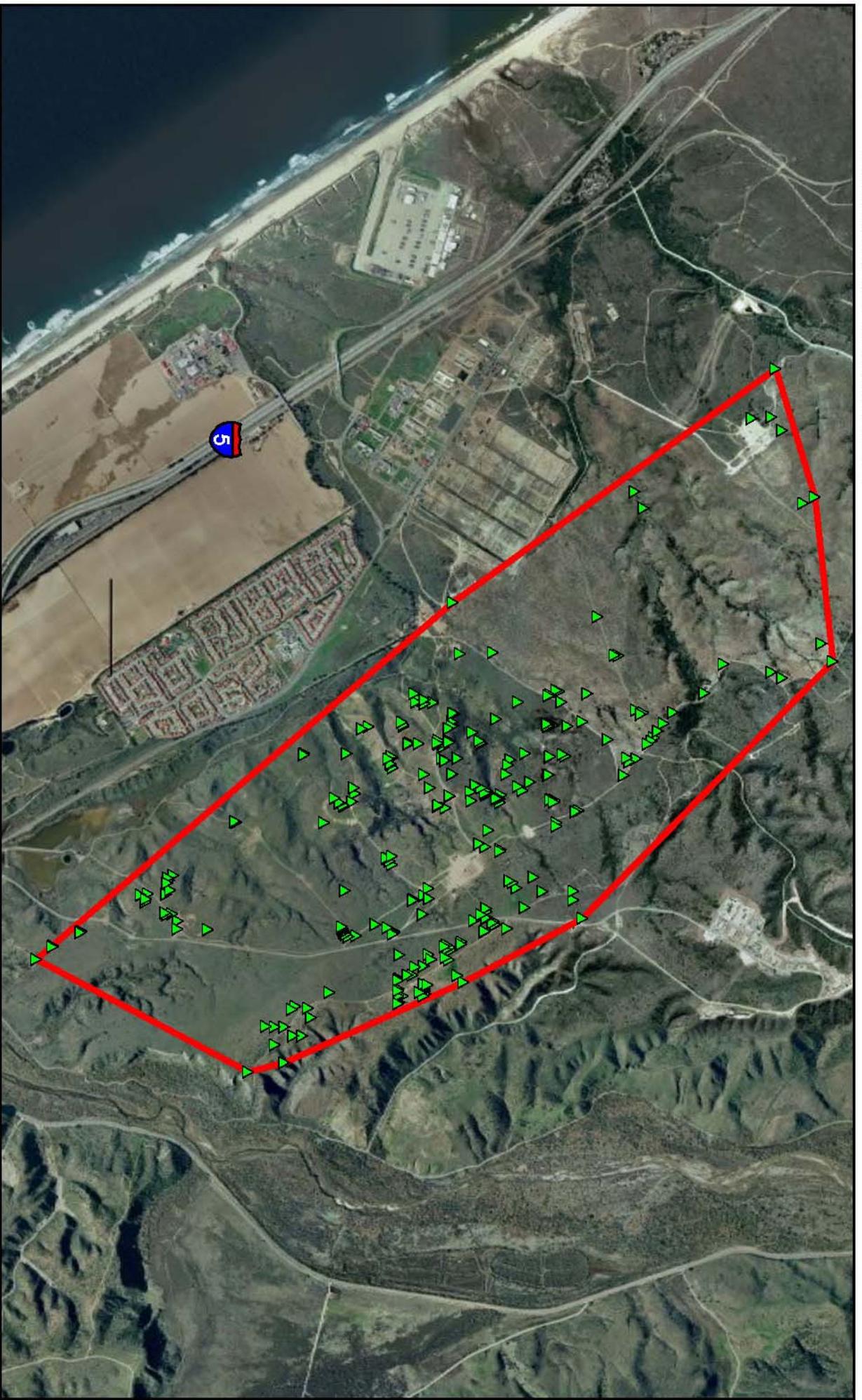


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Figure 4: Santa Margarita PPM Locations and Minimum Convex Polygon



- Legend**
- ▲ PPM Capture Locations
  - Minimum Convex Polygon

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CARLSBAD FIELD OFFICE  
GIS CONTACT: EDWIN TURNER  
BIOLOGY CONTACT: WILL MILLER  
MAP DATE: 03/06/10  
DATA SOURCE: FWS  
IMAGE SOURCE: IQJEED, 2008  
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grassland ecotonal areas, mixed native and nonnative grassland/forblands, and dense nonnative grasslands. A number of different soils are also found across the range of the Santa Margarita population including fine sandy loams, loamy fine sands, clay loams, and loamy and gravelly soils (Service 1999a, p. 4). Topographically, the Santa Margarita population occurs on a gently sloping coastal terrace that is traversed by Macs Road and is divided by a number of drainages and erosion gullies that drain to the west. To the south and east are steep cliffs that drain to the Santa Margarita River, to the west is Stuart Mesa Road, military housing and barracks, and to the north are undeveloped coastal foothills that fall within designated military training areas.

The minimum convex polygon surrounding historical capture records of PPM is 741 ha (1,831 ac) (Service 2006, pp. 12-14), which covers a mosaic of habitat suitability that ranges from unsuitable unoccupied areas to areas of high habitat suitability that are sometimes capable of supporting hundreds of individuals (Spencer 2007, pp. B-43-B-56; Service 2008a, pp. i-94). Thus, the overall area of suitable habitat that is occupied by PPM within the bounds of capture records is likely to be considerably less than that which falls within the minimum convex polygon, but there has been no systematic attempt to characterize the amount of suitable habitat within this area. Conversely, as with other PPM populations, the area of documented occupancy is an artifact of survey effort that could expand with additional trapping along presumed population boundaries.

Due to the range of habitat suitability and land use practices across this area, the Santa Margarita population is best characterized according to three general areas. These areas include: 1) The Upper Mesa in Oscar One, which covers about 103 ha (255 ac) and is mostly northeast of Macs Road; 2) the Lower Mesa in Oscar One, which covers about 352 ha (869 ac) and is southwest of Macs Road; and 3) the Edson Range portion of the population, which covers about 286 ha (707 ac) northwest of Oscar One.

Although the Upper Mesa is within the Oscar One Training Area, it is exposed to very low levels of training. This portion of the Santa Margarita population is traversed by power-lines with associated towers and dirt roads that provide access for power-line maintenance. The soil on the Upper Mesa consists of a mosaic of sandy and less sandy soils, and the vegetation consists primarily of native grasses and forbs, with sparse cover by white sage and other shrubs. Areas to the northeast have increasing cover by sage scrub and areas near Macs road are dominated by nonnative grasslands. Survey efforts have documented relatively high numbers of PPM within this portion of the Santa Margarita population, with less variability in population density having recently been observed relative to the Lower Mesa (Service 2008a, pp. 38-39).

The Lower Mesa of Oscar One is actively used for recruit training and includes an extensive training/obstacle course (Crucible Course), buildings, bivouac sites, toilet facilities, and remnant sewage settling ponds. The vegetation on the Lower Mesa consists of a mix of native grasses and forbs, coastal sage scrub, and nonnative grassland. Soils on the Lower Mesa consist of a mosaic of fine sandy loams, loamy fine sands, clay loams, and loamy and gravelly soils (Service 1999a, p. 4). In addition to the use of roads, facilities and obstacles, military recruits frequently traverse portions of the lower mesa on foot during land navigation and other military preparedness training. Until the last few years, portions of the lower mesa supported high densities of PPM.

The Edson Range portion of the Santa Margarita population is also used for recruit training and has similar facilities to the Lower Mesa, such as dirt roads and outbuildings, in addition to live firing ranges. A rifle and other firing ranges are predominant features within Edson Range, which for safety reasons limit troop use across portions of the range (i.e. downrange from live firing areas). To minimize the potential of wildfire ignitions from ammunition strikes escaping the rifle range, vegetation within Edson Range is managed by frequent (e.g. annual) prescribed fires, which generally results in very sparse vegetation cover across much of the range. PPM within Edson Range have been found in areas of nonnative grasslands, valley needlegrass grasslands, and coastal sage scrub (Montgomery 2003, p. 24). Soils in Edson Range are mapped as loams, cobbly loams, clay loams, terrace escarpments (a non-specific association of various soil types) and sandy loams, with PPM captures recorded within all of these soil types (Montgomery 2003, p. 19). Despite a large proportion of Edson Range having soils with moderate to high clay content, PPM have consistently been detected at low densities within this area (Montgomery 2003, pp. 14-17; Spencer 2007, p. B-50-B-52; Shier 2008b, pp. 15-17).

Around 31 trapping efforts have occurred within the Santa Margarita population since a single PPM was captured in 1995 in a herpetofauna survey pitfall array in the Oscar One training area. As with survey efforts for PPM elsewhere, goals and survey methods have been modified over time as information has been gained about the population, compromising the ability to directly compare results among efforts. Overall goals of the surveys can be grouped into three general categories that include: studying the distribution of the Santa Margarita population; refining population monitoring methods and studying PPM demography; and making behavioral observations to support development of a translocation protocol. Because the Santa Margarita population extends across such a large area where high spatial and temporal variability in population density has been observed, there has not yet been an attempt to estimate abundance of the population as a whole. The results of all trapping efforts are summarized in Table 4, with results pertinent to the distribution and abundance of the Santa Margarita population discussed below.

Following the initial discovery of PPM in the Oscar One training area, the Marine Corps contracted with the Service to help map the distribution of the Santa Margarita population within Oscar One. Survey methods involved the subjective placement of trap lines in areas deemed most suitable for PPM, and ready movement of traplines to new areas once PPM was detected along a trapline (Service 1999a, p. 7). Using this methodology in 1996, the Service made 221 PPM captures of an unknown number of individuals on 90 trap-lines distributed across the Upper and Lower Mesas of Oscar One, and along the boundary of Edson Range (Service 1999a, p. 7).

Multiple PPM capture locations were recorded within each of these areas. Using similar methods, Montgomery (2003, p. 16) surveyed portions of Edson Range that fell outside of the Service's study area, but concentrated many of his traplines along roadways. He captured 20 unique individuals on 15 traplines and suggested, based on finding a lower relative abundance of capture locations relative to what was found in Oscar One, that habitat conditions in Edson Range are likely to support lower densities of PPM relative to Oscar One (Montgomery 2003, p. 19). Finally, between 1998 and 2003 the Service paired soil sampling with PPM trapping across the Upper and Lower Mesas to look for correlations between soil characteristics and PPM

Table 4. Pacific Pocket Mouse (*Perognathus longimembris pacificus*) Survey Efforts at Oscar One and Edson Range, 1995 to 2008.

Date	Investigator	Location	Purpose	Effort (trap nights)	# of PPM Captured
1995: 8/14-8/26	Service 1996a	Oscar-1	Presence/absence	2219	51
1995: 5/28-6/10	Service 1996a	Oscar-1	Localized grid trapping	4000	3
1996: 5/13-8/10	Service 1999a	Oscar-1	Distribution assessment	6965	221*
1996: 7/8-7/15	Boggs 1996	Edson	project related trapping	1100	1
1996: 7/15-7/20	Boggs 1996	Oscar	project related trapping	1395	14*
1996: 7/22-8/1	Boggs 1996	Oscar	project related trapping	1327	13
1996: 8/12-8/22	Service 1999b	Oscar-1	Localized grid trapping	4800	112
1996: 9/4-9/18	Church 1996	Oscar	project related trapping	478	4
1997: 7/16-8/8	Dodd and Montgomery 1998	Oscar-1	Localized grid trapping	4800	70
1997: 8/5-8/15	Service 2002c	Oscar-1	Localized grid trapping	3920	55
1997: 9/14-9/27	Service 2002c	Oscar-1	Localized grid trapping	3920	44
1998: 4/21-5/1	Service 2002c	Oscar-1	Localized grid trapping	3920	21
1998-2003	Service <sup>8</sup>	Oscar-1	Soil study		47
1998: 6/22-8/23	Montgomery 2003	Edson	Distribution assessment	5337	21
2002: July	Service 2008b	Oscar-1	trapping grid "D"	980	19
2003: May	Service 2008a	Oscar-1	trapping grids "A/D"	5400 / 5400	17 / 101
2003: July	Service 2008a	Oscar-1	trapping grids "A/D"	4800 / 6000	32 / 169
2003: Sept.	Service 2008a	Oscar-1	trapping grids "A/D"	6000 / 4800	152 / 257
2004: April	Service 2008a	Oscar-1	trapping grids "A/D"	3600 / 4800	137 / 172
2004: June	Service 2008a	Oscar-1	trapping grids "A/D"	3600 / 3000	274 / 229
2004: Aug.	Service 2008a	Oscar-1	trapping grids "A"	3600	174
2004: Sept.	Service 2008a	Oscar-1	trapping grids "A/D"	2400 / 3600	20 / 20
2005: April	Service 2008a	Oscar-1	trapping grids "A/D"	4200 / 2400	55 / 10
2005: July	Service 2008a	Oscar-1	trapping grids "A/D"	3000 / 3600	90 / 8
2005: Sept.	Service 2008a	Oscar-1	trapping grids "A/D"	3000 / 3000	78 / 9
2006: April	Service 2008a	Oscar-1	trapping grids "A/D"	3600/3000	80 / 13
2006:July-Aug.	Shier 2007	Oscar-1	Behavioral observations	~ 3450	16
2007	Spencer 2007	Oscar-1 and Edson	Spatial sampling for impact assessment in Oscar-1/Edson Range	9,920 / 2080	7
2007: June 25-July 15	Shier 2008a	Oscar 1	Behavioral observations, search for prospective donor sites	59480	57
2008	Shier 2008b	Oscar-1	Behavioral observation and search for donor sites	35000	125
2008	Shier 2008b	Edson	Impact assessment	2688	7

\* Represents total captures of PPM – number of unique individuals is unknown.

presence. Cumulatively, a minimum convex polygon drawn around capture locations from these and subsequent efforts circumscribe an area of 741 ha across the Oscar One and Edson Range training areas.

While localized population monitoring of PPM at specifically designated locations occurred within Oscar One between 1996 and 2006 (discussed below), additional efforts to characterize the distribution of the Santa Margarita population did not occur until 2007. In the Spring of 2007, Shier (2008a, p. 12) used positive historical trapping data to survey 11 areas of presumed high PPM density (5 in the Upper Mesa and 6 in the Lower Mesa) in an effort to identify potential source locations for animals to use in a PPM in a translocation experiment. Ninety-three percent (53 of 57) of individuals captured during this effort were found within three survey grids placed in the Upper Mesa, two individuals were captured in a fourth grid in the Upper Mesa and one individual each was captured within two of six survey grids placed on the Lower Mesa (Shier 2008a, p. 12). Strikingly, only two individuals were detected across portions of the Lower Mesa that were previously thought to be densely occupied by PPM, and no individuals were captured within a monitoring location where 100's of individuals had been captured in 2004 by the Service.

A more systematic trapping study was also performed in 2007 within the Lower Mesa and Edson Range portions of the Santa Margarita population to help analyze impacts associated with a road improvement project currently proposed across these areas (Spencer 2007, pp. B-43 – B-56). To contrast population densities of PPM along dirt roads in the Lower Mesa relative to habitat away from those roads, 31 grids of 40 traps each were randomly placed along dirt roads, and 31 similarly configured grids were placed in habitat away from roadways. No PPM were captured within any of these trapping grids. Within the Edson Range area, another 13 trapping grids were randomly placed solely along the roadways. This effort captured 7 individuals at 5 locations (Spencer 2007, B-52). Thus, despite 83 percent of the sample effort having been focused within the Lower Mesa in an area where PPM were once broadly distributed, PPM were only detected within Edson Range where they have been thought to occur at lower densities.

In 2008, Shier again selected 10 locations within Oscar One (9 on the Lower Mesa and 1 on the Upper Mesa) to identify potential source animals for a translocation experiment (Shier 2008b, pp. 1-23). These sites were again identified on the basis of PPM detections during previous years, having appropriate soil types (fine loamy sands) for PPM, or otherwise showed evidence of possible PPM activity via tail drags or active burrow entrances (Shier 2008b, p. 9). Shier (2008b, p. 9) also re-sampled 4 of the 5 locations within Edson Range where PPM were captured by Spencer in 2007. The Edson Range trapping was designed to study PPM's possible association with roadside habitat in this portion of its range.

Within Oscar One, Shier (2008b, p. 16) only captured five individuals, three of which were captured within the one grid placed in the Upper Mesa, and one individual each that was captured in two grids located on the Lower Mesa. This result appears to confirm the apparent recent fall off in population numbers across the Lower Mesa portion of the Santa Margarita population. Within Edson Range, Shier (2008b, p. 16) captured 7 unique PPM, with detections made at each of the four sampled areas. Four individuals were captured within 8 m (26.2 ft) of the roadway, and 3 individuals were captured an average of 29.3 m (96.1 ft) from the roadway

(range 24-32 m). Because of small sample size, Shier (2008b, p. 19) performed a Monte Carlo simulation with this data, which suggests that PPM were not randomly distributed within the survey grids and were more likely to be captured in traps placed near the roadway ( $p < 0.04$ ).

Of potential help explaining patterns of PPM distribution and abundance within the Santa Margarita population is data that was collected from the Spring of 2003 to the Spring of 2006 at two 1.38 ha (3.4 ac) population monitoring grids (Service 2008a, pp. 1-94). The monitoring grids were established in association with a biological opinion (Service 1996c, pp. 1-21) addressing construction of the Crucible Challenge course within the boundaries of the Santa Margarita population. Locations of the monitoring grids were selectively placed within areas known to be occupied by PPM, with one grid located on the Upper Mesa away from troop training activities, and the other located on the Lower Mesa in close proximity to a training obstacle. The grids included 600 trap stations each, and were operated from 3 to 4 times a year across the period of above ground activity for PPM (e.g. from April to September).

Results from this monitoring suggest populations on the two grids underwent an irruption in 2003, with rapid population growth observed over the summer of 2003 and high animal densities being maintained into the summer of 2004 (see Figures 5 and 6, below). Although the effective trapping area is certain to have extended beyond the boundaries of the 1.38 ha trapping grids due to animal movements, peak estimated abundance was  $322 \pm 69$  individuals in June of 2004 on the Upper Mesa, and  $302 \pm 31$  individuals in September of 2003 on the Lower Mesa. By September of 2004 PPM detections fell off dramatically on both grids, suggesting that most animals had already entered dormancy by the survey bout performed at this time. This was followed by near record rainfall during the winter of 2004-2005 (22.73 in. rain in Oceanside, CA between Sept 2004 and April 2005-<http://wunderground.com>), which appears to have led to low overwinter survivorship. By April of 2005, estimated abundance on the grids fell to  $63 \pm 9$  individuals on the Upper Mesa and  $9 \pm 1$  individuals on the Lower Mesa (Service 2008a, pp. 38-39). While the size of the population on the Upper Mesa appears to have quickly rebounded and more than doubled over the summer of 2005, the PPM population on the Lower Mesa failed to rebound significantly throughout the remainder of the population monitoring study (Service 2008a, pp. 38-39).

In conclusion, the Santa Margarita population is the largest of the known extant occurrences of PPM and is critical to maintenance of the subspecies since it is the only known population of appreciable size and extent where large numbers and re-colonization dynamics are likely to protect against localized extirpations. However, despite the large area circumscribed by capture locations, not all habitat within this area is suitable for PPM, with portions of the Upper and Lower Mesas covered by dense, nonnative grasses. Additionally, dramatic population fluctuations have been observed across the Santa Margarita population with what appears to be the near disappearance of PPM from the Lower Mesa, an area that historically supported one of the densest concentrations of PPM. Significantly, the Lower Mesa represents 47 percent of the documented range of the Santa Margarita population. Factors that may be associated with this decline include the drought conditions experienced across southern California over the last several years ((70% of normal mean precipitation 2005-2006, 52% of normal mean precipitation 2006-2007, and 39.5% of normal mean precipitation 2007-2008) and increasing levels of ground and vegetation disturbance from increased military training within the Lower Mesa.

