Western Riverside County
Multiple Species Habitat Conservation Plan (MSHCP)
Biological Monitoring Program

Stephens' Kangaroo Rat (*Dipodomys stephensi*) Survey Report 2008

15 April 2009

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NOTE TO READER:

This report is an account of survey activities undertaken by the Biological Monitoring Program for the Western Riverside County Multiple Species Habitat Conservation Plan (MSHCP). The MSHCP was permitted in June 2004. The Biological Monitoring Program monitors the distribution and status of the 146 Covered Species within the Conservation Area to provide information to Permittees, land managers, the public, the California Department of Fish and Game, and the U.S. Fish and Wildlife Service. Monitoring Program activities are guided by the MSHCP species objectives for each Covered Species, the information needs identified in MSHCP Section 5.3 or elsewhere in the document, and the information needs of the Permittees.

We would like to acknowledge the land managers in the MSHCP Plan Area, who in the interest of conservation and stewardship facilitate Monitoring Program activities on the lands for which they are responsible. A list of the lands where this year's data collection activities were conducted is included in Section 7.0 of the Western Riverside County Regional Conservation Authority (RCA) Annual Report to the Wildlife Agencies.

Partnering organizations and individuals contributing data to our projects are acknowledged in the text of appropriate reports. We would especially like to acknowledge the Santa Ana Watershed Association, the Center for Natural Lands Management, and the Orange County Water District for their willingness to initiate or modify their data collection to complement our survey efforts in 2008.

While we have made every effort to accurately represent our data and results, it should be recognized that our database is still under development. Any reader who would like to make further use of the information or data provided in this report should contact the Monitoring Program to ensure that they have access to the best available or most current data. All Monitoring Program data, including original datasheets and digital datasets are stored in the Monitoring Program office in downtown Riverside, CA.

The primary author of this report was the 2008 Mammal Program Lead, Bill Kronland. If there are any questions about the information provided in this report, please contact the Monitoring Program Administrator. If you have questions about the MSHCP, please contact the Executive Director of the RCA. For further information on the MSHCP and the RCA, go to www.wrc-rca.org.

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INTRODUCTION

Stephens' kangaroo rat (*Dipodomys stephensi*; "SKR") is a small fossorial mammal that was added to the federal list of endangered species in 1988 and to the California state list of threatened species in 1971. The geographic range of SKR lies entirely within portions of western Riverside and north-central San Diego Counties, and extends from the Potrero Valley in the north to the Romana Valley in the south, and from the Anza Valley in the east to the Corona Hills in the west (Bleich 1977). Stephens' kangaroo rat most often occurs in open grasslands or sparse shrub-lands, and is only rarely detected in shrub dominated habitats (O'Farrell 1990; Price et al 1991). Density of vegetation cover may also be an important characteristic of SKR habitat, since the species has often been recorded in sparsely vegetated areas with a predominance of bare ground (Bleich 1973; O'Farrell and Clark 1987; O'Farrell 1990).

Western Riverside County Multiple Species Habitat Conservation Plan (MSHCP) species-specific objectives for SKR require that a minimum 15,000 ac (6070 ha) of occupied habitat (as measured across any consecutive 8-year period) be conserved among at least 6 Core Areas (Lake Mathews-Estelle mountain, Motte Rimrock Reserve, Lake Skinner-Domenigoni Valley, San Jacinto State Wildlife Area-Lake Perris, Sycamore Canyon-March Air Force Reserve Base, Steele Peak, and Potrero ACEC), with an additional 3000 ac (1214 ha) of occupied habitat conserved in Anza-Cahuilla Valleys and Potrero Valley (Dudek & Associates 2003). Moreover, at least 30% of the total occupied habitat conserved within the Plan Area must maintain a population of medium or higher density (i.e., 5-10 individuals per ha) with no single Core Area accounting for more than 30% of the conservation target. We discuss here the methods and results from 2008 surveys used to address species-specific objectives in Anza-Cahuilla Valleys and Potrero Valley.

Our survey goals prior to 2007 focused on refining methods proposed by Diffendorfer and Deutschman (2002) to derive point estimates of population size, and to develop a protocol to identify and measure habitat characteristics that correlate with SKR presence and abundance. We implemented a protocol and timed survey efforts that addressed these goals in cooperation with the Riverside County Habitat Conservation Authority (RCHCA) in 2006 and spring 2007. Results from our 2006 survey efforts suggested that the implemented monitoring scheme did not generate sufficient sample sizes to allow for the use of capture-recapture analyses, and therefore could not provide true estimates of abundance (Hallett et al 1991). Furthermore, indices of abundance (e.g., minimum number alive index) could not be applied because approximately 40% to 50% of initial captures occurred on the last night of each trapping effort, suggesting that the ratio of unique individuals captured (M_{t+1}) to the actual population (N) was very low. Indices based on small M_{t+1} to N ratios can lead to inferences of abundance that include an excessively large negative bias (McKelvey and Pearson 2001). Therefore, practical implementation of methods proposed by Diffendorfer and Deutschman (2002) required further development if useful population estimates were to be derived from them.

Our survey goals in 2007 focused on developing a sampling protocol that would produce an estimate of occupied area, generate sufficient sample sizes to derive point estimates of population density (e.g., $n \geq 50$), and effectively sample populations with low M_{t+1} to N ratios. We developed a sampling strategy that tested the use of numerous 5x5 (60m x 60m) grids and applied a closed-capture occupancy model developed by MacKenzie et al (2002) to estimate percent area of occupied suitable habitat at Potrero Valley. We also examined the ability and practicality of 12x12 (165m x 165m) grids to generate large sample sizes, and investigated the number of nights required to effectively trap SKR populations. We concluded that 5x5 grids and the occupancy model could be an effective method of estimating distribution if the sampled habitat produced detections on fewer than 90% of grids trapped. We also found that 12x12 grids generated large numbers of detections, but were cumbersome and limited in scope to large parcels of contiguous habitat. Results from our attempt to effectively trap SKR populations were inconclusive, but suggested that a possible trap-initiation period required extended trapping efforts of up to 10 nights that could conflict with the negative effect of moon phase on detectability.

We incorporated 2007 survey results into our 2008 strategy of estimating occupied habitat and population density in the Anza-Cahuilla Valley and Potrero Valley regions. We first estimated occupied habitat by sampling each region with 5x5 grids, expanding our 2007 coverage at Potrero Valley to include all suitable soils and slopes because the 2006 Esperanza Fire had likely expanded SKR habitat across otherwise poor quality shrubland and chaparral. We then sampled each region with circular trapping webs to estimate density according to distance sampling methods (Buckland et al 2005). Trapping webs were advantageous over 12x12 grids because we were able to alter web configuration to fit narrow habitat patches and valleys while maintaining the ability to derive density estimates. Distance sampling also required that populations be effectively trapped only at the webs' center rather than across the entire sample plot, thus making the problem of detecting M_{t+1} individuals on the final trap night more manageable. Specifically, our survey goals and objectives for 2008 were as follows:

Goals and Objectives

1. Estimate area of suitable habitat occupied by Stephens' kangaroo rat at Anza-Cahuilla Valley and Potrero.

    a. Identify areas of moderate- to high-suitability habitat according to an index created by Dudek & Associates (2007).
    b. Sample Stephens' kangaroo rat populations with 5x5 (60 m x 60 m, 25 trap) grids.
    c. Estimate occupancy with a closed-capture model using Program MARK.
    d. Incorporate habitat covariates into occupancy models to refine the habitat index.

