OCCURRENCE AND PREVALENCE OF THREE RODENT SPECIES ON THE NAVAL PETROLEUM RESERVES: SAMPLING IMPLICATIONS

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ABSTRACT: Between September 1980 and November 1984, an extensive live-trapping program was conducted to inventory the small mammal community on the Naval Petroleum Reserves in California (NPRC). We utilized this data to determine the occurrence and prevalence of the short-nosed kangaroo rat (*Dipodomys nitratoides brevinasus*), giant kangaroo rat (*Dipodomys ingens*), and San Joaquin antelope squirrel (*Ammospermophilus nelsoni*), on 14 sites located throughout NPRC. Our results indicated that, while San Joaquin antelope squirrels occurred on all sites at fairly similar capture rates, the occurrence and prevalence of short-nosed kangaroo rats and giant kangaroo rats varied substantially among sites and over time. This suggests that the composition of rodent communities at one site may not be representative of nearby unsampled sites. Therefore, sampling of rodents at one or a few sites may be inadequate to accurately estimate many ecological parameters or to document the presence or abundance of some rodent species, particularly across large areas.

Key Words: *Ammospermophilus nelsoni, Dipodomys ingens, Dipodomys nitratoides brevinasus*, giant kangaroo rat, Naval Petroleum Reserves in California, occurrence, prevalence, San Joaquin antelope squirrel, short-nosed kangaroo rat, San Joaquin Valley

1999 TRANSACTIONS OF THE WESTERN SECTION OF THE WILDLIFE SOCIETY 35:22-28

The semi-arid grasslands of the southern San Joaquin Valley support a variety of small mammal species, many of which are either Federally or State listed or otherwise considered species of special concern. Several of these species occur on the Naval Petroleum Reserves in California (NPRC), including two federally endangered species, the giant kangaroo rat (*Dipodomys ingens*) and the Tipton kangaroo rat (*Dipodomys nitratoides nitratoides*); and one State threatened species, the San Joaquin antelope squirrel (*Ammospermophilus nelsoni*) (Otten and Cypher 1997). Four additional species are categorized as species of special concern, the short-nosed kangaroo rat (*Dipodomys nitratoides brevinasus*), Tulare grasshopper mouse (*Onychomys torridus tularensis*) and San Joaquin pocket mouse (*Perognathus inornatus*).

In an attempt to inventory the small mammal community on NPRC, an extensive live-trapping program was conducted between September 1980 and November 1984 (EG&G Energy Measurements 1988). Results of this program indicated that short-nosed kangaroo rats, Tulare grasshopper mice, and San Joaquin antelope squirrels were common and widespread on NPRC and that giant kangaroo rats and San Joaquin pocket mice, although locally common, were more patchily distributed. Tipton kangaroo rats were captured only at isolated locations near the extreme eastern boundaries of the Reserves. Preliminary summaries of live-capture data indicated that the site-specific structure of rodent communities on NPRC, and the occurrence and prevalence of many of the species varied considerably among sites (EG&G Energy Measurements 1988).

We analyzed these data to examine and document variation in species-specific occurrence and prevalence among sites and over NPRC. We selected 3 of the captured rodent species (hereafter referred to as target species) for inclusion in this analysis: short-nosed kangaroo rats, giant kangaroo rats, and San Joaquin antelope squirrels. These species were selected because 2 of them occurred on all trapping sites (short-nosed kangaroo rat and San Joaquin antelopes squirrel); occurrence and prevalence of 2 species appeared to be highly variable among sites (short-nosed kangaroo rat and giant kangaroo rat); or they were State or Federally listed species (giant kangaroo rat and San Joaquin antelope squirrel).

STUDY AREA

The Naval Petroleum Reserves in California (Fig. 1) are located at the southern end of the San Joaquin Valley approximately 40 km west/southwest of Bakersfield and are composed of well developed oil fields interspersed with areas of relatively undeveloped grassland-shrub vegetation. The NPRC study area was divided into two trapping areas: Naval Petroleum Reserve No. 1 (NPR-1) and Naval Petroleum Reserve No. 2 (NPR-2). The vegetative community has been broadly described as belonging to the Allscale Series (Sawyer and Keeler-Wolf 1995) and was composed primarily of annual