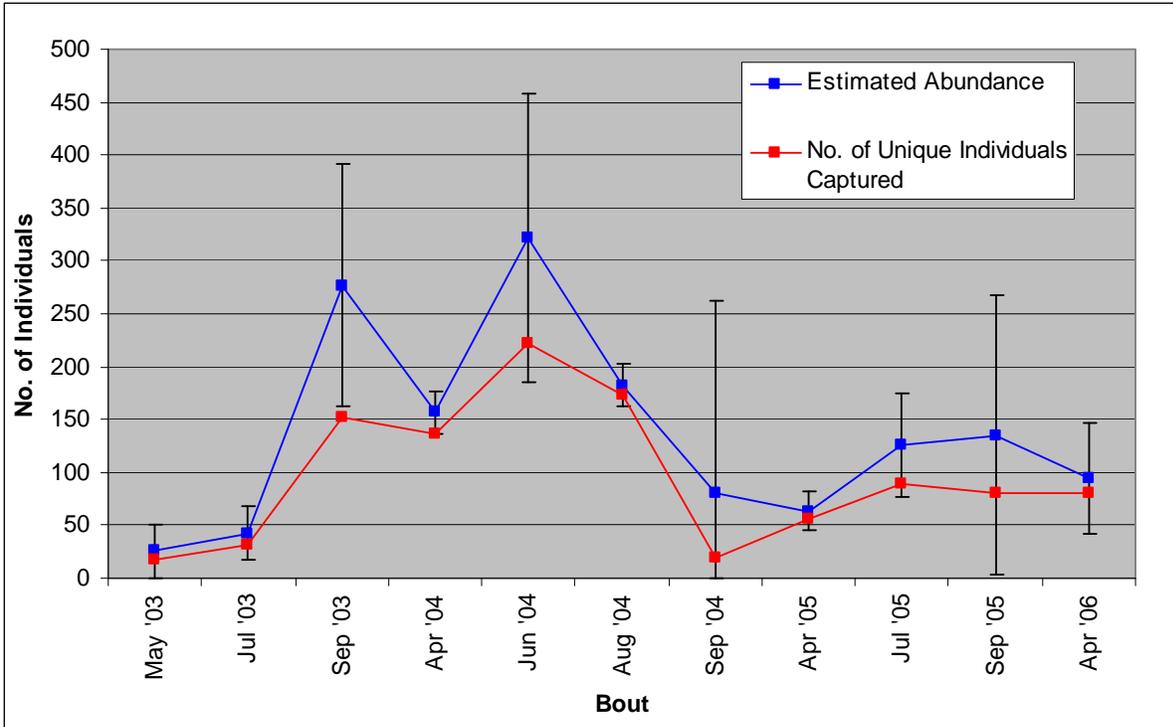


Figure 5: Estimated abundance and number of unique Pacific pocket mouse individuals captured on a population monitoring grid operated in the Upper Mesa portion of the Santa Margarita population.

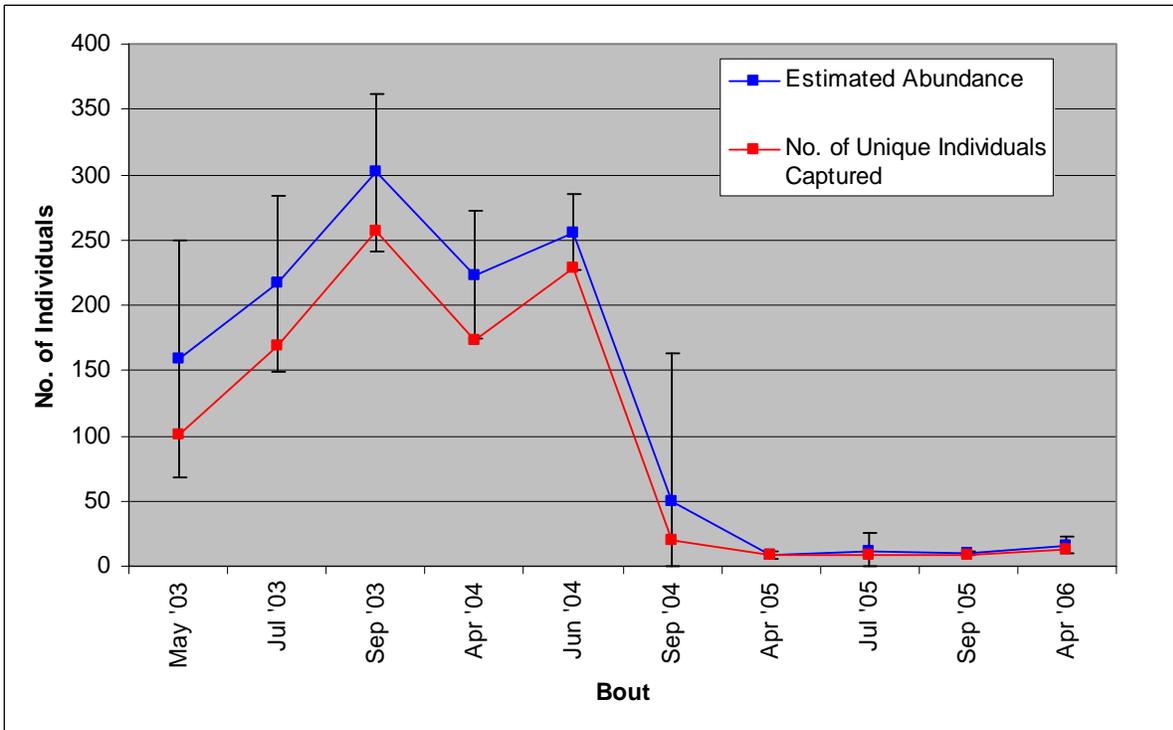


Figure 6: Estimated abundance and number of unique Pacific pocket mouse individuals captured on a population monitoring grid operated in the Lower Mesa portion of the Santa Margarita population.

## Habitat or Ecosystem

Two key habitat components that appear to be important to the distribution of PPM are vegetation and soils. PPM is commonly associated with coastal sage scrub vegetation, but has been found in a range of plant communities, including coastal strand, coastal dunes, ruderal vegetation on river alluvium, and coastal sage scrub (Mearns 1898, p. 299; Bailey 1939, pp. 325-327; von Bloeker 1931a, pp. 369-370; von Bloeker 1931b, pp. 431-432; Grinnell 1933, p. 149; Meserve 1976a, pp. 647-648; Brylski 1993, p. 5; Ogden 1997, p. 29; Service 1999a, p. 8; MBA and LSA 1997, pp. 14-22; Germano 1997, p. 28; Williams 1986, p. 27; Erickson 1993, unpaginated). Of the extant occurrences, the three northern sites are vegetated with coastal sage scrub while the Santa Margarita population occurs across an area intermixed with sage scrub and grassland/forblands, with portions of this occurrence distributed across areas with relatively little shrub cover. Within these vegetation associations, PPM is thought to prefer open, sparsely vegetated areas and small open patches within dense vegetation. PPM is typically not found in areas covered by dense nonnative grasses and thatch that are intermixed with the sage scrub-grassland ecotone mosaic north of the Santa Margarita River.

Dominant shrub species at the three northern sites include *Artemesia californica* (California sagebrush), *Eriogonum fasciculatum*, *Lotus scoparius*, and *Salvia apiana* (white sage) (Germano 1997, p. 28; MBA and LSA 1997, p. 14; Dodd et al. 1999, pp. 14-18). At Dana Point, Germano (1997, p. 19) found areas documented to be occupied by PPM contained 57 percent shrub cover and 33 percent bare ground, while habitat presumed unoccupied by PPM contained 74 percent shrub cover and 15 percent bare ground. Another study at Dana Point characterized vegetation cover in occupied and presumed unoccupied areas according to the height of vegetation above ground (Dodd et al. 1999, pp. i-31). This study suggests that the vegetation layer 0-10 cm (0-3.9 in) from the ground is the layer that most influences PPM because this is where PPM concentrate their activity. PPM appeared to avoid areas with relatively high shrub cover and high exotic forb and grass cover in this stratum (Dodd et al. 1999, p. 16), while cover values higher in the vegetation canopy appeared less important to PPM habitat preferences.

Within the Santa Margarita population on Camp Pendleton, Loda et al. (1999, pp. i-18 + Appendices) compared the dominant floristic components between 20 sites where PPM were detected and 32 sites where PPM went undetected, but were geographically interspersed with the occupied sites. Loda et al. (1999, p. 8) found that grids where PPM were not detected had a higher prevalence of *Artemesia californica* and suggested that higher shrub density (canopy) and high grass density may preclude PPM from occupying an area. However, Loda et al. (1999, pp. 6-7) found no significant relationship between the composition of shrubs and the occurrence of PPM, supporting the idea that PPM can tolerate a range of plant associations.

Based on these results and qualitative observations during trapping, several researchers have proposed that PPM prefer more open habitat with less shrub cover than is present in the mature coastal sage scrub that covers much of the Dana Point Headlands and San Mateo North sites (Germano 1997, p. 28; Loda et al. 1999, p. 8; Spencer et al. 2000, pp. 12-15; Montgomery 2005a, pp. 7-8). To study whether manipulation of shrub cover can enhance habitat for PPM, some small-scale experimental hand-thinning of shrubs and litter removal was performed in areas of dense cover adjoining PPM capture locations at the Dana Point Headlands (Dodd and

Montgomery 2001, pp. i-26). Vegetation was also manipulated by means of a small, 1.4-ha (3.4-ac) prescribed burn that was carried out adjoining the San Mateo North PPM population in January 2001 (Montgomery 2005a, pp. 1-42).

At the Dana Point Headlands, shrub cover was reduced from approximately 70 percent to 28 percent and bare ground was increased from 7-19 percent to 19- 44 percent on the thinning plots (Dodd and Montgomery 2001, pp. 18-19). Initial trapping results suggested PPM responded favorably to the hand-thinned areas, but a number of factors complicate the interpretation of results. First, it is not known if vegetation thinning affected detection probabilities. Second, the vegetation thinning appears to have preceded a period of apparent population decline at Dana Point, providing small sample sizes for comparing population densities in thinned and unthinned areas. Finally, the same individuals appeared to move between thinned and unthinned areas, making it difficult to attribute a population response to the scale of the vegetation manipulations performed.

Within the footprint of the prescribed burn at San Mateo North, shrub cover was initially reduced from approximately 51 percent to 9 percent, and bare ground was increased from approximately 5 percent to 47 percent. Since then there has been a significant increase in the density of herbs with more gradual increases in shrub cover (Montgomery 2005a, pp. 30-31). Investigators were hopeful that PPM would move, either through juvenile dispersal or through adult relocations, into the area of the prescribed burn. However, no PPM have been captured in the burn area to date, and very few have been captured in the area immediately adjoining the prescribed burn. Failure of PPM to colonize the prescribed burn may be due to the small number of animals in adjoining habitat (Montgomery 2005a, p. 30), the large percent cover of herbs that became established following the burn (particularly 0-10 cm (0-3.9 in) from the ground (58 percent in 2003)), or possibly other factors related to habitat suitability.

In the desert environment PELO is associated with shrub cover (Brown and Lieberman 1973, p. 793; Kenagy 1973, p. 1204; Thompson 1982a, p. 1303; Kotler 1984, p. 697; Bowers 1986, p. 46; Jones and Longland 1999, p. 8) where it tends to concentrate its foraging activity (Thompson 1982a, p. 1307). Foraging beneath shrubs is thought to confer greater safety to PELO from predators relative to foraging in the open (Thompson 1982b, p. 1318; Kotler 1984, pp. 696-700; Longland and Price 1991, p. 2261). Shrub removal experiments in the desert resulted in increases in the activity of kangaroo rats but not increases in another *Perognathus* species (Rosenzweig 1973, p. 116). Conversely, Thompson (1982b, pp. 1313-1321) manipulated “interplant” distances in a desert environment by deploying cardboard shelters that were fashioned to simulate shrub cover, thus increasing the “shrubiness” of the habitat. He found that PELO occurred at lower densities on his experimental plots than would have been predicted from population trajectories on adjacent control plots. This appears to have been associated with invasion of the experimental plots by two habitat generalists in the genus *Peromyscus* (Thompson 1982b, p. 1318). Thus, it is likely that PPM benefit by some level of shrub cover, but there may be a balance beyond which increasing or decreasing shrub cover could detrimentally affect habitat suitability by altering resource levels or favoring other members of the small mammal community.

Since the vegetation thinning experiment at Dana Point there have been a number of management actions that have continued to open up the vegetation and create more bare ground at this site. These actions include: creation of a fuel modification area that was planted with native species at low density in an area adjoining a residence; nonnative species removal efforts throughout the Dana Point Preserve; and removal of woody debris and dense leaf litter from beneath shrubs at a subset of PPM monitoring grid cells. Although these actions are correlated with a recent apparent increase in the PPM population within the Dana Point Preserve, it is unclear to what degree these actions have contributed to this increase. Thus, despite ambiguous results from targeted experimental vegetation thinning at Dana Point and the prescribed burn at San Mateo North, high shrub cover over portions of these sites is of continuing concern and further research into the benefits of vegetation thinning is warranted.

The second important habitat component of soils is thought to possibly be more limiting to PPM distribution (Spencer et al. 2000, p. 6). PPM is typically associated with sandy soils that may be necessary for PPM to construct their burrows. Soils in areas of historical habitat occupancy have been described as alluvial river bottom sand, loose sandy soils, fine-grain sandy soil, dry, rocky and gravely soils, and tidal flats (Bailey 1939, p. 325; Grinnell 1933, p. 149; von Bloeker 1931a, p. 370; M'Closkey 1972, p. 658; Meserve 1976b, p. 659; Brylski 1993, p. 5; Mearns 1898, p. 299). Available soils mapping for each of the known extant PPM occurrences (Dana Point, San Mateo North, San Mateo South, and Oscar One) indicates that PPM have been found in areas classified by the Soil Conservation Service as sand, loamy sand, sandy loam, loam, clay loam, and terrace escarpments (U.S. Soil Conservation Service 1973, 1978).

To better understand PPM soil preferences, a number of studies have been performed to characterize soils where PPM have been found. Prior to discovery of PPM in the Edson Range portion of the Santa Margarita population distribution, Germano (1997, pp. i-38) conducted an examination of the soils at each of the known extant PPM sites and the historical locale near the Mexico border. At all sites, he found the soils at the surface and at 20 cm (7.9 in) depth contained 95-97 percent sand, and classified the soils as sands, fine sands, loamy sands, and fine loamy sands (Germano 1997, pp. 24-28). Bornyasz (2003, unpaginated) also evaluated soils at the three northern extant PPM occurrences (San Mateo North, San Mateo South, and Dana Point) and found that each of the occupied sites was dominated by loamy sands on the surface and sands and loamy sands below the surface. Surface soils ranged from 80 to 94 percent sand and never exceeded 3 percent clay. He found soil depths (which may be of relevance to a burrowing rodent) at the northern sites ranged from 20 cm (7.9 in) to greater than 60 cm (23.6 in). Finally, a study of the relationship between soil parameters associated with occurrences of mice in just the Oscar One training area portion of the Santa Margarita population suggests that PPM primarily occur on well-drained loamy sand soils with less than 10 percent clay, a bulk density averaging  $1.3 \text{ gm/cm}^3$  ( $4.6 \text{ oz/in}^3$ ), and gravel content under 5 percent by weight (Winchell et al. 1999). However, this study did not examine soil affinities in the Edson Range portion of the Santa Margarita population, and specifically excluded sampling in areas where soil had been visibly disturbed or anthropogenically altered (Mark Pavelka pers. comm.).

PPM have been documented in soft, friable road berms along dirt roads on the Base that were mechanically created in areas with sandy loam to clay loam soils (Boggs 1996, unpaginated; Service 1999a, p. 8). Within the Santa Margarita population, early investigations also

documented PPM within clay loam soils, which was attributed to surrounding and closely adjacent sandy soils (Ogden 1997, p. 25). However, in 1998, while studying the potential distributional limits of the Santa Margarita PPM population, Montgomery (2003, pp. 19-23) discovered PPM in portions of the Edson Range training area mapped as clay loam soils where no sandy soils occur in close proximity. Recent captures of PPM with Edson Range (Spencer 2007, B-50-B-52; Shier 2008, pp. 15-19) indicates that PPM have persisted in this area despite its lack of sandy soils. Thus, while PPM appears to have a definite affinity for sandy soils, these findings suggest PPM is capable of occupying and persisting in a wider range of soils than previously reported.

A factor that has been hypothesized to make habitat unsuitable for PPM is the modification of otherwise suitable soils by historical agricultural use (Montgomery 2003, pp. 23-24; Ogden 1997, p. 26). This conclusion has been based in part on presence/absence surveys at San Mateo North and South where surveyors believed PPM captures were restricted to areas with high potential soils that had not been used for farming (Ogden 1997, p. 26). Close examination of mapped capture locations for PPM in comparison with historical aerial photos reveal, however, that a number of PPM capture records at San Mateo North fall within the boundary of historical agricultural field that has reverted to native vegetation (Service 2008c, p. 146).

In conclusion, PPM appear to be associated with shrublands, grasslands, forblands and grassland-sage scrub ecotonal areas that have a moderate level of cover for predator avoidance with a degree of openness and bare soils to support foraging behavior. Because they typically have not been documented in dense nonnative grasslands, which are often associated with loam to clay soils, it is suspected that the density of vegetation at ground level in combination with soil conditions make this vegetation community unsuitable for PPM. Although PPM appear to be strongly associated with sandy soils, their use of road berms and persistence in clay loam soils in the Edson Range portion of their distribution indicates they are able to persist in areas without sandy soils under certain circumstances.

#### Changes in Taxonomic Classification or Nomenclature

There have been no changes in taxonomic classification or nomenclature since the PPM was listed in 1994.

#### Genetics

Although Hall (1981, pp. 536-540) formerly recognized 19 subspecies of the little pocket mouse PELO, Williams et al. (1993, pp. 177-184) synonymized several subspecies to currently recognize 16 PELO subspecies. More recently, McKnight (2005, p. 830) has suggested, based on DNA sequence data from the mitochondrial cytochrome-b gene, there is some support for splitting PELO into two species; 1 containing at least 3 subspecies distributed in northern Arizona, southern Utah and southeastern Nevada, and another containing the remaining PELO subspecies including PPM.

Because several subspecies in southern California are of conservation concern, including Los Angeles pocket mouse (*Perognathus longimembris brevinasus*), Palm Springs pocket mouse (*P.*

*l. bangsi*), International pocket mouse (*P. l. internationalis*), and PPM, there has been interest in clarifying the systematic relationships of PELO and its subspecies (Williams 1986, p. 28; McKnight 2005, p. 826). Swei et al. (2003, pp. 501-514) studied the geographic genetic structure of the nominate subspecies, *P. l. longimembris*, and the four southern California subspecies of conservation concern using sequence variation of the mitochondrial cytochrome b gene. Because mitochondrial DNA is maternally inherited and reveals maternal genetic diversity, distinct mitochondrial genotypes are referred to as haplotypes, with differences among haplotypes resulting from mutations altering the sequence of nucleotides within a gene. Populations sharing common haplotypes generally reveal a close temporal relationship to one another and/or evidence of female gene flow. Similarly, distinct haplotypes that differ by only one or a few nucleotides are assumed to be more closely related than those showing greater sequence divergence.

Sixty-two unique haplotypes were found among 99 individuals sampled across the five subspecies (Swei et al. 2003, p. 505). Phylogenetic analysis of genetic variability did not reveal lineages that were entirely concordant with subspecies designations, but most haplotypes did group by subspecies (Swei et al. 2003, pp. 506-508). A substantial proportion of total haplotype variation was also attributed to the subspecies or to local populations within a subspecies range, indicating the relative evolutionary independence of the subspecies, geographic segments within the subspecies, or local populations (Swei et al. 2003, pp. 508-509).

Within PPM, haplotype diversity was notably low at the Dana Point site relative to Santa Margarita (Oscar One) and the Santa Mateo sites (combined for this analysis) (Swei et al. 2003, pp. 505-506). There was also a limited number of common haplotypes among the extant populations, with only one haplotype shared among Dana Point and San Mateo South, two haplotypes shared among San Mateo North and San Mateo South, and one haplotype shared among San Mateo South and the Santa Margarita (Oscar One) population (Table 5).

Table 5: Sample sizes (Ni), number of haplotypes (Nh) and shared haplotypes among historical and extant populations of PPM (from Swei et al. 2003, pp. 501-514).

Geographic subdivision	Ni	Nh	Shared haplotypes (site w/ common haplotype)
Dana Point (DP)	27	9	1 (SMS)
San Mateo North (SMN)	5	4	2 (SMS)
San Mateo South (SMS)	10	10	1 (DP) 2 (SMN) 1 (OO)
Oscar One (OO)	6	6	1 (SMS)
El Segundo	1	1	0
Oceanside	6	3	0
Tijuana	5	3	0

Although estimates of gene flow are likely to be biased low due to maternal inheritance of mitochondrial DNA and a typical pattern of female philopatry in mammals, gene flow estimates among the extant populations of PPM were all below the threshold where these populations are likely to diverge by genetic drift alone, excepting estimated gene flow between the two San Mateo populations and between San Mateo North and the Santa Margarita (Oscar One) population (Swei et al. 2003, p. 510). Estimated gene flow between Dana Point and the Camp Pendleton populations suggests that Dana Point has been relatively isolated from Camp Pendleton for some time (Swei et al. 2003, p. 510). A similar pattern was also observed among genetic samples taken from museum specimens, indicating a pattern of relative isolation among PPM populations already existed 70 years ago (Swei et al. 2003, p. 510).