2. Estimate population density of Stephens' kangaroo rat on occupied habitat at Anza-Cahuilla Valley and Potrero.
    a. Use distance sampling methods and circular trapping webs (148 traps, 12 trap lines, 100-m radius, 3.14 ha) centered on occupied 5x5 grids.
    b. Estimate population density using program DISTANCE.

METHODS

Site Selection

We defined the region of the Anza-Cahuilla Valley as Conserved Lands occurring from State Road 79 north to the San Bernardino National Forest, and east of Sage Road (County Road R3) to the Plan Area boundary. We also divided the region into Silverado Ranch and Wilson Valley because of the expanse of unsuitable SKR habitat that existed between these 2 sites. Silverado Ranch (elevation 1250 m) generally consisted of moderate- to high-density annual grassland interspersed with occasional patches of big sagebrush (*Artemisia tridentata*) and California buckwheat (*Eriogonum fasciculatum*), and surrounded by moderate- to high-density expanses of mixed chaparral (*Adenostoma sparsifolium* and *Cercocarpus betuloides*). In contrast, Wilson Valley (elevation 600 to 800 m) typically consisted of low- to moderate-density shrubland (e.g., *Erigonum fasciculatum*, *Encelia farinosa*, *Rhus ovata*, and *Opuntia parryi*) with occasional patches of annual grassland surrounded by moderate- to high-density coastal sage scrub (*Adenostoma fasciculatum* and *Erigonum fasciculatum*) and mixed chaparral (*Adenostoma fasciculatum*, *Adenostoma sparsifolium*, and *Rhus ovata*). Sampling occurred on lands that were managed by the Regional Conservation Authority (RCA) and Center for Natural Lands Management (CNLM).

We sampled areas of Potrero Valley (elevation 600 to 750 m) that were included in the Potrero Unit of the San Jacinto State Wildlife Area (Potrero) and 2 adjoining Bureau of Land Management quarter sections (T3S R1W S26 NW&SW). The region generally consisted of annual grassland and low-density shrubs (*Erigonum fasciculatum*) along valley floors, and moderate- to high-density coastal sage scrub (*Erigonum fasciculatum* and *Adenostoma fasciculatum*) and mixed chaparral (*Quercus berberidifolia*) on upland areas and along most slopes. Much of the area was severely burned in October 2006 by the Esperanza Fire, which greatly reduced cover across all vegetation communities. Annual grasslands began to approach pre-fire cover densities following the winter and spring rains of 2008, but shrub cover in burned areas generally remained at low to moderate densities during the period of this survey.

We classified habitat across Anza-Cahuilla Valley and Potrero based on a suitability index created by Dudek & Associates (2007) using ArcGIS 9.2 Global Information System (GIS) software (ESRI 2006) and GIS-based vegetation (CDFG et al 2005), soil (Soil Survey Staff et al 2006), and slope (USGS 2006) layers (Appendix A). We modified the index when classifying Potrero by removing vegetation parameters and considering only soil and slope attributes to account for the post-fire expansion of habitat into areas otherwise considered unsuitable for SKR (e.g., high-density shrub cover). We also included human-disturbed lands (e.g., abandoned homesteads, fallow agricultural lands) while classifying both Anza-Cahuilla Valley and Potrero when disturbances occurred on suitable soils and slopes, and had not completely altered the underlying vegetation community. We then identified areas classified as low suitability (e.g., chaparral >40% cover density) and removed them from our model because these habitats were defined by Dudek & Associates (2007) as non-typical and could support only trace SKR densities (e.g., <1 per ha). Limited availability of field personnel also dictated that we focus on more typical SKR habitat.

Occupied Habitat

We used the Hawth's Tools (Beyer 2004) extension for ArcMap 9.2 to distribute regular points across areas classified as moderate- to high-suitability habitat at Anza-Cahuilla Valley (828.9 ha) and Potrero (1105.6 ha). We maintained a density of 1 point every 13.4 ha at each site by spacing them at 200-m intervals at Anza-Cahuilla Valley and 225-m intervals at Potrero (Figures 1, 2). We also ensured that a 5x5 (60 m x 60 m, 25 traps) grid would lie completely within modeled moderate- to high-suitability habitat by placing a 50-m circular buffer around each point to represent the approximate area covered by a grid plus 5 m to account for Global Positioning System (GPS) error in the field. We then removed points from the sample whose buffer fell outside targeted habitat.

Much of the suitable habitat in the Anza-Cahuilla Valley occurred in patches too small or linear to be sampled with a 5x5 grid, or was of moderate size with a perimeter shape that allowed only the non-random placement of a single grid. Therefore, we were unable to place grids on approximately 302.5 ha at Anza-Cahuilla Valley because of the size and shape of suitable-habitat patches. Potrero also contained 79.8 ha of suitable soil that was distributed across patches too small to be randomly sampled, and 118 ha in the northwest portion of the preserve could not be safely accessed during night surveys because of very steep and degraded roads. Our results reported here only reflect sampled habitat patches at Silverado Ranch (256.9 ha), Wilson Valley (269.6 ha) and Potrero (907.8 ha).

We centered 5x5 grids on each regular point distributed across Silverado Ranch (n = 36), Wilson Valley (n = 25), and Potrero (n = 80). We marked each grid at the southwest corner with a uniquely labeled 2-m wood stake, and placed a labeled pin flag at each trap station. We then sampled grids over multiple 5-night efforts, beginning at Anza-Cahuilla (13 to 18 April, 27 April to 2 May, 4 to 9 May, and 11 to 16 May) and finishing at Potrero (1 to 6 June, 8 to 13 June, 6 to 11 July, 13 to 18 July, and 27 July to 1 August). We timed our efforts to coincide with new-moon cycles because lunar brightness may negatively affect small-mammal activity (Daly et al. 1992). We also minimized the potential of introducing sampling bias into our estimates by semi-randomizing the order grids were checked each night within an effort (time bias) and alternating field-crew grid assignments (observer bias; MacKenzie and Royle 2005).

Figure 1. Occupancy-survey design with occupied and non-occupied 5x5 grids at Anza-Cahuilla Valley region.