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grasses, annual forbs, and xerophytic shrubs (Heady 1977). The dominant grasses were red brome (*Bromus madritensis*) and mousetail fescue (*Vulpia myuros*), the dominant forbs were red-stemmed filaree (*Erodium cicutarium*) and fiddleneck (*Amsinkia menziesii*), and the dominant shrubs were desert saltbush (*Atriplex polycarpa*) and bladderpod (*Isomerus arborea*). The climate of the NPRC region has been generally described as Mediterranean and is characterized by hot, dry summers and mild, wet winters (Major 1977). Mean monthly temperatures range from 8.6°C (January) to 28.7°C (July) with a mean annual temperature of 18.3°C. Mean annual precipitation is 15.0 cm, 82% of which falls from October through March (National Oceanic and Atmospheric Administration, 1998).

METHODS

Rodent Trapping

Rodents were live-trapped along 14 transect lines established on the NPRC between 1980-1984 (Fig. 1). On NPR-1, rodents were captured on 4 unpaired transects during 44 monthly sessions between 1980-1984. Transects were randomly allocated throughout NPR-1 and designated 1A, 1B, 1C, and 1D. Each transect consisted of 25 trap stations spaced at 15-m intervals. Initially, one 8 cm x 9 cm x 33 cm non-folding Sherman live trap was placed at each station and covered with a rigid aluminum tent to reduce trap heating. The density of traps was occasionally and temporarily doubled (2