To obtain insight into the population demography of PPM, Swei et al. (2003, p. 505) calculated the genealogical growth parameter,  $g$ , from haplotype data from Dana Point and combined data from the two San Mateo sites. This parameter can give insight into the likelihood of population expansion following a recent population bottleneck wherein genetic diversity was reduced. Estimates of this parameter for Dana Point and San Mateo were positive and significantly different from zero, suggesting that each population has experienced population expansion in their respective haplotype genealogies (Swei et al. 2003, p. 510). However, Swei et al. (2003, p. 510) caution that growth estimates based on genetic samples reflect a pattern that becomes evident over evolutionary time scales and it takes time for the measured genetic characteristics of an extant population to reflect its immediate past history. Thus, the lack of consistency of the pattern of genetic data with actual population sizes or the apparent trend of decline among extant populations suggested by recent studies does not necessarily mean that these populations are expanding. Consistent with the loss of genetic diversity in association with small population size, the Dana Point population was found to exhibit the lowest haplotype diversity of any sample from southern California. Population genetic theory predicts that if this population remains as small and isolated as current data suggests, it will continue to lose genetic diversity.

Overall, the findings of Swei et al. (2003, pp. 501-514) suggest that each subspecies of PELO in southern California and most of their member geographic units or populations have been genetically independent for some time. With such low levels of estimated gene flow among populations it appears that local populations have remained sufficiently large to prevent the loss of genetic variation via genetic drift. However, if gene flow estimates are correct and PPM populations are as small as has been suggested by recent trapping studies, loss of genetic variability, particularly for the Dana Point population is predicted.

#### Species-specific Research and/or Grant-supported Activities

Since the listing a number of studies have been performed to better understand the ecology and habitat preferences of PPM and to address specific recovery actions identified in the recovery plan (Service 1998, pp. i-112).

#### *Survey Methods and Detectability*

To help refine survey methods (Recovery Plan Action 1.3a) Dodd and Montgomery (1998, pp. i-21+Appendices) investigated the influence of trap spacing and trapping duration on survey

success. They found that 10 m trap spacing is less efficient at detecting individual PPM than trapping grids employing 3m - 7m trap spacing (Dodd and Montgomery (1998, pp. 14-16). Over 24 consecutive nights of trapping on a fixed trapping grid, Dodd and Montgomery (1998, pp. 16-18) also continued to capture new individuals, suggesting that individuals below ground were emerging from dormancy or transient individuals were moving onto the grids during the trapping interval.

During intensive demographic monitoring, the Service (2008a, p. i-94) has obtained similar results, and found that PPM detectability can sometimes be quite low, and likely varies in response to a number of factors including time of the trapping event, and the sex and age of individuals. These results suggest that live trapping studies may often miss individuals in the population that remain dormant belowground, and that high trap densities (e.g. 53 traps per acre) deployed over 5 or more nights are likely necessary to document PPM presence when animal densities are low (Service 2008a, pp. 80-81).

Recently, the U.S. Geological Survey has been piloting less invasive survey techniques, including the use of tracking tubes and scent dogs to document PPM presence (Brehme 2010, in litt.). While these methods show promise, additional study is needed to document their efficacy.

### *Habitat Preference*

To refine our understanding of PPM habitat suitability, a number of studies have been performed to characterize the soils and vegetation present at historical and extant PPM locales (Germano 1997, pp. i-38; MBA and LSA 1997, pp. i.-24+Appendices; Dodd et al. 1999 pp. i-31 + Appendices; Loda et al. 1999, pp. i-18+Appendices; Dodd and Montgomery 2001, pp. i-26+Appendices; Montgomery 2005a, pp. 1-42+Appendices; Bornyas 2003, unpaginated; Service 2008c, p. 146; Winchell et al. 1999; Bonterra 2007, pp. 1-6+ Appendices). These studies are consistent in showing PPM to be restricted to sandy loam or loamy sand soils within a range of forb, grassland and scrub vegetation communities; with soils likely being more limiting than vegetation to the distribution of PPM. However, persistence of a portion of the Santa Margarita population in clay loam soils and use of roadside berms by PPM suggest PPM may be able to utilize non-sandy soils under certain conditions.

An apparent negative association of PPM with dense shrub cover has led investigators to hypothesize that PPM prefer vegetation communities with an open canopy and some bare ground. Within areas of dense scrub vegetation adjoining areas of PPM occupancy, hand thinning (Dodd and Montgomery 2001, pp. i-26+Appendices) and prescribed fire (Montgomery 2005a, pp. 1-42+Appendices) have been tested as management treatments to enhance habitat for PPM. Recently, the Service funded California State Parks to thin dense sage scrub vegetation at San Mateo North in an effort to enhance habitat for PPM at this locale (Service 2010, pp. 1-34). The response of PPM to this vegetation manipulation will be documented through follow up surveys to document the distribution and density of PPM at this location (Service 2010, p. 4).

Recently, the Center for Natural Lands Management has begun to implement a monitoring and management program for PPM within the Dana Point Preserve (Brylski et al. 2009, pp. i. -32; Brylski et al. 2010, pp. i-33). The United States Marine Corps has also contracted with the U.S.

Geological Survey to develop a monitoring program for PPM on Marine Corps Base Camp Pendleton (Brehme et al 2009, pp. i-21+Appendices). The initial methods employed by both of these programs are designed to allow for refinement of PPM habitat suitability models by comparing habitat occupancy with environmental covariate data collected at each monitoring location.

### *Potential Translocation*

The Foothill/Eastern Transportation Corridor Agency funded a three phase study program to address a number of the actions identified in the PPM recovery plan. The first phase addressed translocation feasibility (Recovery Plan Action 5.1) and dispersal characteristics (Recovery Plan Action 4.8.2) of PPM (Spencer et al. 1999, pp. i-64+Appendices). The investigators concluded that a translocation/reintroduction program is probably necessary to achieve recovery of PPM but not enough was known about PPM ecology or the availability of suitable receiver sites to attempt translocation of PPM at the time. The investigators also recommended gathering detailed information on the dispersal characteristics of PPM but suggested that logistical difficulties of marking and tracking a species as small as PPM would first need to be overcome to make this feasible.

The second phase of this study program (Spencer et al. 2000, pp. i-44+Appendices) addressed recommendations from Phase I and developed a Geographic Information System (GIS) habitat suitability model for identifying prospective receiver sites for PPM translocation. Investigators also performed laboratory and field studies of marking techniques on other subspecies of *Perognathus longimembris* as surrogates for PPM. The GIS habitat evaluation model suggested that sufficient acreage of potential habitat for PPM exists to warrant pursuing a translocation program. The study of marking methods recommended further evaluation of subcutaneous Passive Integrated Transponder (PIT) tags as a marking technique for the study of PPM life history, but endorsed toe clipping as the easiest, most reliable and least harmful technique available for application over the near term.

The third phase of the study program (Spencer et al. 2001, pp. i-36 + Appendices) followed up on the Phase II report primarily by refining the GIS habitat evaluation model to incorporate more precise habitat discrimination based on soil type, and by performing field reconnaissance at sites identified as potential PPM habitat by the GIS model. Based on field evaluations, seven prospective sites for pursuing translocation were identified including: Wire Mountain on Marine Corps Base Camp Pendleton, Torrey Pines State Reserve, the Manchester Conservation Area in Encinitas, Point Loma Ecological Reserve, Tijuana River Valley, and habitat adjacent to the San Mateo North and South PPM populations (Spencer et al. 2001, pp. 6-13).

To explore the feasibility of establishing additional PPM populations via translocation, the San Diego Zoological Society's Institute for Conservation Research (formerly Conservation and Research for Endangered Species) have begun to study the behavior of PPM and, based on work with other Heteromyiid rodents, have developed working hypotheses to test regarding factors that are likely to be associated with translocation success (Shier and Swaisgood 2006, pp. 1-21; Shier 2008a, pp. 1-58).

During her behavioral studies, Shier (2008a, pp. 9-30) demonstrated the feasibility of radio-tracking individual PPM and developed an alternative to toe-clipping as a permanent marking method. The permanent marking method involves the use of Visible Implant Elastomer (VIE) tagging. VIE is a bio-compatible two-part silicone based material that is mixed with a fluorescent color and implanted hypodermically into the skin at the base of the tail so that it remains visible. This method is easy to use under field conditions and does not cause trauma to animals (Shier (2008a, p. 10).

Although the Institute for Conservation Research is prepared to proceed with a translocation experiment, this effort has been stalled by the inability to locate a source population that is sufficiently robust to support removal of 40-80 individuals (Shier 2008b, pp. 1-23). Thus, the Institute of Conservation Research recommends that a captive PPM population be established to support translocation research and the establishment of additional PPM populations (Shier and Swaisgood 2008, unpaginated).

The PPM Recovery Plan calls for implementing a captive breeding program with a surrogate species first (e.g. another subspecies of *Perognathus longimembris*) then implementing captive breeding with PPM, if necessary to prevent the 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 (Service 1998, pp. 66-68). While there is a benefit to refining captive breeding protocols with a surrogate species, the Service must weigh this benefit in the context of available information on captive breeding of Heteromyiids, applicability of results to PPM, and the timeliness of instituting a captive breeding program for PPM.

The following are groups are actively working on the recovery of PPM:

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## Five-Factor Analysis

The following five-factor analysis describes and evaluates the threats attributable to one or more of the five listing factors outlined in section 4(a)(1) of the Act.

### **FACTOR A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range**

At listing, PPM was only known from the Dana Point Headlands where the landowners were seeking approval from the City of Dana Point for a development proposal that would result in the loss of habitat on and near the area where PPM were detected (59 FR 49759). The imminent threat of this development proposal, the complete or partial loss of habitat from urban development at five of eight historical locales for the subspecies, and the extent of land development in coastal southern California led us to conclude that habitat destruction from urban, suburban and agricultural development is the principle factor responsible for the decline of the subspecies. However, in addition to the likelihood of continued habitat conversion from development within its historical range, a number of other factors were cited as contributing to the on-going destruction or degradation of PPM habitat including: habitat fragmentation; channelization and regulation of river flows; increased fire frequencies and fire prevention strategies; type conversion of coastal sage scrub to grassland vegetation; artificial night time lighting; disking or blading of soils; pedestrian, horse and off-road vehicle traffic, and invasion of habitat by nonnative rodent species (59 FR 49761). Because so little was known about the distribution of PPM at this time, many of these threats were identified based on observations of habitat conditions and land use practices at historical collection locales and within the historical range of PPM.

Subsequent to the listing and prior to drafting of the Recovery Plan (Service 1998, pp. i-112), PPM was discovered at San Mateo North, San Mateo South, and north of the Santa Margarita estuary. All three of these locations fall within Camp Pendleton, an area discussed in the final rule as having the greatest potential to continue to support the subspecies (59 FR 49760). Given prior consideration of this portion of the subspecies range and the broad array of threats identified in the final rule, the Recovery Plan did not identify any new threats specific to the Camp Pendleton locations (Service 1998, pp. 17-26). However, the Recovery Plan (Service 1998, p. 25) did identify an additional threat to PPM habitat; the invasion of coastal sage scrub vegetation by nonnative Argentine ants (*Linepithema humile*). Argentine ants were identified as a potential threat, because of their ability to displace native ants important for seed dispersal in habitat fragments (Suarez et al. 1998, p. 2041). This threat was identified based on the potential for Argentine ants to alter ecosystem processes important for maintenance of the sage scrub vegetation community occupied by PPM.

With the exception of the Camp Pendleton locations, no additional PPM populations have been discovered since the listing despite at least 82 targeted PPM survey efforts performed across its historical range since 1993 (2009 CFWO Survey Report Data Base). Nevertheless, seasonally variable patterns of surface activity and poor detectability at low population densities (Service 2008a, pp. 38-39; Shier 2007, p. 9) suggest there remains some potential that additional undiscovered populations of PPM persist within its range. As such, threats discussed in the final

rule that apply to the historical range of the subspecies continue to threaten PPM. Most notably, habitat losses and habitat fragmentation within coastal southern California have continued and are likely to continue in the foreseeable future. Of the areas cited in the final rule as having the greatest potential to continue to support PPM, development has proceeded and is ongoing within the Palos Verdes peninsula in Los Angeles County, the San Joaquin Hills in Orange County, and within Camp Pendleton and the vicinity of the Mexico border in San Diego County. Pre-project surveys have been performed to evaluate the potential for direct impacts from these development activities on PPM; development continues to fragment remaining coastal habitat with potential to support PPM within its historical range.

Within the known extant populations of PPM a number of factors continue to threaten PPM habitat including: project construction; military training activities (including wildfires ignited by live fire training); fire management practices; fire breaks and fuel breaks; road and utility maintenance; recreation activities and unauthorized habitat disturbances from the public (Service 1998, pp. 17-26; Ogden 1997, pp. 39-41; Service 2007b, pp. 1-3).

### Project Construction

In February of 2005, the City of Dana Point approved the Dana Point Headlands Development and Conservation Plan, which involves residential and commercial development on about 29-ha (71-ac) of the 48.0-ha (121-ac.) Dana Point Headlands site, and conservation of much of the remaining open space. Grading for the developed portion of the property was initiated in the spring of 2005 and development is now proceeding. A portion of the 18.3-ha (45.2 ac) area identified by Brylski (1993, p. 8) as suitable for PPM falls within the development area. Habitat permanently conserved in association with the development includes the 11.3-ha (27.9 ac) Dana Point Preserve, which includes the area of documented historical occupancy by PPM. A hiking trail within the Dana Point Preserve was constructed in 2007 with access to the trail during daylight hours provided to the public in December of 2009. Since listing, the quantity of available habitat has decreased, impacts from edge effects have increased from new residential and commercial development (e.g. increased ambient light levels, irrigation runoff, intrusion from pets), and human intrusion into PPM habitat is increased. However, the Dana Point Headlands Development and Conservation Plan has resulted in the permanent conservation and management of habitat occupied by PPM at this location.

In April of 2008, the Service completed formal consultation on the extension of State Route 241, which would have run immediately adjacent to the San Mateo North population of PPM (Service 2008c, pp. 1-246). The extension of State Route 241 would have included the construction of up to six vehicle travel lanes, a vehicle interchange and associated lighting abutting the minimum convex polygon circumscribing PPM capture locations at San Mateo North. Direct loss of habitat within the minimum convex polygon would have been avoided, but there would have been a loss of suitable surrounding habitat with potential to support PPM. The loss of suitable habitat would have reduced the size of the area supporting the San Mateo North PPM population and would have limited options for population expansion and shifts in PPM spatial utilization over time. To offset the loss of habitat in this vicinity and indirect impacts to PPM from SR 241, the project would have provided funding for restoration and management of habitat at San Mateo North. However, in December 2008, the Secretary of Commerce upheld a California

Coastal Commission ruling that the proposed SR 241 extension is inconsistent with the Coastal Zone Management Act. Therefore, the project consulted on by the Service is not viable at this time.

Within the Santa Margarita population, the Service has consulted with the Marine Corps on one project and is currently consulting on another. In 1996, the Service completed consultation on the Crucible Challenge Course, which was built within the Oscar One training area (Service 1996c, pp. 1-21). That project involved the loss of 3.2 ha (8 ac) of occupied or suitable PPM habitat within Oscar One as a result of the construction of military training obstacles. Use of the Crucible Course by recruits was proposed to be maintained within a 20 foot buffer surrounding each obstacle course element, and to the existing network of dirt and paved roads used by recruits to travel by foot from obstacle to obstacle (Service 1996c, p. 4). Maintenance of the Crucible course was anticipated to involve replacement of obstacle components due to wear or damage, mowing of vegetation within the footprint of the obstacles, and grading and gravel replacement on improved roads. In practice there has been an accretion of habitat impacts from use of the Crucible Course due to changes to obstacle course elements, adjustments to use areas and modification of training practices. Use of the Crucible Course is contemplated to result in the take of one PPM per company of recruits using the Crucible Course, and one PPM per year due to road maintenance activities (Service 1996c, p. 15).

Currently, the Marine Corps proposes repairs and improvements to 26 kilometers (km) (16 miles (mi)) of the existing dirt road network within the Oscar One and Edson training areas. These roads are used primarily for recruits to access the Crucible Obstacle Course and other training areas within Edson Range. Proposed improvements include regrading roads, creating drainage ditches, side slope repairs, constructing asphaltic concrete and Portland concrete cement roads, and installing culverts and all-weather crossings. Within PPM habitat, the road improvements will consist primarily of widening the roads by about 1.2 m (4 ft) and replacing native soil with Class 2 fill material (a combination of aggregate, fines, and gravel). The total amount of PPM habitat proposed to be permanently and directly impacted by the project is estimated to be about 11.5 ha (28.4 ac) including about 6 ha (14.8 ac) in the Lower Mesa portion of Oscar One, 3 ha (7.3 ac) in Edson Range, and about 2.5 ha (6.3 ac) in an area southwest of the minimum convex polygon surrounding the Santa Margarita population (NAVFAC 2008, p. IV-20). Additional indirect effects are also likely from habitat fragmentation, redirected drainage, and altered road use patterns. To benefit PPM, an as yet unspecified quantity of disturbed areas and nonnative annual grasslands within Oscar One are proposed to be restored to a vegetation community capable of supporting PPM. Road repairs are anticipated to reduce the need for routine road maintenance.

### Military Training Activities

At present there does not appear to be regular use of the San Mateo South area by the Marine Corps for training, although it may be subject to occasional on-road military vehicle use and on- and off-road foot traffic training. Based on the apparent infrequent use of this site for training activities, it is likely that few PPM are currently being impacted at this site by training activities.

Military training within the vicinity of the Santa Margarita population primarily involves recruit training using various elements of the Crucible Course, live firing ranges, bivouac sites, dirt roads and trails and associated facilities. The U.S. Marine Corps expanded their training activities in the Oscar One training area that was not addressed in the context of the biological opinion for the Crucible Challenge Course (USMC 2007, in litt.). Observed impacts from this expansion within undeveloped areas include removal or reduction of vegetation, soil compaction, addition of new training elements, and increased foot and off-road vehicle traffic over a large portion of the Lower Mesa within Oscar One. One of the primary new training activities includes land navigation training that involves the movement of large numbers of troops on foot through habitat areas. This has resulted in a reduction of vegetative cover, creation of trails and compaction of soils throughout portions of the Lower Mesa documented to be historically occupied by PPM. In addition to the potential for direct impacts to mice from crushing of burrows, these impacts have degraded habitat quality for PPM by reducing vegetative cover and availability of seed resources, and reducing the quality of soils for constructing burrows. Given the pre-existence of nonnative annual grasses and weeds in this area, the movement of troops throughout this area is also likely to degrade habitat quality for PPM by facilitating their continued invasion and spread. When present in adjoining areas, nonnative grasses and forbs are often capable of rapidly expanding into areas that have experienced disturbance (D'Antonio and Vitousek 1992, pp. 63–68; O'Leary and Westman 1988, pp. 778–779; Stylinski and Allen 1999, p. 547; Gelbard and Belnap 2003, pp. 424–425). Following the initial documentation of expanded training activities in late 2006, the Marine Corps removed most of the expanded training areas from PPM habitat, but the land navigation training continues to take place. The Service is currently working with the Marine Corps to address ongoing impacts to PPM associated with the land navigational activities (Service 2007b, pp. 1-3), and the Marine Corps has committed to initiate consultation with the Service to address this issue (USMC in litt. 2007; J. Paull, USMC, pers. comm. to K. Goebel, USFWS, March 11, 2010).

Associated with military training activities, particularly use of the live firing ranges within Edson Range, is the periodic ignition of fires. A review of fire events larger than 5-acres that have been mapped by Camp Pendleton since 1972 reveals no record of fire for San Mateo North, one large event covering San Mateo South in 1976 and a smaller event that burned a portion of this area in 1989, and a complex history of frequent fires within portions of the Edson Range and Oscar One training areas (Service 2005, pp. 1-3). Frequent fire within military training areas has the potential to alter plant successional dynamics (D'Antonio and Vitousek 1992, p. 73), resulting in the conversion of shrublands to nonnative grasslands (Keeley et al. 2005, p. 2109; Minnich and Dezzani 1998, pp. 383–384; O'Leary and Westman 1988, p. 779). Because nonnative grasslands are not preferred cover for PPM, high fire frequency from military training activities has potential to degrade habitat quality for PPM.

### Fire Management Practices

The seasonality, size, intensity and frequency of fire in coastal southern California has likely changed drastically over the last century in association with human settlement. As a result of fire suppression activities, many of coastal southern California's natural areas may be subject to less frequent fire than occurred historically, while military use of Camp Pendleton has led to increased fire frequencies over much of the Base.