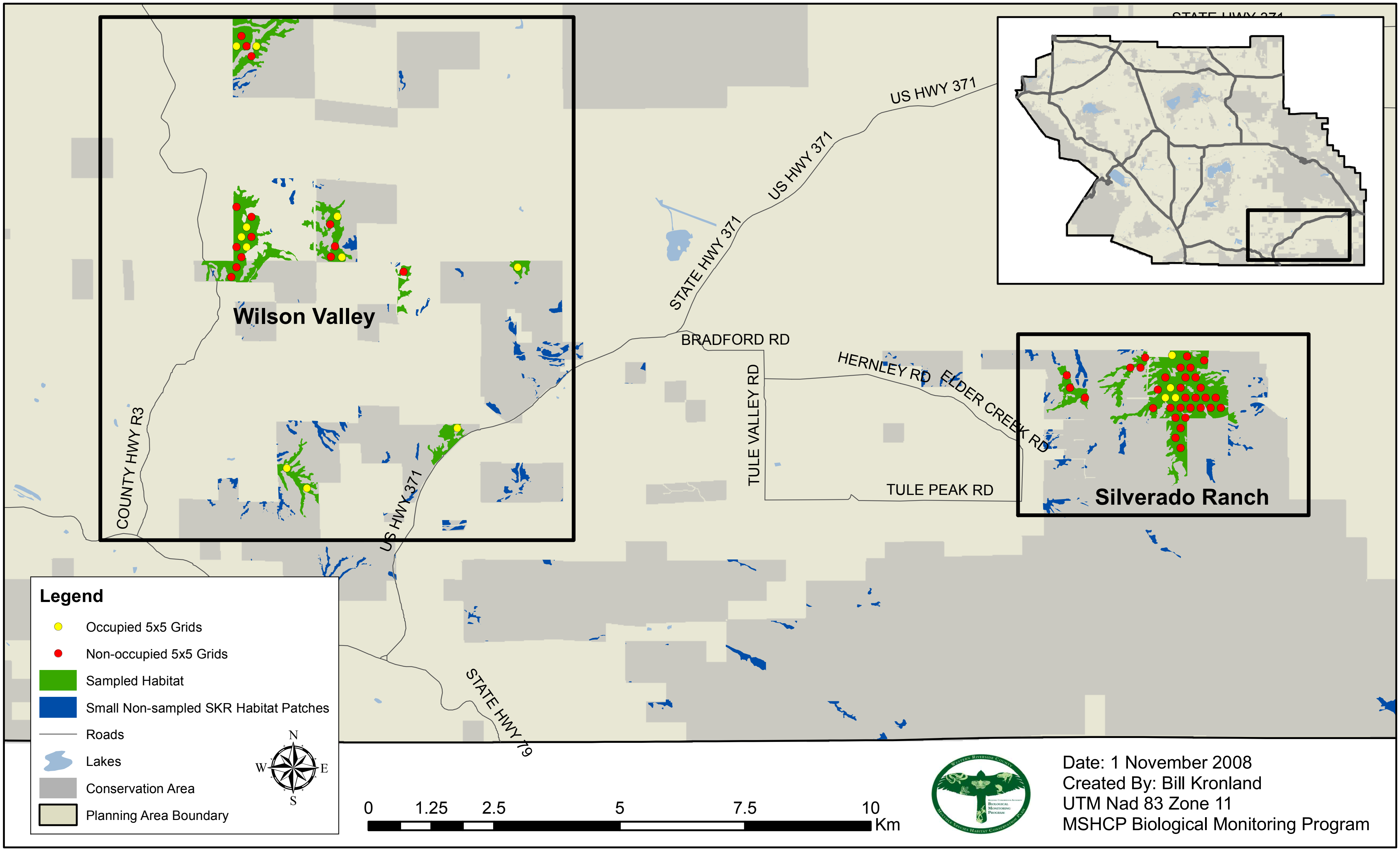
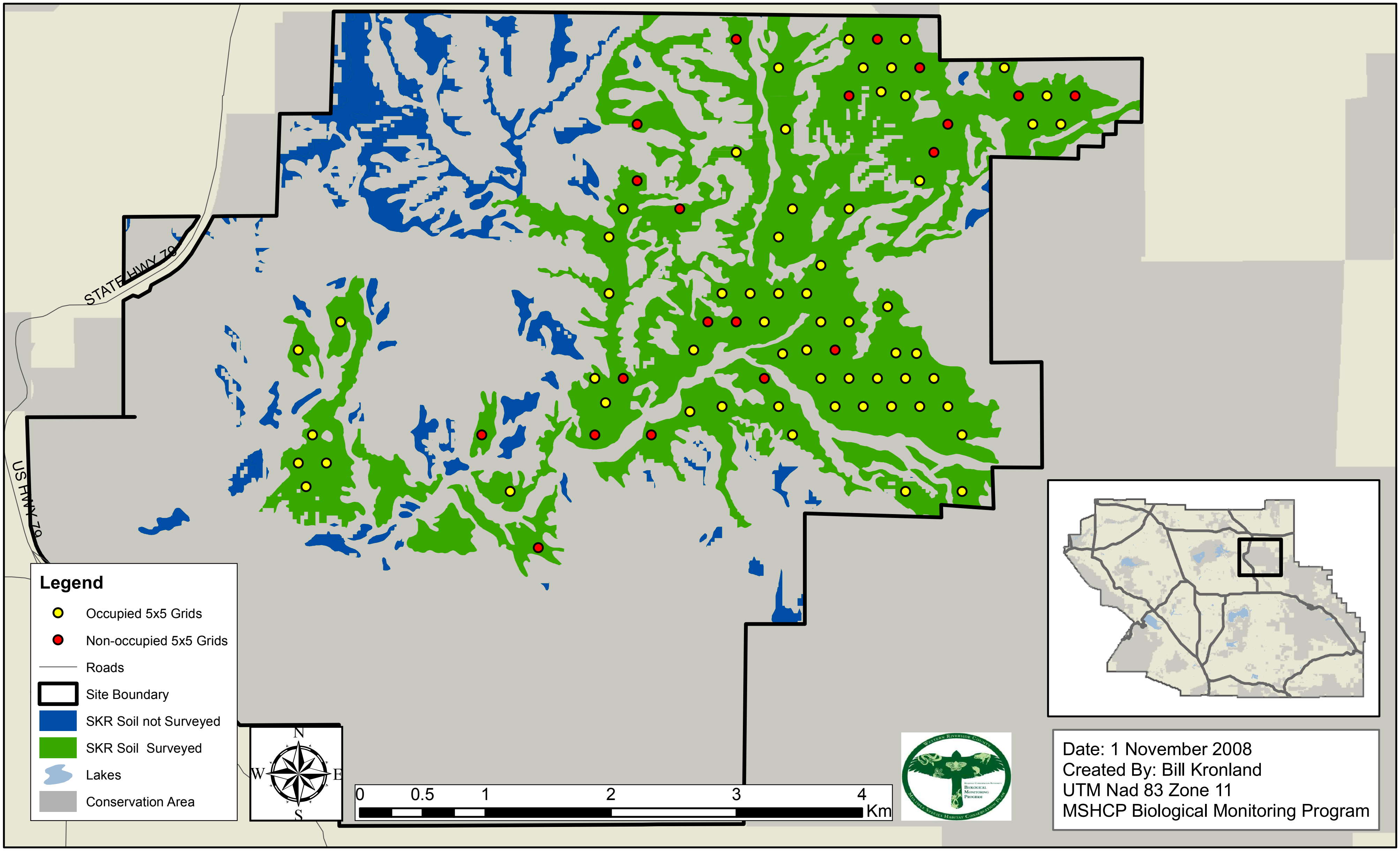


Figure 2. Occupancy-survey design with occupied and non-occupied 5x5 grids at Potrero Valley region.



We sampled trapping grids using 12″ x 3″ x 3.5″ Sherman live traps baited with 1 tablespoon of large-white Proso millet and modified with paper clips to restrict trap doors from closing completely and potentially damaging animal tails. Traps were placed no more than 1.5 m from pin flags to assure that none were missed during night surveys. We checked traps twice each night in accordance with U.S. Fish and Wildlife Service 10(a)(1)(B) permit specifications. Our first check was at the midpoint of each night (e.g., midnight) when traps were reset and bait added as needed. We again checked grids beginning 1 hour before dawn. All traps were closed immediately following this second check, and excess millet was removed to avoid attracting ants to trap sites. Grids were reopened and baited 1 to 3 hours before sunset the following evening, and closed on the final night of each survey by removing traps and excess bait as the dawn check was conducted.