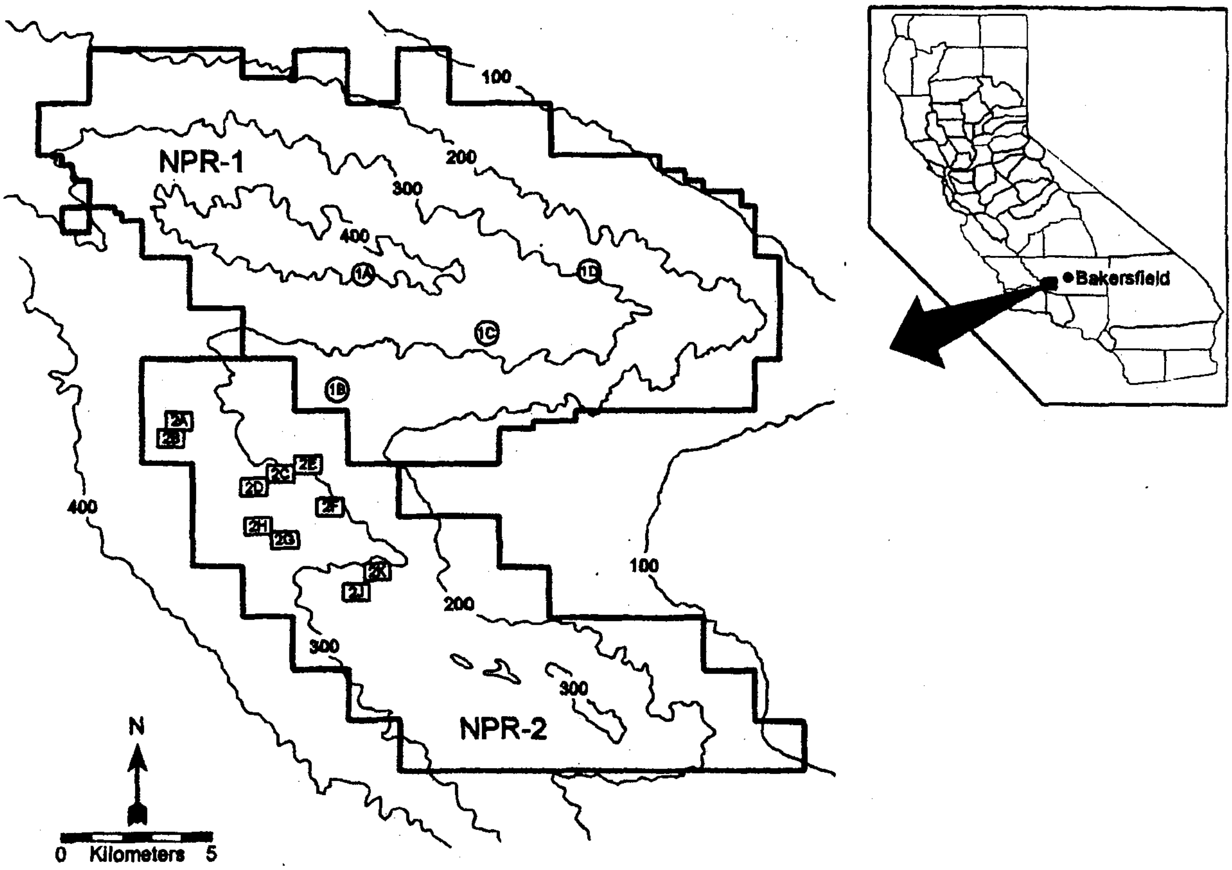

Fig. 1. Location of live-trapping sites to document the occurrence and prevalence of 3 rodent species on Naval Petroleum Reserve No. 1 (NPR-1) and Naval Petroleum Reserve No. 2 (NPR-2), California, 1980-1984. Sites on NPR-1 and NPR-2 are indicated by numbered circles and number rectangles, respectively. Approximate elevations are indicated by 100 m contour intervals.

in rodent capture rates. While the particular sessions and duration of trap density doubling varied among transects, trap densities at individual stations did not vary within transects.

On NPR-2, rodents were captured on 10 paired transects during 13 monthly sessions in 1983 and 1984. Paired transects were located in close proximity to each other (200-450 m apart) and were sited in similar vegetation/physiography. Transects were randomly allocated as pairs throughout the northern half of NPR-2 and designated 2A and 2B, 2C and 2D, 2E and 2F, 2G and 2H, and 2J and 2K. Each transect consisted of 15 trap stations spaced at 15-m intervals. Two 8 cm x 9 cm x 33 cm non-folding aluminum Sherman live-traps were placed at each station and covered with a rigid aluminum tent. The density of traps on NPR-2 transects was not increased between sessions.

All transect lines were operated for 3 consecutive nights during each trapping session. Traps were set during late afternoon, baited with a mixture of peanut butter and rolled oats, and checked the following morning for captures. Captured rodents were individually marked with numbered eartags or toeclips (depending on the species), sexed, weighed, and released at the capture location. The session-specific number of individuals captured of each species was tallied for all trapping transects.

Data Analysis

We evaluated the occurrence of target species on NPRC sites by calculating the proportion of sites on which each species was captured, and by calculating the site-specific proportion of trapping sessions during which each species was captured. A species was considered to have occurred on a site if at least one individual was captured on the site, regardless of the number of sessions during which it was captured. A species was considered to have occurred within a specific trapping session if at least one individual was captured during that session.

We evaluated the prevalence of target species on NPRC by calculating mean standardized capture rates for each species and by determining cumulative species compositions. Species-specific standardized capture rates were calculated for each trapping session as the total number of individuals captured per 100 trap-nights of effort. The arithmetic mean and associated coefficient of variation (CV) was calculated for each site and each species as a measure of average species prevalence over time. Cumulative species compositions were determined for each site across sessions as the percentage of total individuals captured, accounted for by each of the target species. Captures of non-target species were grouped and categorized as "other species". Species compositions were represented graphically as stacked bar charts and are referred to as species composition profiles.

We made non-statistical comparisons among NPR-1 sites and among NPR-2 sites to identify potential patterns in the occurrence and prevalence of target species. Statistical analyses were not performed due to the unequal trapping effort among NPR-1 transects, and the short duration of trapping on NPR-2. Thus, comparisons were limited to identifying and quantifying numerical and proportional differences in presence, mean capture rates, and species compositions among sites. Due to differences in methodology, comparisons were not made between NPR-1 sites and NPR-2 sites.

RESULTS

Approximately 36,000 trap nights of effort were expended on NPRC trapping sites (about 24,000 on NPR-1 and 12,000 on NPR-2) between 1980-1984. In addition to the 3 target species, 5 other rodent species were captured with some regularity: the deer mouse (*Peromyscus maniculatus*), western harvest mouse (*Reinthrodontomys megalotis*), Heermann's kangaroo rat (*Dipodomys heermanni*), San Joaquin pocket mouse, and Tulare grasshopper mouse. Non-target rodents constituted the majority of captures on approximately half of the sites (Fig. 2).