At Dana Point and San Mateo North a lack of recent fire has resulted in a majority of these sites being dominated by mature large stature sage scrub shrubs that overlap with one another and provide nearly continuous canopy cover over the ground. The continuity of shrub cover at these sites may be reducing habitat quality for PPM by eliminating habitat openings that are thought to be an important component of PPM's preferred microhabitat (Germano 1997, p. 28; Loda et al. 1999, p. 8; Spencer et al. 2000, pp. 12-15; Montgomery 2005a, pp. 7-8), and possibly by suppressing growth of annual forbs and grasses that are an important source of seeds for PPM.

Within the Santa Margarita PPM population, prescribed fire is frequently used to prevent fires ignited by ordnance training from escaping the vicinity of the live firing ranges within Edson Range. Consequently a large portion of Edson Range is maintained with very low vegetative cover. This suppresses plant seed production which is an important food resource for PPM, and also reduces structural plant cover that is needed for predator avoidance. The Camp Pendleton Fire Department follows measures proposed by the Assistant Chief of Staff, Environmental Security (AC/S, ES) to minimize the impact of prescribed fires and related activities on PPM. Nevertheless, it is likely that the high frequency of fires within Edson Range is suppressing the PPM population in this portion of its range.

In summary, the longer term impact of fire at the population level is unknown, with potential for both positive and detrimental effects. For instance, the use of prescribed fire in Edson Range may be protecting the adjoining Oscar One area from overly frequent burning that would otherwise be caused by live fire training. Similarly, occasional wildfire may be beneficial to PPM if fire frequency and intensity remains low enough to support open-canopy CSS thought to be preferred by PPM, and enough individuals survive to repopulate burned areas. However, if fires occur frequently or at the wrong time of year, seed availability can be significantly diminished or nonnative grasses and forbs can be favored to invade and displace native forbs and shrubs that are preferred cover for PPM (D'Antonio and Vitousek 1992, pp. 63-68; Minnich and Dezzani 1998, pp. 383-384; O'Leary and Westman 1988, p. 779; Keeley et al. 2005, p. 2109). Overall, frequent fire from military training activities is a threat to the Santa Margarita PPM population, while fire suppression may be contributing to a decline in habitat suitability for PPM elsewhere.

### Fire Breaks and Fuel Breaks

Other fire management activities on Camp Pendleton include the maintenance of fire breaks and fuel breaks in the vicinity of the San Mateo North, San Mateo South, and the Santa Margarita populations. At San Mateo North, a firebreak about 20 m (66 ft) wide runs along the western boundary of the habitat area between habitat and the adjoining residential community. This firebreak has been maintained by periodic discing of the earth and spreading of mulch. While PPM burrows and individuals may occasionally be crushed or killed by discing of soil, the layer of mulch along this firebreak has also created favorably moist conditions for Argentine ants to colonize this area (Brehme and Fisher 2009, p. 32; Suarez et al. 1998, p. 2050). Colonization of San Mateo North by Argentine ants is thought to be one of the factors detrimentally affecting habitat for PPM at this location (Brehme and Fisher 2009, p. 32). Correlative study suggests small mammal densities can sometimes be negatively associated with Argentine ant colonies

(Laakkonen et al. 2001, pp. 783-784), while Argentine ants also have the potential to alter the vegetation community by displacing other ants important to native seed dispersal (Rodriguez Cabal 2009, pp. 500-501).

There are two primary firebreaks that traverse the area of San Mateo South: one that traverses the ridgeline from southwest to northeast through the San Mateo PPM population (the “Ridgeline Firebreak”), and another that occurs to the northeast that is roughly perpendicular to the ridgeline, traveling across the San Onofre and San Mateo drainages (the “San Onofre-San Mateo Firebreak”). These firebreaks range between 15-25 m (49-82 ft) in width and have been maintained by discing or blading the earth to bare mineral soil. Maintenance of the Ridgeline Firebreak within the known-occupied San Mateo South PPM habitat (i.e. the minimum convex polygon of capture locations) has been suspended pending completion of formal consultation between the Service and the Marine Corps regarding all Marine Corps activities on the Base in upland habitats. Maintenance of the Ridgeline Firebreak to the east of the known-occupied PPM habitat continues, while the current status of maintenance of the San Onofre-San Mateo Firebreak is unknown. Recently, PPM were discovered to the east of the San Onofre-San Mateo Firebreak (Vergne 2009, pp. 5-6) suggesting the San Mateo PPM population is more extensively distributed than previously recognized. In addition to the potential for maintenance of these firebreaks to result in the periodic injury or mortality of PPM residing within burrows within them, these firebreaks degrade habitat quality for PPM by eliminating vegetation cover, disturbing soil and providing a source of disturbance that facilitates the invasion of nonnative plant species into adjoining areas (Merriam et al. 2006, p. 515).

As a measure to prevent fires escaping Edson Range from burning large tracts of land, a fire break was established adjoining a dirt access road that extends from the southeastern side of Edson Range across Oscar One towards MACS Road. This area encompasses approximately 22-ha (54-ac) and has been maintained through frequent prescribed burns. As discussed above, prescribed burns have potential to degrade habitat quality for PPM by eliminating a food source, reducing cover from predators and by leading to an increasing prevalence of nonnative annual grasses which are not the preferred cover of PPM.

### Road and Utility Maintenance

Camp Pendleton’s Facilities Maintenance Department (FMD) maintains most dirt roads on the Base, unless those roads are regularly maintained by right-of-way holders (such as public utilities) or lessees (e.g. agriculture lessees). Maintenance activities include correcting problems created by surface runoff and filling in ruts which may involve blading the road surface or adding decomposed granite or road base to the road surface. Routine maintenance of roads within occupied PPM habitat requires approval from the AC/S, ES. The AC/S, ES typically requires that the FMD follow practices that avoid and minimize the potential to injure or kill PPM. Therefore, it is likely that routine road maintenance results in few, if any, individual PPM injured or killed on an annual basis. Road conditions within the Oscar One and Edson Range training areas have deteriorated over time. As discussed above, in an effort to reduce road maintenance requirements, the Marine Corps is proposing a major upgrade to 26 km (16 mi.) of dirt roads in the Oscar One and Edson Range training areas (NAVFAC 2008, pp. ES-1-VIII-4+Appendices).

Utility companies (San Diego Gas and Electric (SDG and E), Southern California Edison (SCE)) maintain dirt roads to provide access for maintenance of power lines, power poles and towers, and other structures. SDG and E powerlines and roads bisect or are in the vicinity of all three PPM populations on the Base while SCE powerlines and roads bisect San Mateo South. Ongoing road and facility maintenance activities occasionally involve soil and habitat disturbance that could result in disturbance, injury, or mortality of PPM (Service 1999c, pp. 1-2; Montgomery 2005b, pp. 1-6). SDG and E currently conducts road and facility maintenance actions according to a Natural Community Conservation Plan/Habitat Conservation Plan (NCCP/HCP) that specifies that SDG and E will generally avoid impacts to occupied PPM habitat, but some incidental take of PPM within their plan area is authorized (Service 1995, p. 37). SDG and E routinely coordinates with the Service to avoid and minimize take of PPM to the maximum extent practicable (Service 2004, p. 1), though it is likely that routine maintenance may result in a few PPM individuals being injured or killed each year. SCE does not currently have incidental take authorization for activities associated with maintenance of their facilities, although SCE has informed the Service that they are developing avoidance and minimization protocols for activities within occupied or suitable PPM habitat.

#### Recreation Activities and Unauthorized Habitat Disturbances

Residential communities fall within close proximity to the Dana Point Headlands, San Mateo North, and San Mateo South PPM populations, and hiking trails pass through the Dana Point Headlands and San Mateo North PPM populations. Public use of these areas has potential to degrade PPM habitat through creation of unauthorized trails and other habitat disturbances from human activities. The Dana Point Preserve was historically fenced and closed to the public, so until recently all prior public use of this area resulted from unauthorized trespass. Because this site is one of the last remaining undeveloped coastal parcels within the City of Dana Point and occurs on a majestic coastal promontory, it experienced frequent and persistent public trespass that resulted in the creation of trails and damage to the surrounding fencing. Exclusion of the public from this area also facilitated use of the area for various unlawful activities including dumping of garden waste, as a location for teens to party late at night, as a location for growing marijuana, and as location for habitation by the homeless (Miller, 2008, pers. obs.). These activities have been curtailed since 2005 due to management of the site by CNLM.

In December of 2009, the public was granted access during daylight hours to a formal trail that was constructed within the Dana Point Preserve in 2007. This likely has reduced some of the impetus for trespass but has also led to a dramatic increase in the amount of human presence within the Dana Point Preserve during daytime due to the popularity of the trail with the public (Miller, 2010, pers. obs.). Increased human presence within the Preserve will have an unknown impact to the PPM population, but has potential to degrade habitat quality by increasing the level of disturbance adjoining the trail and possibly by facilitating the presence of nonnative species such as domestic dogs, (*Canis familiaris*), house mice (*Mus musculus*), rats (*Rattus rattus*, *Rattus norvegicus*) and Argentine ants.

San Mateo North appears to experience the greatest habitat impacts from recreational use and unauthorized habitat disturbances. California State Parks maintains one public access trail

delimited by a strand wire fence through this area and attempts to manage access to the site. However, unauthorized trails receive continual use from mountain bikers, hikers and people walking their dogs. A few years ago, local youths constructed a BMX track with jumps and banked turns in an area formerly known to support PPM. Recent PPM monitoring efforts have also discovered marijuana plants being grown in one location, and several homeless encampments and associated trash within the habitat area (Miller, 2008, pers. obs.; Brehme, 2008, pers. comm.). If domestic dogs are perceived by PPM as a potential predator, heavy use of this site by people walking their dogs has potential to inhibit the foraging behavior of PPM in areas where dogs leave behind olfactory cues (urine, feces) of their presence (Herman and Valone 2000, p. 139; Brinkerhoff et al. 2005, p. 662).

Because San Mateo South falls entirely within a military installation, it receives the least impact from unauthorized trail creation and public trespass. However it does receive occasional use from nearby residents that primarily use the existing road network for mountain biking and hiking.

Overall recreation activities and unauthorized habitat disturbances at the three northern PPM populations have led to a low level of continual disturbance that sometimes involves the deposition of trash, creation of trails, bare areas, and compacted soils. Indirect impacts from these habitat disturbances include the potential facilitation of invasion of these sites by nonnative annual grasses and weeds and disturbance by nonnative animals (Argentine ants, house mouse and nonnative rats). While each of these activities may affect only a small portion of the habitat within a site at any one time, their cumulative impact may exacerbate the extirpation risks of these populations by degrading habitat quality and depressing what are likely already small PPM populations.

#### **FACTOR B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes**

At listing, the large number of specimens collected for scientific purposes from the El Segundo area in 1931 and 1932 was cited as a potential factor contributing to the decline of the historical PPM population at this locale (59 FR 49761). However, the final listing rule included no information to suggest that scientific over-collecting remained a threat to PPM. Similarly, overutilization for any purpose does not appear to be a threat at this time.

#### **FACTOR C: Disease or Predation**

At the time of listing, the synergistic effect of habitat fragmentation and loss of top predators (e.g. coyote) from habitat fragments was cited as a significant threat to PPM populations leading to an increase in the number of smaller carnivores (e.g. domestic cats) within habitat fragments. Correlative analysis suggests this phenomenon, termed “mesopredator release,” increases the vulnerability of birds and small mammals to extirpation in habitat fragments since smaller carnivores are principle predators of birds and small vertebrates (Crooks and Soule 1999, pp. 563-565).

Two of the predators specifically mentioned as threats to PPM in the listing include the introduced red fox (*Vulpes fulva*) and domestic and feral cats (*Felis catus*) (59 FR 49762). The red fox includes small mammals in its diet and at the time of listing was found to be broadly distributed and abundant throughout habitat fragments in coastal southern California (Lewis et al. 1993, p. 26). Predation by the red fox has been suggested as a factor that contributed to the apparent extirpation of PPM from the El Segundo dunes (Patten et al. 1998, p. 84). It is also hypothesized that in locations where food is limiting, supplemental feeding of foxes by the public may sometimes increase the local carrying capacity for them (Lewis et al. 1993, p. 24); thereby increasing their predatory threat in habitat fragments.

Domestic cat owners boost cat populations far beyond the carrying capacity of habitat fragments adjoining residential developments, by providing food to their pets (Crooks and Soule 1999, p. 565). Along with native predators, domestic and feral cats have the ability to deplete a rodent population very quickly (Pearson 1964, pp. 180-183). At the time of the listing, there was a documented instance of a domestic cat preying upon PPM at the Dana Point Headlands, suggesting cats from the adjoining residential development pose a specific threat at this location (59 FR 49762).

The small size and adjacency of the Dana Point Headlands, San Mateo North and San Mateo South PPM populations to residential developments suggest that domestic and feral cats continue to pose a predatory threat to PPM at these locations. At the Dana Point Headlands this threat has been ameliorated to some extent by management of the Dana Point Preserve. During 2009, the CNLM trapped and removed a stray cat detected on the Preserve (Lee Ann Carranza, pers. comm. 2009). However, domestic pet activity remains fairly heavy at San Mateo North, and Montgomery (2003, p. 31) observed several cats from the adjoining military housing entering occupied PPM habitat at San Mateo South.

Based on their study of the response of rodents to habitat fragmentation in southern California Bolger et al. (1997, pp. 559-560) suggest that house cats are just one of a suite of rodent predators that may be involved in extinctions of small mammals from habitat fragments; noting that “[H]ousecats (*Felis catus*), coyotes (*Canis latrans*), striped skunks (*Mephitis mephitis*), raccoons (*Procyon lotor*), opossums (*Didelphis virginiana*) Great-horned owls (*Bubo virginianus*), and Red-tailed Hawks (*Buteo jamaicensis*) are potential rodent predators that appear to be as abundant or more abundant in fragments than in unfragmented habitat.” At the small and isolated Dana Point Headlands site, camera surveys have recently detected a relatively large number of potential predators of PPM including housecat, striped skunk, raccoon, coyote, longtail weasel (*Mustela frenata*), grey fox (*Urocyon cinereoargenteus*), and bobcat (*Lynx rufus*) (Lee Ann Carranza pers. comm. 2009). Thus, the small size and isolation of PPM populations, particularly at the Dana Point Headlands and San Mateo North, suggests that predation from a suite of potential predators remains a threat to PPM.

At the time of listing there was no information to suggest that disease is a particular threat to PPM. Since then, most captured PPM have not shown evidence of heavy parasite loads or disease (Montgomery 2003, p. 32; Ogden 1997, p. 36; Miller, 2008, pers. obs.), although this has not been specifically studied. At Camp Pendleton, PPM are occasionally observed with fleas and yellow-orange mites around their tail and genitals, and at least one individual has been observed

with mange (Miller, 2008, pers. obs.). However, most animals appeared healthy and were free of skin irritations with glossy fur and normal body weights (Miller, 2008, pers. obs.; Montgomery 2003, p. 32).

At the Dana Point Headlands, co-occurring desert woodrats (*Neotoma lepida*) have been observed with severe skin infections, possibly of fungal origin (Montgomery 2003, p. 32) but it is not known whether there is a risk of transmission to PPM. Based on microhabitat differences among these species, it is likely that the risk of disease transmission is greatest in association with trapping studies involving successive captures of the two species within the same trap.

#### **FACTOR D: Inadequacy of Existing Regulatory Mechanisms**

At the time of listing, regulatory mechanisms identified as possibly providing for some protection of PPM in the absence of federal listing included: (1) the Act if the species were to occur sympatrically with a listed species, (2) the California Natural Community Conservation Planning effort, (3) the California Environmental Quality Act, (4) land acquisition and management by Federal, State, or local agencies or by private groups and organizations, and (5) local laws and regulations (59 FR 49762). Subsequent to the listing, PPM was discovered on the federally owned Marine Corps Base Camp Pendleton where it may receive some protection from the National Environmental Policy Act and the Sikes Act. Protections provided for PPM under various regulatory mechanisms are described below.

##### **State Protections**

The PPM is identified by the State of California as a “Species of Special Concern”. This is an administrative designation that carries no formal legal status. Rather, this designation is intended to focus attention on animals at conservation risk and to highlight the need to promote their conservation and recovery before they meet criteria for listing under the California Endangered Species Act.

State laws that provide potential protection to the PPM are the California Environmental Quality Act (CEQA), the Natural Communities Conservation Planning Act (NCCP), and the California Coastal Act (CCA).

##### California Environmental Quality Act (CEQA)

The CEQA is the principal statute mandating environmental assessment of projects in California. The purpose of CEQA is to evaluate whether a proposed project may have an adverse effect on the environment and, if so, if that effect can be reduced or eliminated by pursuing an alternative course of action or through mitigation. CEQA applies to projects proposed to be undertaken or requiring approval by State and local public agencies (<http://www.ca.gov/state/portal>).

If significant effects are identified through the CEQA process, the lead agency has the option to require mitigation through changes in the project or to decide that overriding considerations make mitigation infeasible (CEQA Sec. 21002). Because coastal dune ecosystems are recognized in California as a declining resource supporting several endemic species, projects

affecting dune habitat that are mandated to comply with CEQA may provide some consideration of impacts to PPM and its habitat. However, any protection afforded rare or sensitive species or their habitats, through CEQA, are at the discretion of the lead agency involved.

### Natural Community Conservation Planning Act (NCCP)

The NCCP program is a voluntary cooperative effort involving the State of California and numerous private and public partners to protect habitats and species. A NCCP program identifies and provides for the regional or area-wide protection of plants, animals, and their habitats, while allowing compatible and appropriate economic activity. The program began in 1991 under the State's NCCP Act (California Fish and Game Code 2800-2835). The primary objective of the NCCP program is to conserve natural communities at the ecosystem scale while accommodating compatible land use (<http://www.dfg.ca.gov.NCCP/>). Regional NCCPs may provide protection to federally listed species, such as the PPM, by conserving native habitats upon which the species depend.

Since PPM was listed, a number of NCCP programs have been adopted within its historical range including the San Diego Gas and Electric (SDGE) Subregional NCCP, the Orange County Central and Coastal Subregions NCCP, the San Diego Multiple Species Conservation Program (MSCP), and the Carlsbad Subarea Plan that falls within the San Diego Multiple Habitat Conservation Program plan area. Overall these plans have conserved around 5,444 hectares (13,452 acres) of habitat within 3.2 km (2 miles) of the coast. Both the MSCP and the Carlsbad Subarea plan potentially benefit PPM through conservation of coastal habitat, but neither of these plans incorporate specific conservation measures for PPM as PPM are not known to occur within the plan areas for these HCPs. The SDGE and Orange County NCCPs include provisions for PPM.

#### *The San Diego Gas and Electric Subregional NCCP*

The SDGE Subregional NCCP addresses installation, use, maintenance and repair of SDGE's gas and electric system and typical expansions to that system within a defined subregion that includes their transmission network across much of San Diego County and a portion of Orange County. The SDGE plan provides for the permanent conservation of 97 ha (240 ac) of land in southern San Diego County, and contemplates that as much as 162 ha (400 ac) of natural areas could be impacted by SDGE activities over a 25 year implementation period. The plan provides "coverage" for impacts to 52 plants and 58 animals, including PPM. The conservation strategy for PPM is: "impacts will be avoided; no direct killing or injury to individuals will occur unless deemed necessary for emergencies or repairs" (San Diego Gas and Electric 1995, Table 3.1). Impact avoidance is achieved through the review of project activities by an environmental surveyor who is responsible for coordinating with the Service and obtaining further review from a biologist if it is deemed there is a potential for impacts to sensitive species. Project review may result in incorporation of avoidance and minimization measures and call for construction monitoring. The SDGE plan is programmatic in scope and does not specify the amount of incidental take anticipated for individual species or where specific habitat impacts will occur. In practice, PPM has occasionally been impacted by SDGE repair and maintenance activities within Oscar One and at San Mateo South (Service 1999c, pp. 1-2; Montgomery 2005b, p. 4).

## *The Orange County Central and Coastal Subregions NCCP*

The Orange County Central and Coastal Subregions NCCP authorizes development within undeveloped portions of a 73,777 ha (182,309 ac) planning area and created a 14,973 ha (37,000 ac) reserve system (including 6,961 ha (17,201-ac) in the Coastal Subregion) primarily focused on conservation of the coastal sage scrub plant community. The NCCP addresses PPM as an “Identified Species” for which special conditions apply (Central and Coastal Subregion NCCP Implementation Agreement, pp. 83-94). Among those conditions is a provision that the non-profit entity charged with NCCP plan implementation shall “allow pocket mice to be relocated onto portions of the Reserve System determined to be suitable for the pocket mouse, and will provide for related enhancement, restoration, propagation and monitoring activities as part of the Adaptive Management Program” (Central and Coastal Subregion NCCP Implementation Agreement, p. 92). Conditions also address development of the one known location for PPM outside of federal ownership at the Dana Point Headlands, and set forth survey and mitigation requirements for landowners that did or did not participate in creation of the NCCP.