We processed animals captured during each survey effort according to standard operating procedures developed by the Biological Monitoring Program for animal handling and data collection (Appendix B). In general, we recorded weight (100-g Pesola spring scale), ear length (tip to notch), hind foot length (*Chaetodipus* species only), sex, age class (adult, sub adult, juvenile), reproductive condition (non-reproductive, scrotal, pregnant, lactating, perforate, plugged), capture history (new, recapture), and trap location of each SKR and non-target Covered Species (e.g., *Dipodomys simulans*) upon initial capture in each survey effort. We also marked the ventral side of all Covered Species (RediSharp non-toxic permanent marker) with a color unique to individual trapping efforts to indicate that the animal had been previously captured during that survey. We released animals recaptured during an effort after species and trap location were recorded. All non-covered species (e.g., *Peromyscus maniculatus*) were released with no mark after trap location and species were recorded. Processing times ranged between 30 s and 3 min depending on the species and capture history. Only field personnel with prior animal handling experience and/or demonstrated proficiency in this area combined with training from experienced Biological Monitoring Program staff processed animals (Table 1). Volunteers occasionally assisted with recording data throughout the trapping season and processed animals under supervision if they had previous handling experience. Program trainings focused on proper animal handling, identification, and standard data collecting procedures in both field and office settings.

We revisited each grid within 30 days of trapping to record habitat characteristics on 0.04-ha circular plots centered on each grid (Appendix C). We visually estimated percent total tree, shrub, and ground cover (live or standing herbaceous), and recorded ocular percent-cover estimates of dominant and co-dominant species within each vegetation class. We also recorded percent cover of stork's bill (*Erodium* spp.) regardless of rank among ground-cover species because of its importance as an SKR food source (Brock and Kelt 2003). Finally, we estimated total percent cover of litter, bare ground, and rocky substrate, and recorded the slope and aspect of each sample plot. We estimated

Table 1. Western Riverside County Multiple Species Habitat Conservation Plan Biological Monitoring Program field staff for Stephens' kangaroo rat surveys in 2008.

Name	Agency	Position
Angie Coates	Regional Conservation Authority	Field Biologist
Ariana Malone	Regional Conservation Authority	Field Biologist
Ashley Ragsdale	Regional Conservation Authority	Field Biologist
Betsy Dionne	Regional Conservation Authority	Field Biologist
Bill Kronland	Regional Conservation Authority	Mammal Program Lead
Christina Greutink	Regional Conservation Authority	Field Biologist
Karin Cleary-Rose	U.S. Fish and Wildlife Service	Program Coordinator
Espie Sandoval	Regional Conservation Authority	Field Biologist
Mandy Breon	Regional Conservation Authority	Field Biologist
Rosina Gallego	Regional Conservation Authority	Field Biologist
Ryann Loomis	Regional Conservation Authority	Field Biologist
Allyson Beckman	Santa Ana Watershed Association	Volunteer
Brian Shomo	Riverside County Habitat Conservation Agency	Volunteer
Chad Young	Riverside County Environmental Programs	Volunteer
Heather Bank	University of California, Riverside	Volunteer
Jill Coumoutso	Santa Ana Watershed Association	Volunteer
Michael Richard	Riverside County Environmental Programs	Volunteer
Samantha Marcum	U.S. Fish and Wildlife Service	Volunteer

percent cover from an overhead perspective and relative among cover classes for a more direct comparison with the Dudek & Associates (2007) habitat index based on satellite-GIS imagery.

Population Density

We surveyed for population density from August to October by using circular trapping webs and distance sampling methods (Anderson et al 1983). Trapping webs (A = 3.14 ha) were centered on 5x5 grid locations where SKR were detected earlier in the year, and consisted of 12 trap lines (l = 100 m) radiating from the center of an occupied grid (i.e., trap station C3) at 30˚ intervals. We placed 12 traps along each line and 4 directly at the web's center for a total of 148 traps per web. We spaced the first 4 traps on each line at 5-m intervals (5, 10, 15, 20 m from the center) and increased the distance between the last 8 stations to 10 m (30, 40, 50, 60, 70, 80, 90, 100 m from the center; Parmenter et al 2003) (Figure 3). Each trap station was marked with a uniquely labeled pin flag indicating trap line (alpha code) and radial-distance category (numeric code).