Short-nosed kangaroo rats were captured on all NPRC sites. However, the percentages of sessions that they were present (i.e., occurrence through trapping sessions) and mean standardized capture rates (i.e., prevalence) varied considerably among sites (Table 1, 2), even between vicinal or adjacent sites (e. g., paired sites 2A and 2B). Site-specific mean capture rates were typically between 0.5 and 4.0 individuals/100 trap-nights of effort, but were as high as 35.4. Short-nosed kangaroo rats were the most commonly captured species on 5 of the 14 sites, and their contribution to total rodent captures also varied widely among sites (Fig. 2). This pattern of occurrence and prevalence suggests that while short-nosed kangaroo rats were present at a baseline density throughout much of NPRC, distributions were noticeably clumped.

Giant kangaroo rats were captured rarely on NPR-1 sites (Table 1) and occurred more commonly and at higher prevalences on NPR-2 sites (Table 2). Overall, the species was captured on approximately half of the trapping sites (8 of 14). Percentages of sessions present and mean standardized capture rates exhibited considerable variation among all sites and between paired sites. The amount of variability among sites, however, was not as marked as that documented for short-nosed kangaroo rats. Giant kangaroo rats were the most commonly captured species on 1 site, but their contribution to total

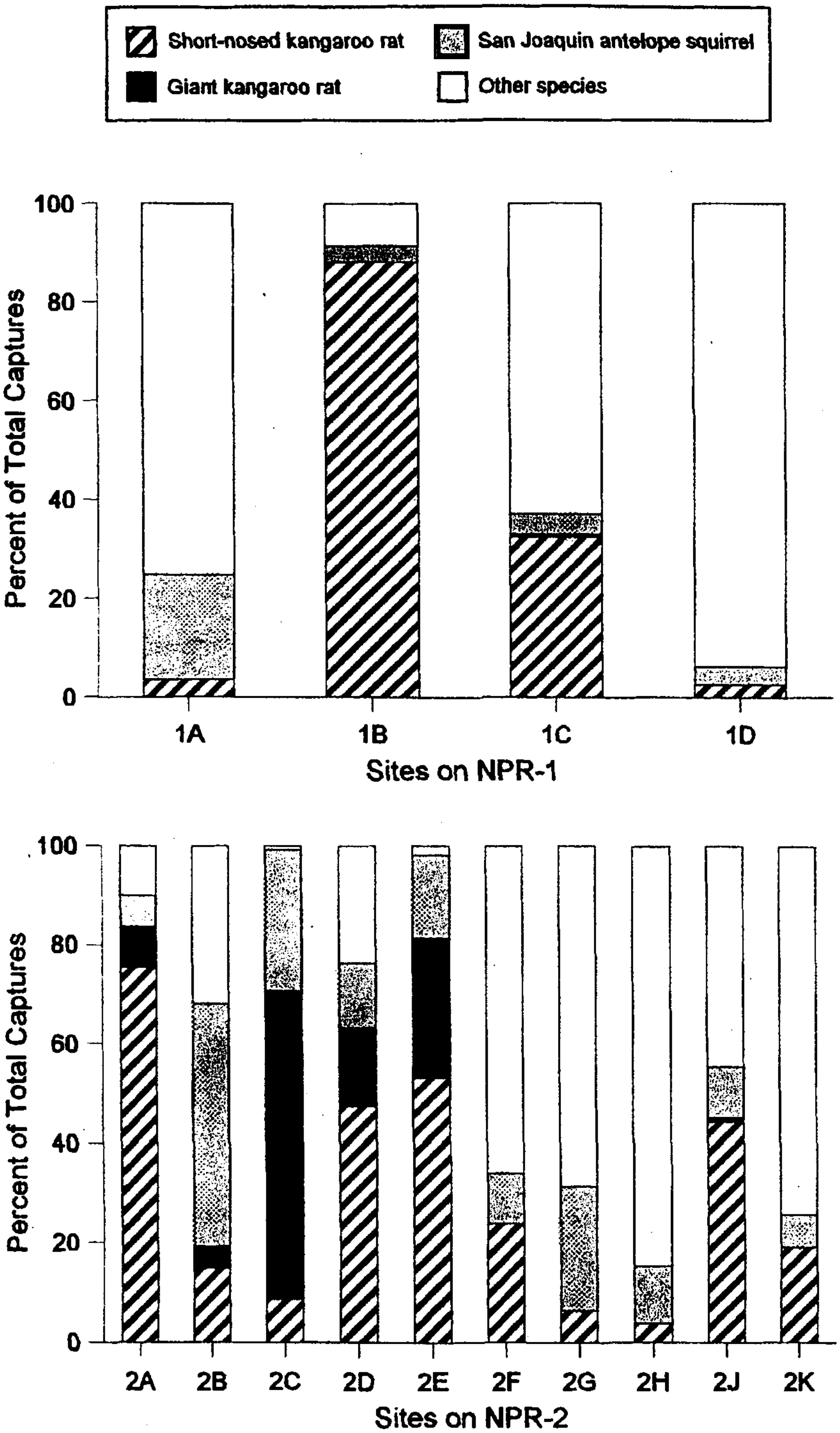

Fig 2. Cumulative species composition profiles of 4 unpaired sites on Naval Petroleum Reserve No. 1 (NPR-1) and 10 paired sites on Naval Petroleum Reserve No. 2 (NPR-2), California, 1980-1984. Paired sites on NPR-2 were 2A and 2B, 2C and 2D, 2E and 2F, 2G and 2H, 2J and 2K. Profiles depict the percentage of total captures accounted for by 3 rodent species and all other species combined. Sites on NPR-1 and NPR-2 were trapped for 44 and 13 monthly sessions, respectively.

rodent captures varied considerably among sites (Fig. 2). This pattern of occurrence and prevalence suggests that giant kangaroo rats were also patchily distributed on NPRC. Unlike short-nosed kangaroo rats, however, they do not appear to have occurred at a baseline density over a wide area.