The Central/Coastal NCCP required the Dana Point Headlands landowners to: contribute \$350,000 towards PPM recovery; contribute \$500,000 toward the NCCP general operating endowment; create an 8-year “Temporary Preserve” over 8.9 ha (22 ac) of the Dana Point Headlands property, including the area where PPM were documented; and to provide the Service the opportunity to purchase the Temporary Preserve should the Service determine the Temporary Preserve is essential to survival of PPM”(Central and Coastal Subregion NCCP Implementation Agreement, pp. 83-94). The landowners have made payments consistent with their monetary obligations, and in 2005 the “Temporary Preserve” was placed under a permanent conservation easement and sold to a non-profit conservation organization, the Center for Natural Lands Management, who now manages the property and its natural resources.

In recognition of survey efforts for PPM undertaken by other Participating Landowners during the NCCP planning period, other Participating Landowners are not required to conduct additional trapping surveys on their land within habitat suitable for PPM. If a PPM population is discovered within one of these land ownerships, the Service “...shall assume the responsibility for identifying and implementing appropriate mitigation at no cost to the Participating Landowners and with no delays to proposed development programs”( Central and Coastal Subregion NCCP Implementation Agreement, p. 93).

Landowners wishing to develop their property that did not participate in creation of the Central/Coastal NCCP may be required to survey for PPM if potentially suitable habitat is identified on their land. If the PPM is discovered as a result of such surveys, the landowner may be required at the discretion of the Service to comply with the Act, or to fund the cost of relocating the PPM population to a suitable site within the Coastal subarea (Central and Coastal Subregion NCCP Implementation Agreement, p. 94).

### California Coastal Act (CCA)

Occupied habitat of a federally listed species occurring within the coastal zone is considered an “environmentally sensitive area” under section 30107.5 of the California Coastal Act of 1976

(Public Resources Code, Division 20). The California Coastal Act requires that environmentally sensitive habitat areas “shall be protected against any significant disruption of habitat values” (section 30240). Therefore, the California Coastal Act can provide protection to PPM in those cases where it would be affected by a proposed project requiring a coastal development permit. The California Coastal Management Program is administered by the California Coastal Commission in accordance with the Federal Coastal Zone Management Act of 1972 (Pub. L. No. 109-58), and includes a system of coastal permits and appeals, planning and implementation of local coastal programs, and Federal consistency review. The PPM has benefited from Coastal Commission review of the Local Coastal Plan governing the Dana Point Headlands Development and Conservation Plan, and from its review of a proposal to extend State Route 241 in the vicinity of the San Mateo North PPM population.

## **Federal Protections**

### National Environmental Policy Act (NEPA)

The NEPA (42 U.S.C. 4371 *et seq.*) provides some protection for listed species that may be affected by activities undertaken, authorized, or funded by Federal agencies. Prior to implementation of such projects with a Federal nexus, NEPA requires the action agency to analyze the project for potential impacts to the human environment, including natural resources. In cases where that analysis reveals significant environmental effects, the Federal agency must propose mitigations that could offset those effects (40 C.F.R. 1502.16). These mitigations usually provide some protection for listed species. However, NEPA does not require that adverse impacts be fully mitigated, only that impacts be assessed and the analysis disclosed to the public. Therefore NEPA does not mandate that proposed actions avoid impacts to PPM, but requires that Federal agencies take such impacts into consideration before proceeding. Because three of the PPM populations occur on a federally owned military installation, NEPA review accompanies most discretionary actions with potential to impact those populations.

### Endangered Species Act (Act)

Since its listing as endangered, PPM has benefited from the protections of the Act, which include the prohibition against take, the requirement for interagency consultation for Federal actions that may affect the species, and provisions which allow the Secretary to permit lawful actions that would otherwise be prohibited by the Act. Section 9 of the Act and Federal regulations pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species without special exemption. “Take” is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct (50 CFR 17.3). “Harm” is further defined to include significant habitat modification or degradation that results in death or injury to listed species to such an extent as to significantly disrupt normal behavioral patterns, which include, but are not limited to, breeding, feeding or sheltering (50 CFR 17.3).

Section 7(a)(1) of the Act requires all Federal agencies to utilize their authorities in furtherance of the purposes of the Act by carrying out programs for the conservation of endangered species and threatened species. Section 7(a)(2) of the Act requires Federal agencies, including the Service, to ensure that actions they fund, authorize, or carry out do not jeopardize the continued

existence of a listed species or result in the destruction or adverse modification of habitat in areas designated by the Service to be critical. A jeopardy determination is made for a project that is reasonably expected, either directly or indirectly, to appreciably reduce the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution (50 C.F.R. § 402.02). A non-jeopardy opinion may include reasonable and prudent measures that minimize the amount or extent of incidental take of listed species associated with a project. Critical habitat has not been proposed for PPM.

Since it was first listed in 1993, the U.S. Marine Corps has consulted and coordinated with us pursuant to section 7 regarding the effects of various activities conducted within Camp Pendleton on PPM. These consultations have addressed construction of the Crucible Challenge Course within the Oscar One training area, implementation of a prescribed burn at San Mateo North, and various other training and fire management activities (Service 1996c, pp. 1-21; Service 2000, pp. 1-21). The Federal Highway Administration has also consulted with us regarding the proposed extension of State Route 241 in the vicinity of the San Mateo North PPM population (Service 2008c, pp. 1-246). Although we exempted PPM habitat losses from the SR 241 project from the take prohibitions of the Act, the California Coastal Commission has found this project to be inconsistent with the California Coastal Act, so it does not appear that the roadway alignment reviewed by us will be implemented.

Currently, we are engaged in a formal programmatic consultation with the Marine Corps to address a range of on-going and proposed activities in upland habitats within Camp Pendleton that have potential to impact several federally listed species, including PPM. The “Uplands Consultation” is proposed to address military training, fire management, facility operation and maintenance, and to set forth streamlined procedures for reviewing certain development activities. We are also consulting with the Marine Corps on the proposed improvement to 26 km (16 mi) of dirt roads in the Oscar One and Edson Range training areas.

Under Section 10(a)(1)(A) of the Act there are provisions to permit the take of PPM for scientific purposes or to enhance the propagation and survival of the species. To promote the survival of PPM through the study of known populations and the discovery of unknown populations, we have authorized individuals to trap and monitor PPM within suitable habitat. We have also issued a permit to the San Diego Zoological Society Institute for Conservation Research to perform behavioral studies of PPM to assist with development of a translocation protocol. Direct take in the form of injury or death to PPM as a result of these activities is negligible, and the results of these activities are tracked by us through the permittee’s reporting requirements.

Section 10(a)(1)(B) allows the Service to permit take that would otherwise be prohibited by section 9 of the Act, provided that such taking is incidental to, and not the purpose of carrying out, an otherwise lawful activity. This provision requires the permit applicant to prepare a (habitat) conservation plan that: (1) specifies the impact that will likely result from such taking; (2) the steps that will be taken to minimize and mitigate such impacts and the funding that will be available to implement such steps; (3) alternatives to the taking that the applicant considered; and (4) such other measures that the Secretary requires as necessary or appropriate for purposes of the plan. Such take can be authorized provided we find that it will not appreciably reduce the likelihood of the survival and recovery of the species in the wild. We have made this finding and

issued incidental take permits in association with the San Diego Gas and Electric and Orange County Central and Coastal Subregions Natural Community Conservation Plans discussed above.

In summary, listing has provided a variety of protections for PPM, including the prohibition against take, the requirement for interagency consultation for Federal actions that may affect the species, and provisions which allow the Secretary to permit lawful actions that otherwise would be prohibited by the Act. In the absence of its status as a listed species, PPM still has potential to benefit from the Act in those instances where it occurs sympatrically with other listed species. PPM co-occurs with the federally threatened California gnatcatcher (*Polioptila californica californica*) at the Dana Point Headlands and within portions of its distribution on Marine Corps Base Camp Pendleton. However, the gnatcatcher is more broadly distributed and less imperiled by extinction than PPM, so it is conceivable that actions which comply with sections 7 and 10 of the Act, but involve losses of individual birds or their habitat, could jeopardize the survival of PPM.

#### Sikes Act Improvement Act (Sikes Act)

The Sikes Act originally recommended military installations develop Integrated Natural Resource Management Plans (INRMPs), but was amended in 1997 to “require” the development of INRMPs. An INRMP is a plan intended “...to guide installation commanders in managing their natural resources in a manner that is consistent with the sustainability of those resources while ensuring continued support of the military mission” (USDoN 2002, p. 1–1). INRMPs are developed in coordination with the State and the Service, and are generally updated every five years. Although an INRMP is technically not a regulatory mechanism because its implementation is subject to funding availability, it is an important guiding document that helps to integrate the military’s mission with natural resource protection.

#### *Integrated Natural Resource Management Plan (INRMP)*

The U.S. Marine Corps adopted an INRMP for Marine Corps Base Camp Pendleton in April of 2007 (MCB Camp Pendleton 2007, pp. i-5-18 +Appendices). The INRMP references the fact that the Marine Corps is in consultation with the Service regarding on-going and proposed activities within upland habitats Basewide, including habitat occupied by the PPM. Thus, the INRMP states that until a final management plan is adopted in association with the Upland Consultation, PPM “...benefits directly or indirectly from current Basewide management practices including exotic vegetation control, exotic animal/predator control (free roaming cats), use of native seed stock when conducting post-fire reseedling to enhance habitat, resource conservation awareness and education programs, and the terms and conditions of the consultation and BO [biological opinion] for the construction, operation and maintenance of the Crucible Challenge Course in the Oscar One and Edson Range areas of the Base that was issued on 14 August 1996.” (MCB Camp Pendleton 2007, p. F-42). The INRMP also references Base Order P3500.1M (Range and Training Regulations), which includes the following programmatic instructions for units training in PPM habitat areas: “1) avoidance of digging (including constructing fighting positions), 2) limiting foot traffic and vehicle/equipment operations near known habitat to existing roads, and 3) keeping bivouac/command post/field support activities at

least 1,000 feet (300 meters) from PPM habitat areas year-round” (MCB Camp Pendleton 2007, p. F-42). Thus, the INRMP identifies Basewide management practices that have potential to benefit PPM but are not targeted specifically to PPM habitat, incorporates by reference adopted range and training regulations that help to govern activities within PPM habitat, and affirms the Marine Corps commitment to uphold the terms and conditions of the Crucible Challenge Course biological opinion.

### **Summary of Factor D Analysis:**

In the absence of its status as a listed species, CEQA and NEPA are environmental disclosure laws that have potential to contribute to the protection of PPM, but such protection is not assured since lead agencies are given discretion over whether to require impact minimization or mitigation measures. The listing of PPM under the Act in 1994 increased awareness of the importance of protecting and managing habitat for the only known population of the species on privately owned land, and provided the impetus for addressing PPM as a covered species as part of the SDGE Subregional and Orange County Central and Coastal Subregions NCCPs. Because occupied habitat of a federally listed species within the coastal zone is considered an “environmentally sensitive area” that “shall be protected against any significant disruption of habitat values”, the California Coastal Act has helped to conserve the Dana Point Headlands and San Mateo North PPM populations. Since the historical distribution of PPM is largely restricted to the coastal zone, the California Coastal Act has the potential to contribute to the conservation of PPM should it be discovered on private or State owned land elsewhere. However, the significance of impacts to PPM evaluated pursuant to the California Coastal Act is determined in part based on its status as a listed species. Since, three of the four known extant populations of PPM occur on federally owned land within Marine Corps Base Camp Pendleton, where the interagency consultation requirements of the Act are the primary regulatory mechanism mandating PPM conservation, existing regulatory mechanisms are likely inadequate to provide for conservation of PPM in the absence of the protections afforded by the Act.

### **FACTOR E: Other Natural or Manmade Factors Affecting Its Continued Existence**

At listing, the Service identified small population size and the extremely restricted and fragmented nature of remaining habitat within PPM’s historical range as factors that make PPM highly susceptible to extinction as a result of environmental and demographic factors alone (59 FR 49762). Despite the discovery of three additional populations of PPM on Camp Pendleton since the listing, PPM continues to have a restricted and fragmented distribution that is characterized by small populations exhibiting dynamic population fluctuations. Climate change has also been recognized as a potential threat since listing and is discussed below.

#### Small Population Size

Small populations have higher probabilities of extinction than larger populations because their low abundance renders them susceptible to inbreeding, loss of genetic variation, high variability in age and sex ratios, and other random naturally occurring events such as droughts or disease

epidemics. Owing to the probabilistic nature of extinction, some small populations will survive in the short term when faced with these demographic, environmental, and genetic stochastic risks, but they are likely to eventually become extirpated.

Intensive trapping surveys at the Dana Point Headlands since the listing have often detected low numbers of individuals, with the highest number of unique individuals ever detected at this site being 80 individuals (Brylski et al. 2010, p. 12). A recent intensive trapping effort that covered the entire area of known occupancy at San Mateo North failed to detect any individuals at this location, lending uncertainty to the continued existence of the San Mateo North PPM population (Brehme and Fisher 2009, p. 3). The greatest number of unique PPM detected at San Mateo South in a single year is 45 individuals (Brehme and Fisher 2009, p. 1), although recent captures of PPM to the southeast of the former area of documented occupancy suggests this population may be distributed over a larger area than previously recognized (Vergne 2009, pp. 5-6; Brehme 2009b in litt.). The Santa Margarita PPM population is the largest of the known extant populations with hundreds of individuals being captured within each of two selectively placed 1.38 hectare (3.4 acre) population monitoring grids within the much larger 741 ha (1,831 ac) area circumscribed by historical capture records. However, population monitoring on these grids reveals that PPM can sometimes exhibit dramatic population fluctuations, with abundance on one of the grids falling to fewer than 20 individuals during the monitoring period (Service 2008a, p. 39). The Santa Margarita area circumscribed by PPM capture records also includes a mosaic of suitable and unsuitable areas (e.g. dense nonnative grasslands) for PPM. Several recent survey efforts have detected very few or no PPM across the Lower Mesa portion of Oscar One (Spencer 2007, pp. B-50 -B-52; Shier 2008b, p. 2), which represents about 48 percent (352 ha (869 ac)) of the area historically documented to be occupied by PPM in this vicinity. Another factor that renders populations vulnerable to stochastic events is habitat fragmentation, which often acts in concert with small population size to increase the probability of extinction.

### Habitat Fragmentation

Urbanization and land conversion have fragmented the historical range of PPM such that extant populations now operate as independent units rather than parts of a stable metapopulation that is maintained by immigration/emigration dynamics. Isolated populations are more susceptible to long-term/permanent extirpation by accidental or natural catastrophes because the likelihood of recolonization following such events is negatively correlated with the extent of isolation (Gilpin 1987, p. 136).

Habitat fragmentation likely reduces habitat quality and increases the likelihood of local extirpation of populations by increasing the vulnerability of remaining habitat to disturbance and invasion by nonnative species, by isolating populations through erection of barriers to dispersal, and by making remaining populations smaller and more vulnerable to catastrophes, deleterious effects of inbreeding, and environmental and demographic stochasticity. The quality of fragmented habitat may also decline as a result of edge effects, such as increased exposure to artificial night-time lighting, which may cause problems for nocturnal rodents by increasing their vulnerability to visually aided predators (Clarke 1983, p. 205; Dice 1945, p. 393), or result in direct habitat avoidance (Brown et al. 1988, p. 408; Kotler 1984, p. 689; Price et al. 1984, pp. 354-355). Bolger et al. (1997a, pp. 552-563) studied the effects of habitat fragmentation on

rodents in southern California and found that species with highly stochastic populations were more frequently extirpated from small habitat fragments. This suggests that small population size and a restricted and fragmented distribution continue to be factors that threaten the continued existence of PPM.

### Climate Change

Since listing, it has become apparent that potential threats exist to biota of the United States from ongoing, accelerated climate change. Current climate change predictions for terrestrial areas in the Northern Hemisphere indicate warmer air temperatures, more intense precipitation events, and increased summer continental drying (Field et al. 1999, pp. 1–63; Cayan et al. 2006, pp. 1–47; Meehl et al. 2007, pp. 747–843). Climate modeling for California indicates similar outcomes in temperature and precipitation. Recent assessments have been carried out running low and medium emission scenarios through the six models used in the 2007 IPCC assessment. The results predict a 1 to 3 degree Celsius (1.8 to 5.4 degrees Fahrenheit) increase in average temperature by the year 2050 (Cayan et al 2009, p. 16). Over the same period, a 12 to 35 percent decrease in precipitation is indicated (Cayan et al. 2009, p. 17).

Predictions of climatic conditions and other physical forces are uncertain. While we recognize that climate change is an important issue with potential effects to listed species and their habitats, we lack adequate information to make accurate predictions regarding its effects to PPM at this time. Therefore, the magnitude of this threat is unknown at this time.

### **III. RECOVERY CRITERIA**

A recovery plan addressing PPM was completed in August of 1998. Recovery plans provide guidance to the Service, States, and other partners and interested parties on ways to minimize threats to listed species, and on criteria that may be used to determine when recovery goals are achieved. There are many paths to accomplishing the recovery of a species and recovery may be achieved without fully meeting all recovery plan criteria. For example, one or more criteria may have been exceeded while other criteria may not have been accomplished. In that instance, we may determine that, over all, the threats have been minimized sufficiently, and the species is robust enough, to downlist or delist the species. In other cases, new recovery approaches or opportunities unknown at the time the recovery plan was finalized may be more appropriate to achieve recovery. Likewise, new information may change the extent that criteria need to be met for recognizing recovery of the species. Overall, recovery is a dynamic process requiring adaptive management, and assessing a species' degree of recovery is likewise an adaptive process that may, or may not, fully follow the guidance provided in a recovery plan. We focus our evaluation of species status in this 5-year review on progress that has been made toward recovery since the species was listed by eliminating or reducing the threats discussed in the five-factor analysis. In that context, progress towards fulfilling recovery criteria serves to indicate the extent to which threat factors have been reduced or eliminated.

The recovery plan contemplates that recovery of PPM will involve a two-stage process that begins with reclassification of the subspecies from endangered to threatened status. Following downlisting, delisting is anticipated when the Service determines that the five listing factors

considered above no longer adversely affect the survival and recovery of the subspecies (Service 1998, p. 36). Criteria identified in the Recovery Plan to downlist PPM from endangered to threatened status, the threat factors they address, and the steps that have been implemented to meet those criteria are discussed below.

*Downlisting Criterion 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.*

Downlisting criterion 1 addresses listing factors A (Destruction, Modification or Curtailment of Habitat or Range), D (Inadequacy of existing regulatory mechanisms), and E (Other natural or man-made factors affecting its continued existence). This downlisting criterion has not been met with just 4 extant populations of PPM known to date. Recovery tasks identified to help attain this criterion include: securing extant populations; refining survey methods and surveying for unknown populations; conducting research on the life history, ecology and population biology of PPM; identifying prospective habitat and population sites; and identifying and implementing measures to create additional populations.

The Dana Point Headlands population is the only PPM population that occurs on privately owned land. A portion of the habitat originally identified as suitable for PPM at this location, including the area of documented PPM habitat occupancy, has been permanently conserved within an 11.3-ha (27.9 ac) conservation easement established in association with approval of the Dana Point Headlands Development and Conservation Plan. The conservation easement area, known as the Dana Point Preserve, is being managed by the Center for Natural Lands Management, which acquired the Preserve in 2005 and has a non-wasting endowment to provide for adaptive management of its natural resources. Coincident with CNLM's management of the Dana Point Preserve there has been a substantial increase in the size of the Dana Point PPM population. The remaining portion of the 18.3-ha (45.2 ac) area originally identified as suitable for PPM at this location (Brylski 1993, p. 8) is divided between the development area and areas dedicated to the City of Dana Point as open space. The Dana Point Preserve is subject to edge effects from adjoining development and a hiking trail that was opened to the public in December of 2009.

The San Mateo North population is located on Marine Corps Base Camp Pendleton but is on land that is leased by the California Department of Parks and Recreation and included as part of San Onofre State Beach. Though this site is not permanently secure from a change in land use, inclusion of San Mateo North in a State Park means it is reasonably secure from development and military training impacts.

Inclusion of San Mateo North within San Onofre State Beach provides for some habitat management by State Parks. Fencing has been erected to confine public access to a

single trail that traverses PPM habitat. Park rangers occasionally patrol the area, and, depending on funding availability, State Parks occasionally removes nonnative invasive weeds (e.g. veldt grass, *Erharta* sp.) from San Mateo North. Despite habitat management efforts, heavy use of this area by the adjoining residential community, and unauthorized trail creation and habitat disturbances are degrading habitat quality for PPM at San Mateo North.