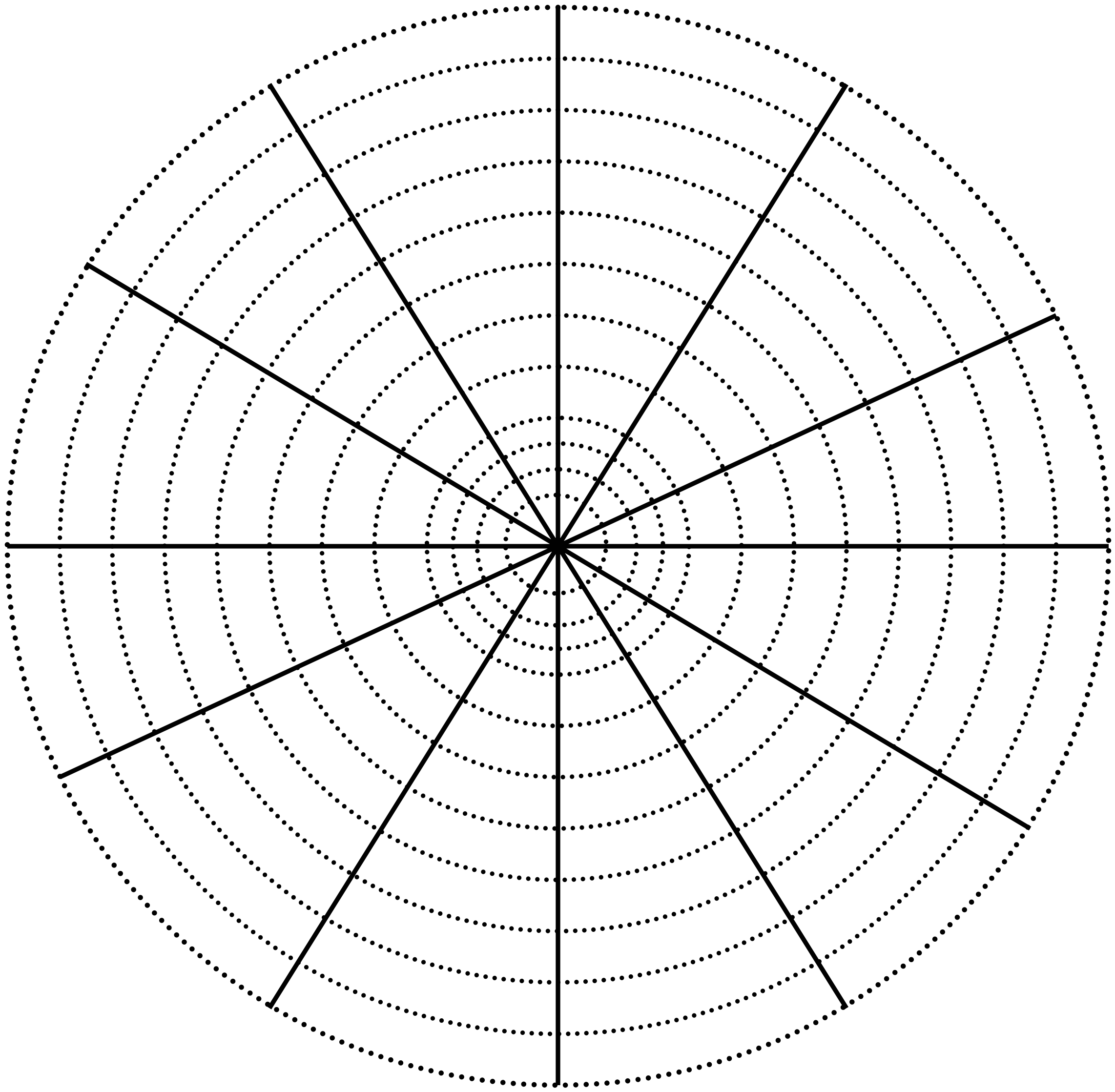


Figure 3. Trapping web design (*A* = 3.14 ha) used to survey for Stephens' kangaroo rat population density. Twelve traps were placed along each of 12 trap lines (*l* = 100 m) that radiated from the center of occupied 5x5-grid sites at 30° angles. The innermost 4 traps were spaced at 5-m intervals, and the outermost traps were placed every 10 m. Four additional traps were placed directly in the center of each trapping web.

We sampled each of the 15 occupied 5x5 grid locations at Anza-Cahuilla in random order with trapping webs (Silverado Ranch: *n* = 4; Wilson Valley: *n* = 11) from 24 to 29 August, 7 to 12 September, 21 to 26 September, and 28 September to 3 October. The number of occupied 5x5 grid locations at Potrero (*n* = 60) was great enough that available staff resources prohibited us from sampling each of them with a trapping web. Therefore, we placed trapping webs on 30% of grid sites (*n* = 18) that had the highest relative abundance because the population-density objective in the MSHCP required a minimum density on 30% of occupied area. We then sampled webs at Potrero in random order from 3 to 8 August, 19 to 24 October, 26 to 31 October, and 16 to 21 November.

The configuration of accessible lands and suitable habitat patches at Anza-Cahuilla and Potrero made it difficult to fit a number of trapping webs entirely within our defined survey area. Including data from portions of trapping webs that fell outside of the survey region risked upward bias in our density estimates because the availability of SKR was likely greater inside the boundary of our habitat-suitability model than outside (Buckland et al 2007). One approach to this problem was to extend trapping webs into a buffer zone, but only record detections within our survey boundary and assign an effort that represented the area of targeted habitat trapped by each web (Buckland et al 2007). We placed a 30-m buffer strip around targeted habitat that represented a reported median for maximum distance moved between captures for SKR (Price et al 1994a). We then surveyed within this buffer whenever it overlapped with trapping web footprints, and attenuated trap lines that extended beyond the buffer-strip boundary. The result was that 1 to 3 trap stations on a number of trap lines fell outside of our defined survey region on 7 webs at Anza-Cahuilla and 4 webs at Potrero. We also removed up to 3 outer trap stations from trap lines on 4 webs at Anza-Cahuilla because land access did not allow us to trap a full web. We attenuated individual trap lines within webs only when they extended beyond our 30-m buffer strip or into non-conserved land.

Distance sampling methods required that 3 assumptions were met before population density could be estimated: 1) all individuals near trapping web centers were detected, 2) distance from web centers to each trap were measured accurately, and 3) there was no directional movement of animals (e.g., movement toward the web's center) (Buckland et al 2005). We addressed the first assumption by defining the web center as the first 2 trap rings plus the 4 traps placed directly in the middle. We then batch marked individuals ventrally with a non-toxic marker, thus allowing us to determine if we had captured all individuals occurring within the first 2 trap rings. We also measured the distance to each trap with a 100-m tape when installing webs. Finally, we applied uniquely numbered ear tags to SKR during the first round of sampling and examined data *post hoc* for animal movement across trap stations within individual webs. To maximize the efficiency of each sampling bout, we did not mark animals with ear tags during subsequent efforts. The distance methods used did not require the incorporation of individual recapture data into the density estimate. Animal handling and data collection procedures otherwise followed methods used while surveying for SKR occupancy.

Data Analysis

We estimated grid occupancy (Ψ) and nightly detection probability (p) at Anza-Cahuilla Valley and Potrero separately using a closed-capture occupancy model that derived estimates based on grid-level presence/absence data (MacKenzie et al 2002). Output from this model was a percent estimate of occupied grids that accounted for animals present but undetected. Accuracy and precision of $\hat{\Psi}$ was generally a function of the number of sampling occasions and grids trapped (and to some extent p) rather than the absolute number of animals detected, thus allowing us to design surveys that would maximize the reliability of estimates given the availability of resources and project timeframes (MacKenzie et al 2002; MacKenzie and Royle 2005). This method also enabled us to incorporate habitat covariates into the model and to investigate group (e.g., site within region or trap effort) and time (e.g., trap night within an effort) effects on our estimates.

Occupancy estimates based on the method described above relied on 4 critical assumptions: 1) occupancy status of sites did not change over the survey period, 2) probability of occupancy was constant among sites, or differences were modeled, 3) probability of detections was constant among sites, or differences were modeled, and 4) capture histories were independent among trap locations (MacKenzie et al 2006). We surveyed each site across 6 (Silverado Ranch and Wilson Valley) to 9 (Potrero) weeks to maximize the probability of population closure during the sampling period (assumption 1), and maintained independence among trap locations by spacing them at 200-m and 250-m intervals (assumption 4). We also used Program MARK to construct separate sets of candidate models at Anza-Cahuilla Valley and Potrero that accounted for differences in Ψ and p among sites and across survey periods (assumptions 2 and 3) (White and Burnham 1999). We compared 8 candidate models for Anza-Cahuilla Valley that addressed site effects on $\hat{\Psi}$, and survey and site effects on p. We also constructed 4 candidate models for Potrero that examined the effect of timing and length of survey effort on p while assuming Ψ to be constant across occasions. We ranked candidate models in each set according to difference in Akaike's Information Criterion for small samples (ΔAIC*c*), and calculated an Akaike weight (w_i) for each. We then derived weighted-average estimates across the entire candidate set unless there was clear support (e.g., $w_i > 0.9$) for a single model (Burnham and Anderson 2002). Finally, we calculated the acreage of occupied suitable habitat at Anza-Cahuilla Valley and Potrero by extrapolating occupied-grid estimates to the area of modeled moderate- to high-suitability habitat at each Core Area.

We attempted to further refine our understanding of SKR habitat by using Program MARK to add 4 habitat covariates to a generalized occupancy model (p(constant) Ψ(constant)) that were based on *a priori* assumptions of SKR habitat selection. Stephens' kangaroo rat has often been found in open-transitional grasslands with occurrence tending to decrease as ground litter accumulates and shrubs encroach (O'Farrell and Uptain 1989; O'Farrell 1990; Goldingay and Price 1997). We included percent ground cover (i.e., standing herbaceous vegetation) and bare ground (i.e., non-organic cover) into our models as continuous variables, but partitioned percent shrub cover into 3 categories (0, 0.1 to 10, and > 10) based on cover-density categories used in the Dudek & Associates (2007) habitat index and the distribution of shrub-cover density across trapping grids, which was low and skewed toward 0. We also included percent cover of *Erodium* because this non-native forb genus has been suggested as a preferred SKR food source (Brock and Kelt 2003). We analyzed *Erodium* in 3 percent-cover categories (0, 0.1 to 10, > 10) because it's overall occurrence was also low and skewed toward 0. We also accounted for underlying site differences that represented unmeasured variables by including Silverado Ranch, Wilson Valley, and Potrero as separate attribute groups (i.e., p(constant) Ψ(site)). Incorporating site into our models as attribute groups rather than as an individual covariate gave us site-specific intercepts that enabled a fuller understanding of how individual covariates affected distribution at each area. Soil type can also be an important indicator of SKR distribution, but we did not test soil condition because sampled areas in Anza-Cahuilla Valley and Potrero all occurred on fine- to coarse-sandy-loam soils with little variation (Price and Endo 1989).