San Joaquin antelope squirrels occurred on all NPRC sites and were captured at comparatively low rates (Table 1, 2). Mean standardized capture rates rarely exceeded 2.5 individuals/100 trap nights of effort and were typically less than 2.0. In general, the occurrence and prevalence of antelope squirrels were fairly similar among sites, particularly on NPR-1. San Joaquin antelope squirrels were the most commonly captured species on 1 site, but typically accounted for less than 20% of total rodent captures (Fig. 2). This pattern of occurrence and prevalence suggests that San Joaquin antelope squirrels were present at some baseline density and evenly distributed throughout much of NPRC.

Cumulative species composition profiles indicated that short-nosed kangaroo rats, giant kangaroo rats, and San Joaquin antelope squirrels constituted more than 50% of total rodent captures on 1 of 4 sites on NPR-1 and 6 of 10 sites on NPR-2 (Fig. 2). Composition profiles also indicated that the site-specific percent contribution of the individual target species to total rodent captures varied considerably on both NPR-1 and NPR-2. Although unpaired sites were generally more dis-

Table 1. Occurrence and prevalence of 3 rodent species captured on 4 unpaired sites on Naval Petroleum Reserve No.1, 1980-1984. Occurrence was evaluated as the percentage of sessions in which at least one individual was captured. Prevalence was evaluated as mean capture rate (individuals captured/100 trap nights of effort), with associated coefficient of variation (CV).

Site	Short-nosed kangaroo rat		Giant kangaroo rat		San Joaquin antelope squirrel	
	Sessions	Mean rate (CV)	Sessions	Mean rate (CV)	Sessions	Mean rate (CV)
1A	32% (14/44)	0.4 (.07)	0% (0/44)	none captured	77% (34/44)	2.3 (2.2)
1B	100% (44/44)	35.4 (11.9)	2% 1/44)	0.0 (0.2)	57% (25/44)	1.4 (1.6)
1C	91% (40/44)	4.0 (3.1)	7% 3/44)	0.1 (0.3)	34% (15/44)	0.5 (0.8)
1D	52% (23/44)	0.9 (1.0)	0% 0/44)	none captured	52% 23/44)	1.2 (1.7)

Table 2. Occurrence and prevalence of 3 rodent species captured on 10 paired sites on Naval Petroleum Reserve No.2, 1983-1984. Paired sites were 2A and 2B, 2C and 2D, 2E and 2F, 2G and 2H, 2J and 2K. Occurrence was evaluated as the percentage of sessions in which at least one individual was captured. Prevalence was evaluated as mean capture rate (individuals captured/100 trap nights of effort), with associated coefficient of variation (CV).