Both the San Mateo South and Santa Margarita populations are located in active military training areas within Camp Pendleton and, as such, are not fully protected or permanently conserved. These areas are managed by the U. S. Marine Corps who work cooperatively with us to conserve PPM and have accommodated research on their land to help promote recovery of the subspecies. The Marine Corps has consulted with us to address impacts from the construction and use of the Crucible Challenge Course within the area occupied by PPM north of the Santa Margarita River (Service 1996c, pp. 1-21). Through this consultation the Marine Corps has committed to implement a monitoring and adaptive management plan to assess the net effect of the Crucible Course on PPM, with the goal of long term maintenance of the PPM population in the Oscar One and Edson Range areas of the Base. The Marine Corps has also proactively adopted training regulations and internal procedures (MCB Camp Pendleton 2007, pp. N-1-N-20) to avoid and minimize the impact of training and infrastructure maintenance and development activities on PPM. Currently, we are consulting with the Marine Corps on proposed repairs and improvements to 26 kilometers (km) (16 miles (mi)) of the existing dirt road network within the Oscar One and Edson Range training areas (NAVFAC 2008, pp. ES-1-VIII-4+Appendices). This project is anticipated to result in the permanent loss of roadside PPM habitat which may be offset by habitat restoration and enhancement efforts performed elsewhere within the Oscar One and Edson Range training areas. We are also engaged in a programmatic consultation to address all of the Marine Corps activities within upland habitats on Camp Pendleton.

The Marine Corps expanded their training activities in the Oscar One training area that was not addressed in the context of the Crucible Challenge Course biological opinion (USMC 2007 in litt.). Observed impacts from this expansion within undeveloped areas include removal or reduction of vegetation, soil compaction, addition of new structures, and increased foot and off-road vehicle traffic over a large portion of the Lower Mesa historically documented to be occupied by PPM within Oscar One. These impacts have degraded habitat quality for PPM within the Lower Mesa portion of the Oscar One training area. We are currently working with the Marine Corps to address increased training impacts not addressed by the Crucible Course consultation (Service 2007b).

Since the time of listing there have been at least 82 targeted surveys for PPM within its historical range (2009 CFWO Survey Report Data Base). The Service and California Department of Fish and Game have implemented several surveys in the vicinity of historical collection locales, but many of these surveys were prompted by the listing of PPM. Listing of PPM has encouraged jurisdictions and lead agencies to require surveys for PPM within potentially suitable habitat as part of the development review process. Suitable habitat has been defined to include areas with sandy soils within 4.8-kilometers

(3-miles) of the coast that are vegetated with coastal sage scrub, open grassland or other vegetation with potential to support PPM. Presence/absence surveys have typically employed 5-consecutive nights of trapping performed between April 15 and August 30, using trap placements and densities judged by the surveyor to provide adequate coverage of the survey area. Despite the number of surveys that have been performed, no new populations have been discovered since 1995.

Population monitoring efforts at Camp Pendleton have recently suggested that PPM survey methods should be refined for more reliable detection of PPM (Service 2008a, pp. 80-81). Population monitoring has revealed that individual PPM have variable and often low nightly detection probabilities (e.g. 20 %). This suggests multiple nights of trapping (e.g. 6 or more) may be needed for even a moderate likelihood (e.g. 74 %) to detect individuals within the survey area (Service 2008a, pp. 65-71). PPM activity patterns also are complex, with different patterns of surface activity exhibited by different aged cohorts within the population. At the population level, PPM usually emerge from dormancy by April, but the onset of dormancy varies annually, likely in response to resource availability and/or environmental conditions. When resources are abundant, PPM may remain active until late September, but PPM may become dormant by July or August during poor environmental or resource conditions. Population monitoring also reveals that individual PPM often range over a relatively small area (0.03 hectare (0.07 acre) over a typical 5 night survey interval (Service 2008a, pp. 76-79). Finally, PPM have been observed to undergo dramatic population fluctuations and populations frequently appear to persist at low densities. These findings suggest that presence/absence surveys for PPM are most reliable when they are performed between mid-April and June and employ high trap densities (e.g. 53 traps per acre) over at least five successive nights of trapping (Service 2008a, pp. 80-81). Ideally, more than one survey should be employed at a given location to improve confidence in negative survey results.

Research on the ecology and population biology of PPM has included study of the habitat affinities of PPM, estimation of demographic parameters governing population dynamics and detailed behavioral observations. Because the ability of PPM to construct burrows is an essential component of their life history, specific attention has focused on the importance of soils to habitat suitability for PPM (Germano 1997, pp. 24-28; Bornyasz 2003, unpaginated; Winchell 1999, Wildlife Society Paper Presentation Abstract). These studies suggest PPM is primarily restricted to areas with sandy loam or loamy sand soils, but the persistence of PPM in the Edson Range portion of Camp Pendleton where there are clay loam soils has lent some uncertainty to the range of soil conditions capable of supporting PPM.

Population monitoring implemented at Camp Pendleton between 2003 and 2006 was designed to permit estimation of demographic parameters (abundance, survivorship, recruitment) underlying observed population dynamics (Service 2008a, pp. i-94+Appendices). Estimates of these parameters and their associated variability can be, but have not yet been used for modeling population viability.

Detailed behavioral observations have been conducted to support development of a translocation protocol that can be employed to establish additional PPM populations (Shier 2007, pp. 1-13; Shier 2008a, pp. 1-58). Investigators have confirmed that, like other heteromyids, PPM dust bathe, which, despite their solitary life history, likely is an important means of communicating with con-specifics through the spreading of scent (Shier 2008a, pp. 31-37). Shier and Swaisgood (2006, pp. 1-21) have developed an experimental translocation protocol that proposes to test one or more hypotheses that may govern translocation success including: 1) whether cues indicating conspecific presence encourage settlement at the release site; 2) whether founder group familiarity influences post release settlement and survival; and, 3) whether habitat similarity between donor and release sites improves performance of translocated individuals.

To identify prospective habitat for PPM, Spencer et al. (2001, pp. 1-36 + Appendices) formulated a geographic information system (GIS) habitat evaluation model using available soil and vegetation mapping for Orange and San Diego Counties. They also performed detailed field reconnaissance at seven sites identified by the GIS model as having potential to support PPM. Comparison of the soil and vegetation conditions at known extant sites for PPM with site conditions at the identified sites suggests the GIS habitat evaluation model performs reasonably well at identifying prospective PPM habitat, but quantitative field analyses and habitat management actions may be necessary prior to attempting a translocation (Spencer et al. 2001, p. 13). Sites south of Los Angeles County that were identified as having potential to support translocated PPM include: Aliso and Wood Canyon Wilderness Park in Orange County; Wire Mountain on Camp Pendleton; the Manchester Conservation Area in Encinitas; Torrey Pines State Reserve in La Jolla; Point Loma Ecological Reserve; and the Tijuana River Valley (Spencer et al. 2001, pp. 7-14). Areas adjoining the extant populations at San Mateo North and South also appear suitable for supporting natural population expansions, particularly to the south and east of the San Mateo South population.

To move forward with establishment of additional PPM populations via translocation, Shier and Swaisgood (2006, p. 13) propose to refine the translocation protocol by testing translocation hypotheses within suitable but presently unoccupied habitat adjoining one of the extant PPM populations. The Marine Corps has consented to a pilot translocation experiment within the Oscar One training area on Camp Pendleton. However, during several years of surveys, Shier has been unable to locate a PPM source population that is robust enough to support the removal of the number of individuals (e.g. 40-80) needed for a meaningful translocation experiment. Although the Santa Margarita population is the largest and best candidate for supporting PPM translocations, recent dynamics within this population suggest that captive propagation may be needed to provide a reliable source of PPM to support translocation efforts. Shier and Swaisgood (2008, unpaginated) have recently proposed to captively propagate PPM in order to support translocation research and attainment of recovery goals.

In conclusion, there are currently four known extant PPM populations, which falls short of the downlisting criterion of having 10 stable and independently viable populations of the subspecies. Habitat supporting just one of these populations has been formerly

conserved in perpetuity via a conservation easement, a second location for the species is effectively conserved through inclusion in a State Park, and habitat supporting the remaining two populations is vulnerable to ongoing military training activities within Camp Pendleton. Though progress has been made to refine survey methods (Dodd and Montgomery 1998, pp. i-21+Appendices; Service 2008a, pp. i-94 +Appendices), multiple targeted surveys have failed to detect any additional PPM populations since 1995. Therefore, attainment of this recovery criterion is likely to rely on the establishment of additional populations by means of translocation. Habitat modeling and site reconnaissance efforts have identified a number of prospective receiver sites for subspecies translocation (Spencer et al. 2001, pp. 7-14) and Shier and Swaisgood (2006, pp. 1-21 ) are prepared to study behavioral factors that may facilitate translocation success. However, progress to establish additional populations via translocation has been stalled by the inability to find a source population that is robust enough to support removal of the number of individuals that are likely necessary to support a translocation effort. Increasingly it appears that captive propagation will be necessary to provide a reliable source of individuals that can be used for the establishment of additional PPM populations.

*Downlisting Criterion 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.*

Downlisting criterion 2 addresses listing factors A (Destruction, Modification or Curtailment of Habitat or Range), D (Inadequacy of Existing Regulatory mechanisms) and E (Other Natural or Manmade Factors). This downlisting criterion has not been met with PPM estimated to occupy less than one half of the area targeted for downlisting.

The level of protection that has been achieved for the four extant PPM populations is discussed under Recovery Criterion 1. Changes in animal densities and the resources on which they rely (*e.g.*, cover, seed resources) can influence the spatial distribution of animals and suggests that the area of occupancy itself should be treated as a dynamic rather than a static variable. Nevertheless, based on minimum convex polygons (MCP) that circumscribe all historical capture locations at each of these locations, the cumulative area of PPM “occupancy” is estimated to cover 793 hectares (1959 acres). However, this is likely to be an overestimate since it is based on the compilation of capture locations over multiple years and it includes developed areas and unsuitable habitat within MCP boundaries.

Recent surveys have failed to detect any PPM at San Mateo North (Brehme and Fisher 2009, p. 19) and a large portion of the Santa Margarita population has experienced a substantial decline (the Lower Mesa portion of Oscar One) (Spencer 2007, pp. B-50-B-52; Shier 2008a, p. 12; Shier 2008b, pp. 15-20). The MCP for the Santa Margarita population, which covers the largest area of any of the extant PPM populations (741-ha/1831-ac), also includes roads, military training obstacles and is distributed amongst a mosaic of suitable and unsuitable habitat areas. Overall, it is not clear if the apparent decline in PPM occupancy suggested by recent surveys is a temporary phenomenon

associated with normal population fluctuations, or is representative of a lasting change in habitat conditions that has led to a decline in habitat occupancy.

Because recovery criterion No. 1 addresses the number of sites supporting PPM that should be protected, and recovery criterion No. 2 addresses the amount of habitat that should be protected, these criteria can be achieved through implementation of many of the same recovery tasks. One task that should contribute to attainment of recovery criterion no. 2 is habitat enhancement performed near or adjacent to PPM populations to expand the distribution and increase population numbers of PPM.

Efforts to expand available habitat for PPM have been implemented at the Dana Point Headlands and at San Mateo North, where dense cover by mature coastal sage scrub may be lowering habitat suitability at these locations (Germano 1997, p. 28; Loda et al. 1999, p. 8; Spencer et al. 2000, pp. 12-15; Montgomery 2005a, pp. 7-8). An initial effort to thin vegetation at the Dana Point Headlands was performed in 2000 with little appreciable impact on PPM distribution at that location (Dodd and Montgomery 2001, pp. i-26). More recently, an increase in the distribution of PPM at Dana Point has been documented (Brylski et al. 2009, pp. i-32; Brylski et al. 2010, pp. i-33) which is likely partially due to nonnative weed removal, the abandonment of Marguerite Avenue, and restoration and enhancement efforts that have been implemented within the roadbed and elsewhere within the Dana Point Preserve since 2005.

To enhance habitat and expand the area of PPM distribution at San Mateo North, a prescribed burn was implemented in January of 2001 by the Marine Corps and State Parks within a 1.4 ha (3.4 ac) area adjoining habitat documented to be occupied by PPM (Service 2000, pp. 1-21). However, subsequent trapping efforts have failed to document use of the burned area by PPM (Montgomery 2005a, p. 25; Brehme and Fisher 2009, p. 19). Recently, the Service funded State Parks to make another attempt to enhance habitat for PPM at San Mateo North (Service 2010, pp. 1-34). Under the Preventing Extinction/Showing Success Grant program, State Parks was funded to perform 6-8 hectares (15-20 acres) of vegetation thinning at San Mateo North during the winter and spring of 2010. This effort is ongoing and is mostly being performed within the historical boundaries of this population, but may extend up to 2.8 hectares (7 acres) outside historical population boundaries.

In conclusion, achieving 2,000 hectares of occupied PPM habitat that are secure and fully protected from threats will rely on safeguarding existing PPM populations, locating and establishing additional PPM populations, and expanding the distribution of extant populations through habitat enhancement efforts. Because experimental habitat manipulations designed to benefit PPM have so far met with limited success, additional study is needed to identify measures that improve habitat for PPM. If PPM have not become extirpated at San Mateo North, habitat manipulation being performed at that location in 2010 should improve our understanding of the methods that are suitable for enhancing habitat quality for PPM.

Downlisting Criterion 3: *All pacific pocket mouse populations are managed through a program to maintain genetic diversity for future generations.*

Downlisting Criterion 3 addresses listing factor E (Other Natural or Manmade Factors Affecting its Continued Existence). Since there has been limited investigation of PPM genetics and a habitat management plan has only been developed for one of the four extant PPM populations (Dana Point), there has not yet been comprehensive management of PPM genetic diversity. Management of genetic diversity at Dana Point currently relies upon maintaining the largest PPM population possible at this locale to prevent the negative consequences of inbreeding and loss of genetic diversity through drift.

The best information about PPM genetics was gathered by Swei et al (2003, pp. 501-514) during a phylogeographic investigation of four southern California subspecies of *Perognathus longimembris*, including PPM. Although they had a limited number of genetic samples from each of the extant PPM populations, estimated gene flow between Dana Point and the Camp Pendleton populations suggests that Dana Point has been relatively isolated from Camp Pendleton for some time (Swei et al. 2003, p. 510). A similar pattern was also observed among genetic samples of historical populations taken from museum specimens, indicating a pattern of relative isolation among PPM populations already existed 70 years ago. With such low levels of estimated gene flow among populations it appears that local populations have remained sufficiently large to prevent the loss of genetic variation via genetic drift. However, if gene flow estimates are correct and PPM populations are as small as has been suggested by recent trapping studies, loss of genetic variability, particularly from the Dana Point and San Mateo North populations is predicted. To address recovery criterion No. 3 an additional genetic study is needed to characterize existing genetic variability within and among populations and to identify suitable methods for maintaining genetic diversity within current and future PPM populations.

Downlisting Criterion 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.*

Downlisting Criterion 4 addresses listing factors: A) Present or threatened destruction, modification, or curtailment of its habitat or range; C) Disease or predation; D) Inadequacy of existing regulatory mechanisms; and E) Other natural or manmade factors affecting its continued existence. This downlisting criterion has not been met since a specific management plan to ameliorate threats to PPM has only been adopted for one of the four known PPM populations.

Recovery tasks identified to help attain this downlisting criterion include identifying and protecting all extant populations and essential habitat, and developing habitat and species management plans. The level of protection afforded the four known PPM populations is discussed under Criterion 1 above. The Service has not yet formally identified physical or biological features that are essential to conservation of PPM, nor has the Service

formally designated geographical areas (i.e. critical habitat) that are essential to conservation of PPM. Thus, one cannot assess the extent to which management of essential habitat has been achieved.

In association with the Headlands Development and Conservation Plan, a *Habitat Management and Monitoring Plan for Dana Point Headlands Biological Open Space* (HMMP) (URS and CNLM 2005, pp. i-54 + Figures) was adopted in April of 2005. The goal of the management plan is to ensure long-term maintenance of ecologically sustainable conservation areas (URS and CNLM 2005, p. 21). Measures to achieve this goal include enhancing and restoring degraded and disturbed habitat, minimizing edge effects through litter removal, pest species control, fence repairs, education and public outreach. The HMMP identifies the Service as the party responsible for monitoring the on-site PPM population, but endowment funding has been provided to the habitat manager, CNLM, to monitor PPM. The CNLM and the Service have jointly developed a monitoring strategy for PPM, and in 2008 and 2009 CNLM performed PPM monitoring at this site in close coordination with the Service (Brylski et al. 2009, pp. i-32; Brylski et al. 2010, pp. i-33). CNLM has overseen nonnative plant species removal and habitat enhancement efforts, and has also established a motion-activated camera trapping program to monitor potential predators of PPM within the preserve. In 2009, a feral cat detected several times within the preserve was trapped and removed from the area. Given the scenic beauty and popularity of the Dana Point Preserve, the intensity of site management likely will need to increase in the future to ameliorate impacts from increased human presence that has resulted from the opening of a public access trail within the Preserve in December of 2009.

Although the San Mateo North PPM population falls within Camp Pendleton, management of this site is primarily implemented by California State Parks, since it is on land leased by the State and included as part of San Onofre State Beach. The General Plan governing management of San Onofre State Beach was adopted in 1984, prior to discovery of PPM at this location. State Parks occasionally patrols the area occupied by PPM, has erected fencing to constrain public access to a single trail, and has partnered with the U. S. Marine Corps and the Service to perform habitat enhancement for PPM (Service 2000, pp. 1-21; Service 2010, pp. 1-34). However, there is currently no comprehensive management strategy for San Mateo North directed towards minimizing current and potential threats to PPM.

In association with the biological opinion addressing operation of the Crucible Challenge Course, the Marine Corps has committed to develop an adaptive management plan to maintain the PPM population in the Oscar One and Edson Range training areas over the long term (Service 1996, p. 5). While progress has been made to develop the monitoring component of that plan (Service 2008a, pp. i-94; Brehme et al. 2009, pp. i-21 + Appendices), adaptive management measures have yet to be identified or implemented. Recently, the Marine Corps has indicated that it intends to develop a management plan(s) for the Camp Pendleton PPM populations in association with its current consultation with the Service regarding on-going and proposed activities within upland habitats Basewide (i.e. the "Uplands Consultation") (MCB Camp Pendleton 2007, p. F-42).

In conclusion, a formal habitat management and monitoring plan that is focused on minimizing current and potential threats to PPM has only been adopted for the Dana Point Headlands PPM population. The San Mateo North PPM population benefits from some habitat management by California State Parks but there is no comprehensive strategy to manage threats specific to PPM at this location. The Marine Corps has made a commitment to develop an adaptive management plan for the Santa Margarita PPM population (Service 1996c, p. 5) and has stated that as part of the Uplands Consultation they intend to develop and adopt a management plan for all Camp Pendleton PPM populations (MCB Camp Pendleton 2007, p. F-42).

#### **IV. SYNTHESIS**

The status of the Pacific pocket mouse (*Perognathus longimembris pacificus*, “PPM”) has improved with the discovery of three additional populations and permanent protection of habitat supporting the one known population at the time of listing. However, many of the principle threats to the subspecies identified at the time of listing remain, including: habitat destruction and fragmentation from development; habitat degradation from human disturbance, high fire frequencies and nonnative plant invasions; and small population size. Loss of bare ground and openings within the canopy of maturing sage scrub may also be reducing habitat quality for PPM at some locations. Despite a multitude of survey efforts, no new populations have been discovered since 1995. The three populations found since listing were all discovered within the boundaries of Marine Corps Base Camp Pendleton. The northernmost of the Camp Pendleton populations is on land that is reasonably secure from development and military training activities, since it is on land leased by the State and included within San Onofre State Beach. This area is subject to frequent disturbance from park users and recent surveys have failed to detect any PPM within this area. The remaining two Camp Pendleton populations are located within active military training areas and are not fully protected or permanently conserved. Population monitoring and survey efforts suggest that three of the extant populations are vulnerable to small population size alone, since each of these populations appear to be very small (e.g. less than 100 overwintering individuals) and susceptible to a range of environmental, demographic and genetic stochastic factors that threaten small populations. The fourth PPM population has been documented to undergo dramatic population fluctuations and a portion of this population recently underwent a dramatic decline in abundance that coincided with an expansion in military training activities within the Oscar One Training area. The PPM remains vulnerable to extinction throughout its range. We therefore recommend that the status of PPM, as endangered, remain unchanged at this time.