We constructed a candidate set of 32 habitat models containing the full combination of the 4 covariates plus the unknown site effect described above. We then ranked models according to AICc values, calculated Akaike weights, and derived the weighted average effect size ($\hat{\bar{\beta}}$) of each covariate (Burnham and Anderson 2002). We interpreted the importance of specific habitat features in determining SKR occupancy based on the summed weight of models containing individual covariates, unless a single model showed overwhelming support (e.g., $w_i > 0.9$).

We estimated population density (SKR per ha) separately for Anza-Cahuilla Valley and Potrero, but pooled sites to estimate the probability of detecting individuals (P_a) because there was no significant difference in detection between sites (Anza-Cahuilla Valley: $\hat{\bar{P}}a$ = 0.23, CI: 0.12, 0.43; Potrero: $\hat{\bar{P}}a$ = 0.26, CI: 0.21, 0.32). We initially examined histograms of first-time detections and removed the 3 outermost distance categories from our analysis because captures here were greater than expected and indicated that we were attracting animals from an unknown distance outside trapping-web footprints (Buckland et al 2007). Truncating data also standardized trapping web size and survey effort in our analysis by effectively removing portions that were sampled with varying effort due to configuration of habitat patches and land access. We then constructed a set of candidate models using program DISTANCE and based on the full combination of 2 key functions (half-normal and uniform) and 3 adjustment terms (cosine, simple polynomial, and hermite polynomial) (Thomas et al 2006). We did not consider negative-exponential or hazard-rate key functions because these models were shown to overestimate density and perform poorly in general (Parmenter et al 2003). Models were removed that did not reasonably fit the shape criterion of the detection function and exhibited poor fit according to a chi-square goodness of fit test. We ranked remaining models according to difference in Akaike's Information Criterion (ΔAIC), assigned Akaike weights, and calculated a weighted-average estimate for density ($\hat{\bar{D}}$)

and detection probability ($\hat{Pa}$) across the candidate set (Burnham and Anderson 2002). Confidence intervals were calculated for $\hat{D}$ and $\hat{Pa}$ using formulas described in Buckland et al (2005).

RESULTS

Occupied Habitat

We captured 33 individual SKR on 5x5 grids at Anza-Cahuilla Valley (Silverado Ranch: $n = 8$, Wilson Valley: $n = 25$) with an average of < 1 detection per grid (Appendix D). Our most productive grid was at Wilson Valley and produced 14 captures. We also captured San Diego pocket mouse (*Chaetodipus fallax fallax*), Dulzura kangaroo rat (*Dipodomys simulans*; DKR), Los Angeles pocket mouse (*Perognathus longimembris brevinasus*), San Diego desert wood rat (*Neotoma lepida intermedia*), and deer mouse (*Peromyscus maniculatus*). We captured 262 individual SKR at Potrero with an average of 3 detections per grid with our most productive site accounting for 18 animals. Non-target species detected at Potrero were San Diego pocket mouse, deer mouse, DKR, California ground squirrel (*Spermophilus beecheyi*), desert shrew (*Notiosorex crawfordi*) and western toad (*Bufo boreas*).

We captured SKR on 25% ($n = 15$) of grids sampled at Anza-Cahuilla Valley with Wilson Valley accounting for more than two-thirds ($n = 11$) of grid-level detections in the region. We observed SKR on only 11% ($n = 4$) of grids sampled at Silverado Ranch while capturing animals on 44% of Wilson Valley grids. Our best supported model (w_i = 0.76) further indicated that occupancy differed between the 2 sites, but that p was similar across the region and differed among trap nights (Table 2). Weighted-average occupancy estimates for Silverado Ranch ($\hat{\bar{\psi}}$ = 0.12, 95% CI: 0.04, 0.29) and Wilson Valley ($\hat{\bar{\psi}}$ = 0.43, 95% CI: 0.25, 0.64) differed marginally from observed grid occupation; a result of our high cumulative probability of detection (P_c = 0.997) across trap nights. We appeared to be successful at detecting SKR with $\hat{p}$ generally rising from 0.49 (SE = 0.11) on the first night of trapping to 0.87 (SE = 0.07) on the final night (Figure 4). Extrapolated area of occupied moderate- to high-suitability habitat from our model-based estimates of grid occupancy was 30.8 ha at Silverado Ranch and 115.9 ha at Wilson Valley.

We captured SKR on 75% ($n = 60$) of grids sampled at Potrero, and considered a single model (w_i = 0.99) that estimated p as varying across trap night, but constant across efforts (Table 3). Grid-level probability of detection consistently rose from 0.43 (SE = 0.06) on the first night of trapping to 0.87 (SE = 0.4) on the last night, with P_c = 0.998 (Figure 5). Extrapolated area of occupied moderate- to high-quality habitat from our model-based estimate of grid occupancy ($\hat{\bar{\psi}}$ = 0.75, 95% CI: 0.64, 0.83) was 680.9 ha. Total area of occupied moderate- to high-quality habitat across areas surveyed at both Anza-Cahuilla Valley and Potrero was 827.6 ha, meeting 68% of the conservation objective for SKR in these regions.

Table 2. Akaike Information Criterion for small samples (AIC*c*), difference in AIC*c* (ΔAIC*c*), Akaike weights (w_i), number of estimated parameters (*K*), and log likelihood of candidate-occupancy models used for estimating grid-level occupancy at 2 sites in Anza-Cahuilla Valley region.

Model	AIC*c*	ΔAIC*c*	w_i	*K*	-2Log(L)
p(trap night)Ψ(site)	160.23	0	0.76	7	144.11
p(constant)Ψ(site)	163.66	3.43	0.14	3	157.24
p(site)Ψ(site)	165.94	5.71	0.04	4	157.23
p(trap night)Ψ(constant)	166.31	6.08	0.04	6	152.75
p(site * trap night)Ψ(site)	168.41	8.19	0.01	12	137.91
p(constant)Ψ(constant)	170.08	9.86	0.01	2	165.88
p(site)Ψ(constant)	172.3	12.07	<0.01	3	165.87
p(site * trap night)Ψ(constant)	173.98	13.75	<0.01	11	146.59

Table 3. Akaike Information Criterion for small samples (AIC*c*), difference in AIC*c* (ΔAIC*c*), Akaike weights (w_i), estimated parameters (*K*), and log likelihood of candidate-occupancy models used for estimating grid-level occupancy at Potrero Valley region.