Site	Short-nosed kangaroo rat		Giant kangaroo rat		San Joaquin antelope squirrel	
	Sessions	Mean rate (CV)	Sessions	Mean rate (CV)	Sessions	Mean rate (CV)
2A	100% (13/13)	7.5 (0.7)	38% (5/13)	0.8 (1.6)	46% (6/13)	0.6 (1.2)
2B	15% (2/13)	0.5 (11.9)	15% (2/13)	0.2 (2.4)	62% (8/13)	1.8 (1.6)
2C	62% (8/13)	0.9 (3.1)	92% (12/13)	0.1 (0.3)	85% (11/13)	3.1 (0.7)
2D	69% (9/13(	1/4 (1.0)	46% (6/13)	0.5 (1.1)	38% (5/13)	0.4 (1.3)
2E	100% (13/13/)	13.0 (0.4)	100% 13/13)	6.9 (0.5)	92% (12/13)	4.1 (0.7)
2F	85% (11/13)	3.4 (0.8)	0% (0/13)	none captured	62% (8/13)	1.5 (1.0)
2G	31% (4/13)	0.3 (1.6)	0% 0/13)	none captured	62% (8/13)	1.2 (1.0)
2H	54% (7/13)	0.7 () 1.1)	0% (0/13)	none captured	69% (9/13)	2.2 (0.9)
2J	100% 13/13)	7.2 (0.4)	15% (2/13)	0.2 (2.4)	62% (8/13)	1.7 (1.1)
2K	100% (13/13)	3.8 (0.4)	0% (0/44)	none captured	46% (6/13)	1.3 (1.4)

similar than paired sites, composition profiles also differed substantially between some sites located in close proximity (e. g., 2C and 2D).

DISCUSSION

The patterns of occurrence and prevalence documented during our study are consistent with the current understanding of target species behaviors and ecological requirements. Both short-nosed and giant kangaroo rats appear to prefer areas where vegetation is noticeably clumped and overall density is low (Best 1991, Williams and Kilburn 1991). As a result, their distribution across a landscape may be rather patchy. This is particularly true for giant kangaroo rats which exhibit more narrow habitat preferences and typically establish burrow systems in colonies of various size (Williams and Kilburn 1991). In addition, previous authors (Bowers and Flanagan 1988, Heske et al. 1994) have reported high kangaroo rat prevalences on sites and the possible exclusion of other rodents through direct competition or vegetation modification. The high mean standarized capture rates observed at some trapping sites suggests that this phenomenon may also have occurred on some areas of NPRC. While the areal distribution of San Joaquin antelope squirrels exhibits some clumping, they are typically present in at least low densities at most locations within their range (Best et al. 1990). This distributional pattern is probably a result of the species' omnivorous diet, mild colonial behavior, and competition with kangaroo rats (Best et al. 1990).

Spatial variability in species presence and abundance appears to be typical of many arid-land rodent communities (Kelt et al. 1996). Most communities are composed of relatively few species that are uniquely sensitive to a suite of site-specific microhabitat components and features, including fine-scale vegetation structure (Rosenzweig 1973, Brown 1975, Price 1978), productivity (Brown and Lieberman 1973), and soil characteristics (Brown and Harney 1993). As a result, species exhibit differential responses to spatial changes in one or more of these microhabitat features (Bowers and Brown 1982, Bowers and Flanagan 1988). The considerable variation in occurrence and prevalence documented among our study sites suggests such species-specific responses occurring on NPRC. Because the vegetation characteristics of trapped sites were not measured, however, the components and features most strongly influencing species occurrence and prevalence were not identified.

The results of our study suggest that the occurrence and prevalence of rodents on sampled sites may not necessarily be representative of nearby unsampled sites. This finding has several important implications for monitoring rodent populations in the southern San Joaquin Valley. Limited areal sampling may potentially result in biased or unreliable estimates of ecological measures such as species abundance, space utilization, dominance, species diversity, and community structure. In addition, live-trapping at one or a few locations or at widely separated locations, may not accurately document the actual occurrence of some species. This is particularly true if the area of interest is large, there are noticeable differences in vegetation structure across the area, or the density of the target species is low.

ACKNOWLEDGEMENTS

This research was sponsored by the U. S. Department of Energy, Naval Petroleum Reserves in California and Chevron U. S. A. Production Company. We thank M. L. Morrison for valuable comments and suggestions on drafts of this manuscript. T. T. Kato and G. D. Warrick provided timely information that is much appreciated. We also gratefully acknowledge the individuals associated with rodent trapping and data collection.

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