## V. RESULTS

### Recommended Listing Action:

- Downlist to Threatened
- Uplist to Endangered
- Delist (indicate reason for delisting according to 50 CFR 424.11):
  - Extinction*
  - Recovery*
  - Original data for classification in error*
- No Change

### New Recovery Priority Number and Brief Rationale: 6C

At this time, we recommend a change in the recovery priority number for PPM from 3C to 6C. The degree of threat remains high due to continued impacts to the habitat, small population size, and nonnatives. However, the recovery potential for PPM is considered low, because threats are difficult to alleviate and methods for intensive management of the taxon have not been well established. Recovery potential may be increased in the future with increased knowledge of captive propagation and translocations. The “C” indicates conflict with construction or other development projects or other forms of economic activity.

## VI. RECOMMENDATIONS FOR ACTIONS OVER THE NEXT 5 YEARS

1. Work with the U.S. Marine Corps to develop and implement management plans to support extant populations at San Mateo North, San Mateo South and Santa Margarita.
2. Work with the San Diego Zoological Society Institute for Conservation Research to establish a captive bred population of PPM that can be used to support translocation research and establishment of additional PPM populations.
3. Work with the U.S. Marine Corps to perform translocation experiments within the vicinity of the Santa Margarita PPM population.
4. Assess the status of the San Mateo North PPM population and translocate PPM to that location following habitat enhancement efforts to augment or re-establish a PPM population in this vicinity.
5. Contact and work with landowners at identified receiver sites to obtain permission and perform environmental reviews necessary to support translocations to those sites.
6. Work with the Marine Corps to re-establish functional connectivity between the San Mateo North and San Mateo South PPM populations.

## VII. REFERENCES CITED

- Allred, D.M. and D.E. Beck. 1963. Range of movement and dispersal of some rodents at the Nevada atomic test site. *J. Mammal.* 44(2):190-200.
- Bailey, V. 1939. The solitary lives of two little pocket mice. *Journal of Mammalogy* 20:325-328.
- Bartholomew, G. and T. Cade. 1957. Temperature regulation, hibernation, and aestivation in the little pocket mouse, *Perognathus longimembris*. *Journal of Mammalogy* 38:60-72.
- Beatley, J.C. 1969. Dependence of desert rodents on winter annuals and precipitation. *Ecology* 50(4):721-724.
- Boggs, J.R. 1996. Report on surveys for Pacific pocket mouse in Edson and Oscar One Ranges. Memorandum prepared by the Natural Resource Office, Southwest Division for the Wildlife Management Branch, Environmental Security, MCB Camp Pendleton. 5 pp.+ map.
- Bolger, D.T., A.C. Alberts, R.M. Sauvajot, P. Potenza, C. McCalvin, D. Tran, S. Mazzoni, and M.E. Soulé. 1997a. Response of rodents to habitat fragmentation in coastal southern California. *Ecological Applications* 7(2):552-563.
- Bonterra Consulting (Bonterra). 2007. SOCTIIP - Revised Appendix C and D. Unpublished report dated August 28, 2007, prepared for the USFWS Carlsbad Fish and Wildlife Office in support of a biological opinion regarding the South Orange County Infrastructure Improvement Project. On file, Carlsbad, California.
- Bornyasz, M. 2003. Pacific pocket mouse translocation receiver site soil habitat study. Incomplete draft report prepared for California Department of Fish and Game. May 15, 2003.
- Bowers, M.A. 1986. Geographic comparison of microhabitats used by three heteromyids in response to rarefaction. *Journal of Mammalogy* 67(1):46-52.
- Brehme, C.S. 2009a. Re: dog detection of PPM at San Mateo North? Electronic mail communication dated August 2, 2009, addressed to Mark Pavelka of the USFWS Carlsbad Fish and Wildlife Office. On file, Carlsbad, California.
- Brehme, C.S. 2009b. Dog scent detection of PPM at San Mateo North. Record of phone conversation with William B. Miller of the USFWS Carlsbad Fish and Wildlife Office. On file, Carlsbad, California.

- Brehme, C.S. 2009c. PPM captured in pitfall array. Electronic mail communication dated June 23, 2009, addressed to Sandy Marquez of the USFWS Carlsbad Fish and Wildlife Office. On file, Carlsbad, California.
- Brehme, C.S. 2010. MCBCP PPM Studies Update. Electronic mail communication dated February 2, 2010 to Ken Burnham of Colorado State and others. On file. USFWS Carlsbad Fish and Wildlife Office, Carlsbad, California.
- Brehme, C.S. and R.N. Fisher. 2009. 2008 Survey Results for the Pacific Pocket Mouse: North and South San Mateo, Marine Corps Base, Camp Pendleton; with additional analyses to inform long-term monitoring design. Prepared for AC/S Environmental Security, Marine Corps Base Camp Pendleton. 40pp.
- Brehme, C.S. and R.N. Fisher in collaboration with Burnham, K., Meserve, P., Spencer, W., Miller, W., Pavelka, M., and D. Deutschman. 2009. Pacific Pocket Mouse Monitoring Plan for Marine Corps Base Camp Pendleton: Short Term Studies and Long Term Goals. 2009. Prepared for Wildlife Management Branch, AC/S Environmental Security, Marine Corps Base Camp Pendleton. 88pp.
- Brinkerhoff, R.J., N.M. Haddad, and J.L. Orrock. 2005. Corridors and olfactory predator cues affect small mammal behavior. *Journal of Mammalogy* 86:662-669.
- Brown, J.H. and B.A. Harney. 1993. Population community ecology of heteromyid rodents in temperate habitats. *In*: H. Genoways and J. Brown (eds.), *Biology of the Heteromyidae*. Special Publication No. 10. Pp. 618-651. The American Society of Mammalogists.
- Brown, J.S., B.P. Kotler, R.J. Smith, and W.O. Wirtz. 1988. The effects of owl predation on the foraging behavior of heteromyid rodents. *Oecologia* 76:408-415.
- Brown, J., and G. Lieberman. 1973. Resource utilization and coexistence of seed-eating desert rodents in sand dune habitats. *Ecology* 54(4):788-797.
- Brylski, P. 1993. A focused survey for the Pacific pocket mouse (*Perognathus longimembris pacificus*) on the Dana Point Headlands, Orange County, California. Prepared for EDAW, Inc. by the Planning Center, Newport Beach, California. August 1993. 10 pp.
- Brylski, P., W.B. Miller, S. Dodd, and S. Montgomery. 2009. Pilot Monitoring Project for the Pacific Pocket Mouse, 2008, CNLM Dana Point Preserve, Orange County, California. Unpublished Report. Prepared for the Center of Natural Lands Management, Capistrano Beach, California. 35pp.
- Brylski, P., W.B. Miller, S. Dodd, and S. Montgomery. 2010. Draft Addendum to the Pilot Monitoring Project for the Pacific Pocket Mouse, 2009, CNLM Dana Point Preserve, Orange County, California. Unpublished Report. Prepared for the Center of Natural Lands Management, Capistrano Beach, California. 36pp.

- Burt W. H. and R. P. Grossenheider. 1980. A field guide to the mammals North America north of Mexico. Houghton Mifflin Company, New York.
- Cayan, D., A.L. Luers, M. Hanemann, G. Franco, and B. Croes. 2006. Scenarios of climate change in California: an overview. Unpublished white paper report from the California Climate Change Center. CEC-500-2005-186-SF, February 2006. v + 47 pp.
- Cayan, D., M. Tyree, M. Dettinger, H. Hidalgo, T. Das, E. Maurer, P. Bromirski, N. Graham, R. Flick. 2009. Climate change scenarios and sea level rise estimates for the California 2008 climate change scenarios assessment. California Climate Change Center, Sacramento, California.
- Chew, R. M. and B. B. Butterworth. 1964. Ecology of rodents in Indian Cove (Mojave Desert), Joshua Tree National Monument, California. *Journal of Mammalogy* 45(2):203-225.
- Chew, R.M., R.G. Lindberg, and P.Hayden. 1967. Temperature regulation in the little pocket mouse, *Perognathus longimembris*. *Comp. Biochem. Physiol.* 21:487-505.
- Church, R. 1996. Unpublished memorandum from the Department of the Navy to the USFWS regarding permit reporting of trapping efforts for the Pacific pocket mouse. On file, U. S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office, Carlsbad, California. 1p + map.
- Clarke, J.A. 1983. Moonlight's influence on predator/prey interactions between short-eared owls (*Asio flammeus*) and deermice (*Peromyscus maniculatus*). *Behav. Ecol. Sociobiol.* 13:205-209.
- Conley, W, J.D. Nichols, and A.R. Tipton. 1977. Reproductive strategies in desert rodents. Pp 193-215 in *Transaction of the Symposium on the Biological Resources of the Chihuahuan Desert Region United States and Mexico*, Sul Ross State University, Alpine Texas, 17-18 October 1974 (R. H. Wauer and D. H. Riskind, eds.). U. S. Department of the Interior.
- Cramer, K. and J. Chapman. 1990. Reproduction of three species of pocket mice (*Perognathus*) in the Bonneville Basin, Utah. *Great Basin Naturalist* 50(4):361-365.
- Crooks, D. R. and M. E. Soule. 1999. Mesopredator release and avifaunal extinctions in a fragmented system. *Nature* 400:563-566.
- D'Antonio, C.M. and P.M. Vitousek. 1992. Biological invasions by exotic grasses, the grass/fire cycle, and global change. *Annual Review of Ecology and Systematics* 23:63-87.
- DeBano, L.F., N.G. Neary, and P.F. Ffolliott. 1998. Fire's Effect on Ecosystems. Chapter 5: Physical Soil System. New York, New York: John Wiley and Sons, Inc. ISBN: 0471163562.

- Dice, L.R. 1945. Minimum intensities of illumination under which owls can find dead prey by sight. *American Naturalist* 79:385-416.
- Dodd, S.C. 2000. Trap results sheet for a trapping survey at San Mateo North PPM population site in July 2000. *In* Results of monitoring surveys for the federally endangered Pacific pocket mouse, other rodents, and vegetation at the management ignited fire location, at the San Mateo North Pacific pocket mouse population site, Marine Corps Base, Camp Pendleton, California. Montgomery, S. J. Unpublished report prepared by S. J. Montgomery for the Marine Corps Base Camp Pendleton, Wildlife Management Branch, Environmental Security under contract N 68711-00-LT-00036. 2005. 42 pp.+ tables, figures, and appendices.
- Dodd, S., P. Brylski, D. Laabs, S. Montgomery, and W. Spencer. 1998. Final report 1997 Pacific Pocket Mouse (*Perognathus longimembris pacificus*) surveys on the Dana Point Headlands, Orange County, California. Unpublished report prepared for the U. S. Fish and Wildlife Service, California Department of Fish and Game, and The Nature Reserve of Orange County. 22 pp. + Appendices. On file, U. S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office, Carlsbad, California.
- Dodd, S., D. Laabs, and J. Greene. 1999. Final report 1998 Pacific pocket mouse (*Perognathus longimembris pacificus*) surveys on the Dana Point Headlands, Orange County, California. Unpublished report prepared for U. S. Fish and Wildlife Service, California Department of Fish and Game, and The Nature Reserve of Orange County. March 19, 1999. 31pp. + appendices.
- Dodd, S. and S. Montgomery. 1998. Draft Report: Results of an investigation of trap spacing and duration of trapping period for monitoring studies of the Pacific pocket mouse (*Perognathus longimembris pacificus*). Unpublished draft report prepared for the California Department of Fish and Game. 21 pp. + appendices.
- Dodd, S. and S. Montgomery. 2001. Final Report Vegetation thinning experiment on the Dana Point Headlands, Orange County, California. Unpublished report prepared for the U. S. Fish and Wildlife Service and California Department of Fish and Game. 26 pp. + Appendices. On file, U. S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office, Carlsbad, California.
- Edmonds, V.W. and D.S. Fertig. 1972. Longevity of the pocket mouse, *Perognathus longimembris*. *Southwest Naturalist* 17(3):300-301.
- Egoscue, H.J., J.G. Bittmenn, and J. A. Petrovich. 1970. Some fecundity and longevity records for captive small mammals. *Journal of Mammalogy* 51(3):622-623.
- Erickson, R. 1993. Pacific pocket mouse (*Perognathus longimembris pacificus*). Draft manuscript to be included *in* Endangered Rodents of the World, to be published by the Species Survival Commission of the International Union for the Conservation of Nature and Natural Resources (IUCN).

- Field, C.B., G.C. Daily, F.W. Davis, S. Gaines, P.A. Matson, J. Melack, and N.L. Miller. 1999. Confronting climate change in California: ecological impacts on the Golden State. Union of Concerned Scientists, Cambridge, MA; Ecological Society of America, Washington, DC.
- Flake, L.D. and C.D. Jorgensen. 1969. Invasion of a "trapped-out" southern Nevada habitat by *Perognathus longimembris*. *The Great Basin Naturalist* 29(3):143-149.
- Franklin, I.R. 1980. Evolutionary change in small populations. Pp. 135-149. *In Conservation Biology: An Evolutionary-Ecological Perspective*, Soule, M.E. and B.A. Wilcox (eds.), Sinauer Associates, Inc., Sunderland, Massachusetts.
- French, A.R. 1976. Selection of high temperatures for hibernation by the pocket mouse, *Perognathus longimembris*: ecological advantages and energetic consequences. *Ecology* 57:185-191.
- French, A.R. 1977. Circannual rhythmicity and entrainment of surface activity in the hibernator, *Perognathus longimembris*. *Journal of Mammalogy* 58(1):37-43.
- French, N., B. Maza, and A. Aschwanden. 1967. Life spans of *Dipodomys* and *Perognathus* in the Mojave Desert. *Journal of Mammalogy* 48(4):537-548.
- French, N., B. Maza, H.O. Hill, A.P. Aschwanden, and H.W. Kaaz. 1974. A population study of irradiated desert rodents. *Ecological Monographs* 44:45-72.
- Gelbard, J.L. and J. Belnap. 2003. Roads as conduits for exotic plant invasions in a semiarid landscape. *Conservation Biology* 17:420-432.
- Germano, D. J. 1997. Distribution and habitat affinities of the Pacific pocket mouse (*Perognathus longimembris pacificus*). Draft Final report prepared for the California Department of Fish and Game, contract No. FG5129WM. January 1997. 38pp.
- Gilpin, M.E. 1987. Spatial structure and population vulnerability. *In* M. E. Soule (ed) *Viable Populations For Conservation*. Cambridge University Press, Cambridge, Great Britain.
- Grinnell, J. 1933. Review of the recent mammal fauna of California. *University of California Publications in Zoology* 40:71-234.
- Gurnell, J., and J.H.W. Gipps. 1989. Inter-trap movement and estimating rodent densities. *J. Zool. Lond.* 217:241-254.
- Hall, E. 1981. *The Mammals of North America*. Second edition. John Wiley and Sons, New York.
- Hayden, P., J.J. Gambino and R.G. Lindberg. 1966. Laboratory breeding of the little pocket mouse, *Perognathus longimembris*. *Journal of Mammalogy* 47(3): 412-423.

- Hayden, P. and R. Lindberg. 1976. Survival of laboratory-reared pocket mice, *Perognathus longimembris*. J. Mammalogy 57(2):266-272.
- Hayne, Don W. 1950. Apparent Home Range of *Microtus* in Relation to Distance between Traps. J. of Mammalogy, 31(1):26-39
- Herman, C.S., and T.J. Valone. 2000. The effect of mammalian predator scent on the foraging behavior of *Dipodomys merriami*. Oikos 91:139-145.
- Howard, W.E., R.L. Fenner, and H.E. Childs. 1959. Wildlife survival in brush burns. Journal of Range Management 12(5):230-234.
- Huey, L.M. 1939. The silky pocket mice of Southern California and northern Lower California, Mexico, with the description of a new race. Transactions of the San Diego Society of Natural History IX(11):47-54.
- Ingles, L.G. 1965. Mammals of the Pacific States: California, Oregon, Washington. Stanford University Press, Stanford, California.
- Jameson, E.W. Jr., and H.J. Peeters. 1988. California Mammals. University of California Press, Berkeley, California.
- Jones, A.L., and W.S. Longland. 1999. Effects of cattle grazing on salt desert rodent communities. American Midland Naturalist 141 (1):1-11.
- Keeley, J.E., M. Baer-Keeley, and C.J. Fotheringham. 2005. Alien plant dynamics following fire in Mediterranean-climate California shrublands. Ecological Applications 15:2109-2125.
- Kenagy, G. 1973. Daily and seasonal patterns of activity and energetics in a heteromyid rodent community. Ecology 54:1201-1219.
- Kenagy, G. and G. Bartholomew. 1985. Seasonal reproductive patterns in five coexisting California desert species. Ecological Monographs 55(4):371-397.
- Kotler, B.P. 1984. Risk of predation and the structure of desert rodent communities. Ecology 65(3) 689-701.
- Kotler, B.P. 1985. Owl predation on desert rodents which differ in morphology and behavior. Journal of Mammalogy 66(4):824-828.
- Laakkonen, J., R.N. Fisher and T.J. Case. 2001. Effect of land cover, habitat fragmentation and ant colonies on the distribution and abundance of shrews in southern California. Journal of Animal Ecology 70:776-788.

- Lewis, J.C., K.L. Sallee, and R.T. Golightly Jr. 1993. Introduced red fox in California. Nongame Bird and Mammal Section Report 93-10. State of California Resources Agency, Department of Fish and Game, Wildlife Management Division. Sacramento, California. 70pp.
- Loda, J., C. Winchell, M. Pavelka, and E. King. 1999. The role of vegetation in determining suitable habitats for the Pacific pocket mouse (*Perognathus longimembris pacificus*). Unpublished report prepared by the U. S. Fish and Wildlife Service for the Marine Corps Base Camp Pendleton, Environmental Security, October 1999. 18 pp. plus Appendices
- Longland, W.S. and M.V. Price. 1991. Direct observations of owls and heteromyid rodents: can predation risk explain microhabitat use? *Ecology* 72(6):2261-2273.
- Marine Corps Base Camp Pendleton. 2007. Marine Corps Integrated Natural Resources Management Plan. U.S. Marine Corps Base, Camp Pendleton, California. Pp i-5-18+Appendices
- Maza, B.G., N.R. French., and A. P. Aschwenden. 1973. Home range dynamics in a population of heteromyid rodents. *Journal of Mammalogy* 54(2):405-425.
- McKnight, M.L. 2005. Phylogeny of the *Perognathus longimembris* species group based on mitochondrial cytochrome-*b*: How many species? *Journal of Mammalogy* 86:826-832.
- M'Closkey, R. T. 1972. Temporal changes in populations and species diversity in a California rodent community. *Journal of Mammalogy* 53:657-676.
- Mearns, E. 1898. Descriptions of three new forms of pocket mice from the Mexican border of the United States. *Bulletin of the American Museum of Natural History* 10:299-302.
- Meehl, G.A., T.F. Stocker, W.D. Collins, P. Friedlingstein, A.T. Gaye, J.M. Gregory, A. Kitoh, R. Knutti, J.M. Murphy, A. Noda, S.C.B. Raper, I.G. Watterson, A.J. Weaver, and Z.-C. Zhao. 2007. Global climate projections. Pp. 747–843 in Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller (eds.). *Climate change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, United Kingdom, and New York, NY.
- Merriam, K.E., J.E. Keeley, and J.L. Beyers. 2006. Fuel breaks affect nonnative species abundance in California plant communities. *Ecological Applications* 16:515-527.
- Meserve, P. 1976a. Food relationships of a rodent fauna in a California coastal sage scrub community. *J. Mammalogy* 57:300-319.
- Meserve, P. 1976b. Habitat and resource utilization by rodents of a California coastal sage scrub community. *Journal of Animal Ecology* 46:647-666.

- Michael Brandman Associates and LSA Associates (MBA and LSA). 1997. Results of focused surveys for the Pacific pocket mouse Foothill Transportation Corridor-South. Unpublished report prepared for Foothill/Eastern Transportation Corridor Agency, Santa Ana, California, February 1997. 26pp. + Appendices.
- Michael Brandman Associates (MBA). 1999. Results of focused surveys for the Pacific pocket mouse Foothill Transportation Corridor-South. Unpublished report prepared for Foothill/Eastern Transportation Corridor Agency, Santa Ana, California, December 1999. 12pp. + appendix.
- Miller, W. B. 2004. August PPM trapping mortalities. Personal email communication summarizing two PPM mortalities sent by William B. Miller to Daniel Marquez on August 9, 2004 at 5:05 p.m.. On file, U. S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office, Carlsbad, California.
- Miller, W. B. 2006. PPM Mortality, April 22, 2006. Personal email communication summarizing trapping related mortality of Pacific pocket mouse sent by William B. Miller to Daniel Marquez on April 24, 2006 at 4:13 p.m.. On file, U. S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office, Carlsbad, California.
- Minnich, R.A. and R.J. Dezzani. 1998. Historical decline of coastal sage scrub in the Riverside-Perris plain, California. *Western Birds* 29:366-391.
- Montgomery, S.J. 2003. 1998-1999 Pacific pocket mouse surveys, Marine Corps Base, Camp Pendleton, California. Unpublished final report prepared for Assistant Chief of Staff, Environmental Security under contract M00681-97-C-0036. May 2003. 42 pp. + appendices.
- Montgomery, S.J. 2005a. Results of monitoring surveys for the federally endangered Pacific pocket mouse, other rodents, and vegetation at the management ignited fire location, at the San Mateo North Pacific pocket mouse population site, Marine Corps Base, Camp Pendleton, California. Unpublished report prepared by S. J. Montgomery for the Marine Corps Base Camp Pendleton, Wildlife Management Branch, Environmental Security under contract N 68711-00-LT-00036. 42 pp. + tables, figures, and appendices.
- Montgomery, S.J. 2005b. Unpublished letter report from SJM Biological Consultants to Essex Environmental regarding trapping, holding, and relocating Pacific pocket mice (*Perognathus longimembris*) at the spur road leading to San Diego Gas and Electric Tower 322253, located in the San Mateo South PPM population area. July 25, 2005. 6 pp. + figures.
- Naval Facilities Engineering Command Southwest (NAVFAC). 2008. Biological Assessment Oscar 1 Training Area Road Repair Marine Corps Base Camp Pendleton, California. United States Marine Corps Naval Facilities Engineering Command Southwest, San Diego, California. Pp. ES-1-VIII-4+Appendices.