Model	AICc	ΔAICc	w_i	*K*	-2Log(L)
p(trap night)Ψ(constant)	442.17	0	0.99	6	429.02
p(constant)Ψ(constant)	463.64	21.47	<0.01	2	459.79
p(effort)Ψ(constant)	467.21	25.04	<0.01	6	454306
p(effort * trap night)Ψ(constant)	483.85	41.68	<0.01	26	405.36

Measured habitat characteristics varied between the 2 regions with Potrero generally having high-density ground cover, low-density shrub cover, and moderate-density *Erodium* cover (Table 4). Percent shrub cover ranged at Potrero from no shrubs on 40% (n = 32) of sampled grids to >10% on 20% (n = 16) of grids. In contrast, 46% (n = 28) of grids at Anza-Cahuilla Valley had >10% shrub cover and 23% (n = 14) had 0% cover. Anza-Cahuilla Valley generally consisted of moderate-density shrub and ground cover with low-density *Erodium* cover. Percent bare ground did not differ significantly between regions or among sites. Distribution of bare ground did deviate between regions with most of it found among more dense shrublands at Anza-Cahuilla Valley while Potrero largely consisted of sparse grasslands.

Our 2 best supported habitat models (site+shrub and site+shrub+erodium) contained 48% of the Akaike weight with no other model accounting for > 13% (Table 5). Models that estimated ψ with a site-varying effect accounted for 100% of weight in

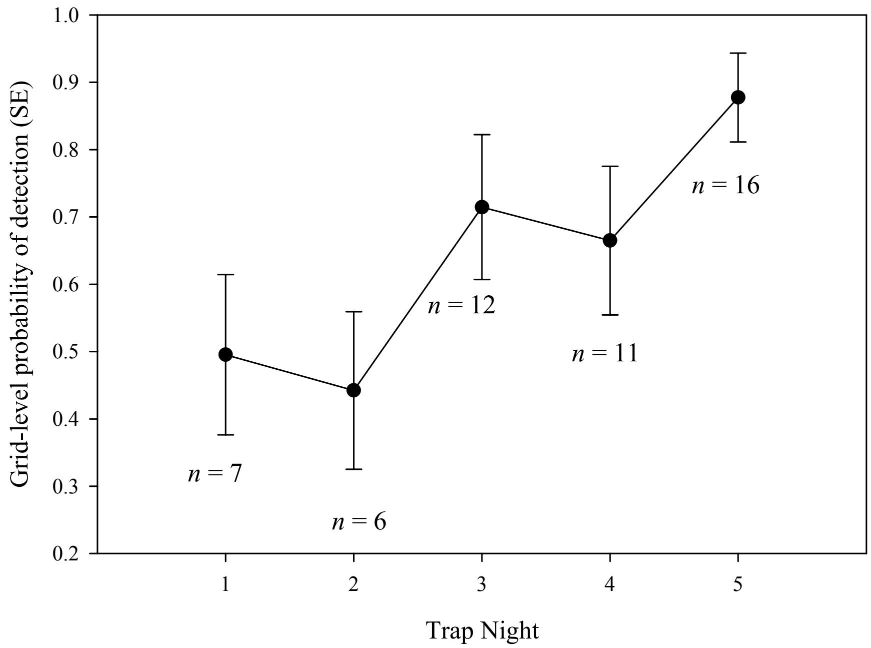


Figure 4. Nightly grid-level detection probability based on an occupancy model,and number of grids out of 61 where Stephens' kangaroo rat were captured (*n*) across 4, 5-night efforts and 2 sites at Anza-Cahuilla region.

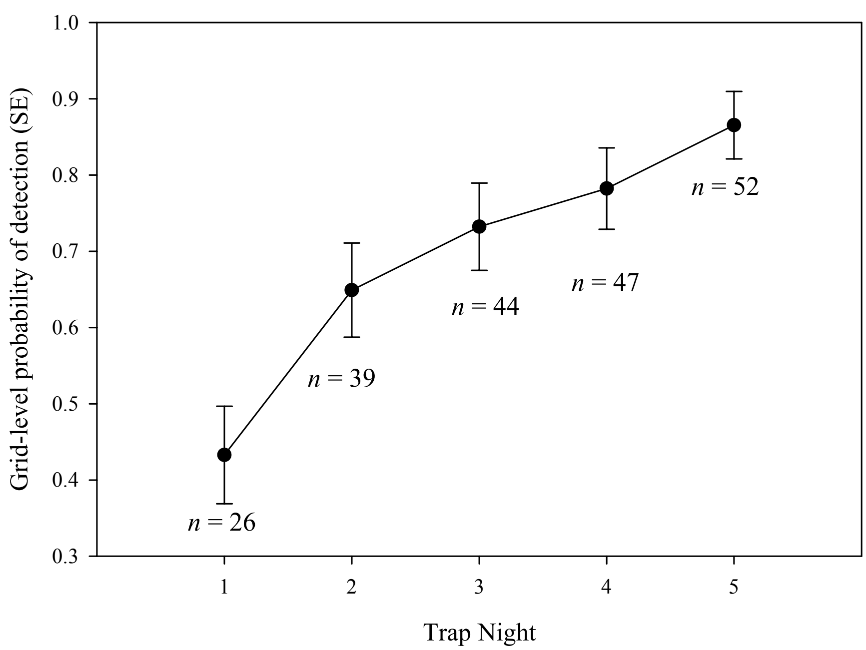


Figure 5. Nightly grid-level detection probability based on an occupancy model, and number of grids out of 80 where Stephens' kangaroo rat were captured (*n*) across 5, 5-night efforts at Potrero Valley region.

Table 4. Average percent (95% CI) of ground cover, bare ground, shrub cover, *Erodium*, and average vegetation height on 5x5 grids sampled at Wilson Valley, Silverado Ranch, Potrero, and across sites combined.

Covariate	Silverado Ranch	Wilson Valley	Potrero	All
Ground Cover	43.1 (36.3, 49.8)	54.4 (46.8, 61.9)	65.5 (61.3, 69.8)	57.8 (54.2, 61.4)
Bare Ground	12.5 (8.8, 16.2)	13.3 (8.7, 17.9)	16.1 (12.6, 19.6)	14.7 (12.3, 17)
Shrub Cover	12.8 (7.3, 18.4)	16.6 (11.3, 21.8)	6.2 (3.8, 8.6)	9.7 (7.5, 12)
Erodium	2.9 (0.6, 5.3)	0.4 (0.1, 0.7)	16.6 (12.4, 20.7)	10.2 (7.5, 12.9)

Table 5. Akaike Information Criterion for small samples (AIC*c*), difference in AIC*c* (ΔAIC*c*), Akaike weights (w_i), estimated parameters (*K*), and log likelihood of the 10 most supported habitat models from a candidate set of 64 that examined effects of site, percent ground cover, percent bare ground, percent shrub cover, and percent cover of *Erodium* on Stephens' kangaroo rat distribution.