- Natural Resources Assessment, Inc. 2003. Presence/absence trapping studies for the Pacific pocket mouse on the Foothill/Eastern Transportation Corridor South. Unpublished report prepared for PandD Consultants, San Diego, California. November 7 2003. 13pp. + appendix.
- O'Farrell, M. 1974. Seasonal activity patterns of rodents in a sagebrush community. *J. of Mammalogy* 55:809-823.
- O'Farrell, T.P., R.J. Olson, R.O. Gilbert, and J.D. Hedlund. 1975. A population of Great Basin pocket mice, *Perognathus parvus*, in the shrub-steppe of south-central Washington. *Ecological Monographs* 45:1-28.
- Ogden Environmental and Energy Services Co., Inc (Ogden). 1995. Biological resources survey report for FY MCON P-577 water distribution plan, MCB Camp Pendleton. Prepared for KEA Environmental, San Diego, September. *In Pacific Pocket Mouse survey, Phase III, Marine Corps Base Camp Pendleton. Ogden, 1997. Unpublished report prepared for the Marine Corps Base Camp Pendleton, AC/S Environmental Security under contract M00681-96-C-0021. November 1997. 45pp.*
- Ogden Environmental and Energy Services (Ogden). 1997. Pacific Pocket Mouse survey, Phase III, Marine Corps Base, Camp Pendleton. Unpublished report. Prepared for Assistant Chief of Staff, Environmental Security. November. 46pp.
- O'Leary, J.F. and W.E. Westman. 1988. Regional disturbance effects on herb succession patterns in coastal sage scrub. *Journal of Biogeography* 15:775-786.
- Patten, M.A., S.J. Myers, C. McGaugh, J.R. Easton, and R.A. Erickson. 1998. *Perognathus longimembris* (Coues 1875) Little pocket mouse. *In Hafner, D.J., E. Yensen, and G.L. Gordon Jr. (Eds.) North American Rodents. Status Survey and Conservation Action Plan. IUCN/SSC Rodent Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK. X + 171 pp.*
- Pearson, O.P. 1964. Carnivore-mouse predation: an example of its intensity and bioenergetics. *Journal of Mammalogy* 45(2):177-188.
- Pietruszka, R.D., J.A. Wiens, and C.J. Pietruszka. 1981. Leopard lizard predation on *perognathus*. *Journal of Herpetology* 15(2):249-250.
- Price, M.V. and J.H. Brown. 1983. Patterns of morphology and resource use in North American desert rodent communities. *Great Basin Naturalist Memoirs* 7:117-134.
- Price, M.V., N.M. Waser, and T.A. Bass. 1984. Effects of moonlight on microhabitat use by desert rodents. *J. of Mammalogy* 65(2):353-356.
- Price, M.V., N.M. Waser, and S. McDonald. 2000. Seed caching by heteromyid rodents from two communities: implications for coexistence. *J. of Mammalogy* 81(1):97-106.

- Reichman, O.J. and M.V. Price. 1993. Ecological aspects of heteromyid foraging. In: H. Genoways and J. Brown, eds. *Biology of the Heteromyidae*. Special Publication No. 10. The American Society of Mammalogists. Pp. 539-574.
- Rodriguez-Cabal, M.A., K.L. Stuble, M.A. Nunez and N.J. Sanders. 2009. Quantitative analysis of the effects of the exotic Argentine ant on seed-dispersal mutualisms. *Biology Letters* 5:499-502.
- Rosenzweig, M.L. 1973. Habitat selection experiments with a pair of coexisting Heteromyid rodent species. *Ecology* 54(1):111-117.
- San Diego Gas and Electric. 1995. Subregional Natural Community Conservation Plan. San Diego Gas and Electric Real Estate Operations Department, San Diego, California. 138pp.
- Shaffer, M.L. 1981. Minimum population sizes for species conservation. *Bioscience* 31(2):131-134.
- Shier, D. 2007. Behavioral ecology and translocation of the endangered Pacific little pocket mouse (*Perognathus longimembris pacificus*): Report for Phase I and Phase II for the period May 2006-December 2006. Unpublished report prepared for Conservation and Research for Endangered Species Division of Applied Animal Ecology, Zoological Society of San Diego, Escondido, California. 13 pp.
- Shier, D. 2008a. Behavioral ecology and translocation of the endangered Pacific little pocket mouse (*Perognathus longimembris pacificus*) for the period January 2007 to December 2007. Unpublished report prepared for an Interagency Agreement between U.S. Fish and Wildlife Service and CRES, Zoological Society of San Diego. Conservation and Research for Endangered Species, Division of Applied Animal Ecology, Zoological Society of San Diego, Escondido, California. 58pp.
- Shier, D. 2008b. Pacific pocket mouse surveys to assess 1) Feasibility of translocation and 2) Oscar One Training Area road repair on Marine Corps Base Camp Pendleton. Unpublished report. Prepared for Assistant Chief of Staff Environmental Security, Marine Corps Base, Camp Pendleton, San Diego, California. 23pp.
- Shier, D. and R.R. Swaisgood. 2006. Behavioral ecology and translocation of the endangered Pacific little pocket mouse, *P. longimembris pacificus*. Unpublished study proposal prepared by the San Diego Zoological Society and submitted to the Carlsbad Fish and Wildlife Office, Carlsbad, California. 21 pp.
- Shier, D. and R.R. Swaisgood. 2008. Captive breeding, anti-predator behavior and reintroduction of the Pacific pocket mouse (*Perognathus longimembris pacificus*). Unpublished proposal prepared by the San Diego Zoological Society and submitted to the Carlsbad Fish and Wildlife Office, Carlsbad, California. Unpaginated.

- Sosa, R. 2009. Record of phone conversation between Roland Sosa of Camp Pendleton Environmental Security and William B. Miller of the USFWS. On file Carlsbad Fish and Wildlife Office, Carlsbad, California.
- Spencer, W.D., C. Schaefer, S. Dodd, S.J. Montgomery. 1999. Pacific pocket mouse studies program, Phase I report: Task 1-Translocation feasibility, Task-3 Dispersal characteristics. Unpublished report prepared for Foothill/Eastern Transportation Corridor Agency and U. S. Fish and Wildlife Service. April 1999. 64pp. + Appendices.
- Spencer, W.D., C. Schaefer, S. Dodd, S.J. Montgomery, and C. Holland. 2000. Pacific pocket mouse studies program, Phase II report, Final. Unpublished report prepared for Foothill/Eastern Transportation Corridor Agency and U. S. Fish and Wildlife Service. May 2000. 44pp. + appendices.
- Spencer, W.D., C. Schaefer, S. Dodd, S.J. Montgomery, and C. Holland. 2001. Pacific pocket mouse studies program, Phase III report, Peer Review Draft. Unpublished report prepared for Foothill/Eastern Transportation Corridor Agency and U. S. Fish and Wildlife Service. February 2001. 36pp. + appendices.
- Spencer, W.D. 2007. Draft Report Pacific pocket mouse surveys in support of Biological Assessment and Environmental Assessment for Oscar roads repairs on Marine Corps Base Camp Pendleton. Unpublished report dated October 2007 prepared for Naval Facilities Engineering Command Southwest (NAVFAC), San Diego, California. 13pp.
- Stamp, N.E. and R.D. Ohmart. 1978. Resource utilization by desert rodents in the lower Sonoran Desert. *Ecology* 59(4):700-707.
- Stylinski, C.D. and E.B. Allen. 1999. Lack of native species recovery following severe exotic disturbance in southern Californian shrublands. *Journal of Applied Ecology* 36: 544-554
- Suarez, A.V., D.T. Bolger, and T.J. Case. 1998. Effects of fragmentation and invasion on native ant communities in coastal southern California. *Ecology* 79(6):2041-2056.
- Swei, A., P. Brylski, W. Spencer, S. Dodd, and J. Patton. 2003. Hierarchical genetic structure in fragmented populations of the little pocket mouse (*Perognathus longimembris*) in southern California. *Conservation Genetics* 4:501-514.
- Thompson, S.D. 1982a. Microhabitat utilization and foraging behavior of bipedal and quadrupedal heteromyid rodents. *Ecology* 63(5) 1303-1312.
- Thompson, S.D. 1982b. Structure and species composition of desert heteromyid rodent species assemblages: effects of a simple habitat manipulation. *Ecology* 63(5) 1313-1321.
- URS Corporation (URS). 2002. Dana Point Headlands Pacific pocket mouse survey, August 18-September 1, 2002. Unpublished letter from URS to USFWS regarding

- methods and results of PPM trapping at Dana Point Headlands. September 19, 2002. 4pp. + table and figures.
- URS Corporation and Center for Natural Lands Management (URS and CNLM). 2005. Habitat Management and Monitoring Plan for Dana Point Headlands Biological Open Space. URS Corporation, San Diego, California. Unpublished document dated April 18, 2005 prepared for the City of Dana Point and Headlands Reserve LLC.
- U. S. Department of the Navy, Southwest Division (USDoN). 2002. San Clemente Island Integrated Natural Resources Management Plan Draft Final, January 2002. San Diego, California. Prepared by Tierra Data Systems, Escondido, California.pp.
- U. S. Department of Transportation (USDOT). 2005. South Orange County Transportation Infrastructure Improvement Project (SOCTIP): Biological Assessment. Unpublished report prepared by U. S. Department of Transportation, Federal Highways Administration, and State of California Department of Transportation. February 28, 2005. 74pp. + appendices.
- U. S. Fish and Wildlife Service (Service). 1994a. Endangered and Threatened Wildlife and Plants: Emergency Rule to List the Pacific Pocket Mouse as Endangered. Federal Register 59:5306-5310.
- U. S. Fish and Wildlife Service (Service). 1994b. Endangered and Threatened Wildlife and Plants: Determination of Endangered Status for the Pacific Pocket Mouse. Federal Register 59:49752-49764.
- U. S. Fish and Wildlife Service (Service). 1995. Biological and conference opinions concerning the issuance of an incidental take permit for the San Diego Gas and Electric (SDGandE) Habitat Conservation Plan in portions of San Diego County, Orange County, and Riverside County , California (1-6-96-FW-07) December 18, 1995.
- U. S. Fish and Wildlife Service (Service). 1996a. Fieldwork on the Dana Point Headlands, 27 August – 6 September 1996 by USFWS and CDFG personnel. Unpublished memorandum, September 11, 1996. On file, U. S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office, Carlsbad, California. 3pp.
- U. S. Fish and Wildlife Service (Service). 1996b. Surveys and status of the Pacific pocket mouse (*Perognathus longimembris pacificus*) on Marine Corps Base Camp Pendleton, California, 1994-1995. Unpublished report prepared by the U. S. Fish and Wildlife Service for the Marine Corps Base Camp Pendleton, AC/S Environmental Security under contract M00681-94-WR-34. 42 pp. + appendices.
- U. S. Fish and Wildlife Service (Service). 1996c. Formal Section 7 consultation on the Crucible Challenge Course, Marine Corps Base Camp Pendleton, San Diego County California (1-6-96-F-35). August 14, 1996.

- U. S. Fish and Wildlife Service (Service). 1998a. Pacific Pocket Mouse (*Perognathus longimembris pacificus*) recovery plan. U. S. Fish and Wildlife Service, Portland, Oregon. 112 pp.
- U. S. Fish and Wildlife Service (Service). 1998b. Unauthorized take of federally endangered Pacific pocket mouse, Oscar One, Marine Corps Base, Camp Pendleton, California (1-6-99-TA-03). Unpublished letter from USFWS to Marine Corps Base Camp Pendleton. October 26, 1998.
- U. S. Fish and Wildlife Service (Service). 1999a. Surveys for the Pacific pocket mouse (*Perognathus longimembris pacificus*) on Marine Corps Base Camp Pendleton, California, 1996. Unpublished report prepared by the U. S. Fish and Wildlife Service for the Marine Corps Base Camp Pendleton, AC/S Environmental Security under contract M00681-95-MP-00075. 18 pp. plus addendum.
- U. S. Fish and Wildlife Service (Service). 1999b. Baseline monitoring of the Pacific pocket mouse (*Perognathus longimembris pacificus*) population in the Oscar One training Area on Marine Corps Base Camp Pendleton, California, 1996. Unpublished report prepared by the U. S. Fish and Wildlife Service for the Marine Corps Base Camp Pendleton, AC/S Environmental Security under contract M00681-95-MP-00075. 18 pp. + addendum.
- U. S. Fish and Wildlife Service (Service). 1999c. Sempra Energy unauthorized Pacific Pocket Mouse grading at San Mateo South, Camp Pendleton, San Diego County, California. Unpublished memorandum. On file, U. S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office, Carlsbad, California.
- U. S. Fish and Wildlife Service (Service). 2000. Formal Section 7 Consultation on the Implementation of a Prescribed Burn in the San Mateo Watershed at Marine Corps Base, Camp Pendleton, San Diego County, California (1-6-00-F-34). May 12, 2000.
- U. S. Fish and Wildlife Service (Service). 2002a. Summary of 2001 Dana Point Headlands Temporary Pacific Pocket Mouse Preserve trapping effort, City of Dana Point, Orange County, California. Unpublished memorandum to the Pacific Pocket Mouse recovery file, June 12, 2002. On file, U. S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office, Carlsbad, California.
- U. S. Fish and Wildlife Service (Service). 2002b. Summary of 2002 Dana Point Headlands Temporary Pacific Pocket Mouse Preserve trapping effort, City of Dana Point, Orange County, California. Unpublished memorandum to the Pacific Pocket Mouse recovery file, December 23, 2002. On file, U. S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office, Carlsbad, California.
- U. S. Fish and Wildlife Service (Service). 2002c. Monitoring of the Pacific pocket mouse (*Perognathus longimembris pacificus*) population in the Oscar One training Area on Marine Corps Base Camp Pendleton, California, 1997-98. Unpublished report prepared by the U. S. Fish and Wildlife Service for the Marine Corps Base Camp Pendleton, AC/S

Environmental Security under contract M00681-96-MP-00065. December 2002. 21 pp. + appendices.

- U. S. Fish and Wildlife Service (Service). 2004. Maintenance of SDG and E access roads on Marine Corps Base Camp Pendleton, San Diego County, California. Unpublished letter from USFWS to San Diego Gas and Electric Company, April 7, 2004.
- U. S. Fish and Wildlife Service (Service). 2005. Summary of fire history within areas occupied by Pacific pocket mouse (*Perognathus longimembris pacificus*, "PPM") at Marine Corps Base Camp Pendleton, California. Unpublished memorandum, August 31, 2005. On file, U. S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office, Carlsbad, California.
- U. S. Fish and Wildlife Service (Service). 2006. Designation of Core Areas and Potential Restoration Sites for the Coastal California Gnatcatcher, Pacific Pocket Mouse and Stephens' Kangaroo Rat on Marine Corps Base Camp Pendleton, California. Unpublished report. Prepared for Assistant Chief of Staff of Environmental Security, Marine Corps Base, Camp Pendleton, San Diego, California. 65pp.
- U. S. Fish and Wildlife Service (Service). 2007a. Memorandum to file regarding April 2007 salvage trapping for Pacific pocket mouse at the Dana Point Headlands Conservation Park, City of Dana Point, California. Report on Salvage trapping at Dana Point. 2pp.
- U. S. Fish and Wildlife Service (Service). 2007b. Letter from Jim Bartel to S.W. Norquist dated October 5, 2007, regarding Habitat disturbance at the Crucible Course within Oscar One Training Area, Marine Corps Base Camp Pendleton, San Diego County, California.
- U. S. Fish and Wildlife Service (Service). 2008a. Monitoring of the Pacific Pocket Mouse (*Perognathus longimembris pacificus*) Population in the Oscar One Training Area on Marine Corps Base Camp Pendleton: 2003-2006. Unpublished report prepared by the U. S. Fish and Wildlife Service for the Marine Corps Base Camp Pendleton, AC/S Environmental Security under contract M-33200-04-MP-00054. 94pp.
- U. S. Fish and Wildlife Service (Service). 2008b. Marine Corps Base Camp Pendleton Pacific pocket mouse monitoring July 8-13, 2002, Oscar One Training Area, Grid D. Unpublished memorandum, January 10, 2008. On file, U. S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office, Carlsbad, California.
- U. S. Fish and Wildlife Service (Service). 2008c. Biological opinion (FWS-OR/MCBCP-08B0352/08F0487) addressing the Proposed Toll Road Corridor (Alignment 7 Corridor-Far East Crossover-Modified) Initial Alternative for the South Orange County Transportation Infrastructure Improvement Project. On file, U. S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office, Carlsbad, California.
- U. S. Fish and Wildlife Service (Service). 2010. Intra-Service Section 7 Consultation (FWS-MCBCP-09B0352-09F0985) on the Funding of Habitat Enhancement for Pacific Pocket

- Mouse in San Onofre State Beach, San Diego County, California. On file, U. S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office, Carlsbad, California.
- U. S. Marine Corps (USMC). 2007. Letter from S.W. Norquist to Jim Bartel dated January 4, 2007, regarding habitat disturbance at the Crucible Course within Oscar-1 Training Area. On file, U. S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office, Carlsbad, California.
- U. S. Soil Conservation Service. 1973. Soil survey of San Diego area, California. USDA, Soil conservation Service and Forest Service. Part 1, 104 pp., Part 2, 118 pp., + maps.
- U. S. Soil Conservation Service. 1978. Soil survey of Orange County and western part of Riverside County, California. USDA, Soil conservation Service and Forest Service. 149 pp. + maps.
- Vergne, P.J. 2009. Focused Presence/Absence surveys for the Pacific pocket mouse (*Perognathus longimembris pacificus*) and Stephens' kangaroo rat (*Dipodomys stephensi*) for the Marine Corps Base Camp Pendleton basewide utility infrastructure improvements project, San Diego County California. Envira Aquaculture, Fisheries, Environmental, Ramona, California. Unpublished survey report dated September 16, 2009, submitted to the USFWS Carlsbad Fish and Wildlife Office.
- von Bloeker, J. 1931a. *Perognathus pacificus* from the type locality. Journal of Mammalogy 12:369-372.
- von Bloeker, J. 1931b. Extension of range of *Perognathus pacificus*. Journal of Mammalogy 12:431-432.
- Williams, D.F. 1986. Wildlife Management Division Administrative Report 86-1:Mammalian species of special concern in California. State of California, The Resources Agency, Department of Fish and Game, Sacramento, California. PP. i-112.
- Williams, D.F., H.H. Genoways and J.K. Braun. 1993. Taxonomy and systematic. In: H.H. Genoways and J.H. Brown, eds. Biology of the Heteromyidae. Special Publication No. 10. The American Society of Mammalogists. Pp. 38-196.
- Winchell, C.W., M. Pavelka, R. Graham, and C. Ribic. 1999. Pacific pocket mouse distribution in relation to soil type. Abstract for oral presentation at The Wildlife Society 1999 Annual Conference.

**U.S. FISH AND WILDLIFE SERVICE**  
**5-YEAR REVIEW**  
**Pacific Pocket Mouse (*Perognathus longimembris pacificus*)**

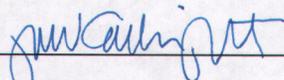
**Current Classification:** Endangered  
**Recommendation resulting from the 5-Year Review**

- Downlist to Threatened
- Uplist to Endangered
- Delist
- No change is needed

**Review Conducted By:** Carlsbad Fish and Wildlife Office

**FIELD OFFICE APPROVAL:**

Lead Field Supervisor, Fish and Wildlife Service

Approve  Date 1 April 2010  
acting DFS