Model	AIC*c*	ΔAIC*c*	w_i	*K*	-2Log(L)
site+shrub	612.32	0.00	0.26	6	599.70
site+shrub+erodium	613.08	0.76	0.22	8	595.99
site+shrub+bare ground	613.94	1.62	0.13	7	599.10
site+shurb+ground cover	614.38	2.05	0.10	7	599.53
site+shurb+erodium+bare ground	614.81	2.49	0.11	9	595.44
site+shurb+erodium+ground cover	615.18	2.85	0.09	9	595.80
site+shrub+bare ground+ground cover	616.16	3.83	0.05	8	599.07
site+shrub+eodium+bare ground+ground cover	617.12	4.79	0.04	10	595.42
site+ground cover	621.68	9.35	0.00	5	611.23
site+bare ground+ground cover	622.53	10.21	0.00	6	609.91

the candidate set, and suggested that one or more unmeasured variables played a significant role in driving SKR distribution. Shrub cover also received strong support ($\Sigma w_i = 0.99$) and exhibited a negative effect on SKR distribution over 10% ($\hat{\beta} = -2.36$, SE = 0.61). Percent cover *Erodium* ($\Sigma w_i = 0.46$), bare ground ($\Sigma w_i = 0.33$), and ground cover ($\Sigma w_i = 0.29$) received less support than shrub cover, and their effects were less clear because of large estimated standard errors. In general, *Erodium* had a positive effect on SKR occupancy between 0.1% and 10% cover ($\hat{\beta} = 0.49$, SE = 0.38) that diminished when cover exceeded 10% ($\hat{\beta} = 0.11$, SE = 0.34). Occurrence of SKR tended to increase with bare ground ($\hat{\beta} = 0.29$, SE = 0.43) and decrease with ground cover ($\hat{\beta} = -0.07$, SE = 0.5).

Expected occupancy, back transformed from the logit scale, dropped sharply when shrub cover was > 10% (Figure 6). Occupancy at Silverado Ranch declined from

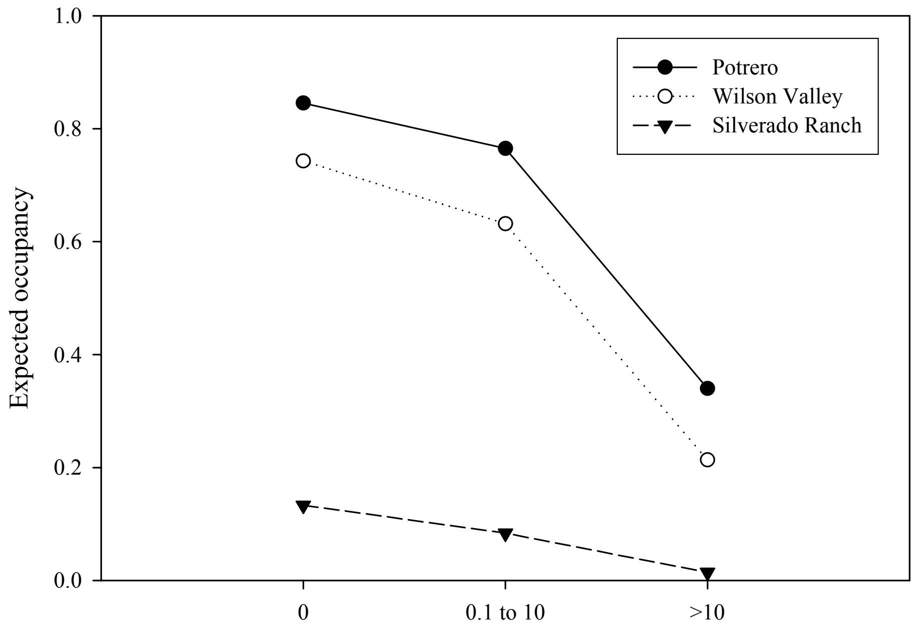


Figure 6. Expected occupancy of Stephens' kangaroo rat on 5x5 grids categorized by 3 levels of percent shrub cover at Potrero, Wilson Valley, and Silverado Ranch. Expected occupancy was reconstitiuted from linear models on the logit scale.

0.13 with no shrub cover to 0.01 with shrub density > 10%. The drop was more precipitous at the other 2 sites, but expected occupancy was still greater with shrub cover > 10% at Potrero ($\psi = 0.34$) and Wilson Valley ($\psi = 0.21$) than at Silverado Ranch with no shrubs present, further indicating the importance of an unmeasured site effect. We captured SKR on 11 of 44 grids surveyed with shrub cover > 10%, and had no detections on grids with >35% shrub cover ($n = 8$).

Population Density

We captured 56 individual SKR across 9 of 15 trapping webs sampled at Anza-Cahuilla Valley (Silverado Ranch: $n = 5$, Wilson Valley: $n = 51$). We also captured San Diego pocket mouse, DKR, Los Angeles pocket mouse, deer mouse, California pocket mouse (*Chaetodipus californicus*), cactus mouse (*Peromyscus eremicus*), San Diego desert wood rat, western harvest mouse (*Reithrodontomys megalotis*), western toad, and dusky-footed wood rat (*Neotoma fuscipes*) (Appendix E). Three of the 6 unproductive trapping webs (Silverado Ranch: $n = 1$, Wilson Valley: $n = 5$) were centered on 5x5-grid sites where only a single animal was captured on a single occasion, and 3 were centered on sites where only 1 to 2 individuals were trapped on 2 or fewer occasions. We captured SKR at all trapping webs sampled at Potrero for a total of 1283 individuals. We also captured San Diego pocket mouse, deer mouse, DKR, California ground squirrel, rock wren (*Salpinctes obsoletus*), California pocket mouse, and cactus mouse.

We successfully met the 3 assumptions of Distance sampling at both Anza-Cahuilla Valley and Potrero. We did not detect first-time captures within the first 2 trap rings on the final trap check for all but 1 of 33 trapping webs sampled. The only new animal detected on the final trap check was a sub-adult male captured on the second trap ring. Ear-tagged animals did not appear to exhibit movement toward web centers, and measured distance of trap stations was maintained throughout each effort.

We tested a total of 6 candidate models with the half-normal+cosine and uniform+cosine models receiving considerable support (Table 6). The half-normal+simple-polynomial model also appeared to perform well, but we removed the remaining 3 models from our analysis because of poor fit based on the shape of the detection curve (i.e., shape criterion) and results of chi-square goodness of fit tests. Weighted-average detection probability was 0.25 (CI: 0.2, 0.3) across the 2 regions, and population density (SKR per ha) was considerably higher at Potrero ($\hat{D}$ = 119, CI: 90, 158) than Anza-Cahuilla Valley ($\hat{D}$ = 6, CI: 3, 13); but we emphasize that Potrero estimates represented the most abundant 30% of occupied area in this region, while estimates from Anza-Cahuilla Valley characterize every site where SKR was detected with 5x5 grids.

DISCUSSION

We estimated that SKR occupied approximately 828 ha of suitable habitat sampled between Anza-Cahuilla Valley and Potrero in 2008, which is 386 ha short of the objective for these regions. Some acreage of occupied habitat may be gained through future land acquisitions as the reserve system in the Anza-Cahuilla Valley region becomes more complete. In the current configuration of Conserved Lands, Potrero accounted for 82% of occupied area with SKR distributed across three fourths of suitable soils in that region. Occupancy at Potrero was likely at or near a maximum in 2008, and can be expected to decline as the area moves through post-fire seral stages of expanding shrub cover and maturing grasslands (Price et al 1995). In contrast, only 11% and 44% of suitable habitat was occupied at Silverado Ranch and Wilson Valley respectively, suggesting that active management could have a greater immediate impact on SKR distribution at Anza-Cahuilla Valley than at Potrero.

Stephens' kangaroo rat has been well documented in intermediate-succession grasslands, and populations have responded well to prescribed fire, shrub removal, and a combination of grazing and mowing (O'Farrell and Uptain 1989; Price et al 1994b; Price et al 1995; Kelt et al 2005). Our results supported previous observations that SKR prefer established grasslands with a forb component (O'Farrell 1990), and further suggested that distribution of the species could be improved with the reduction of shrubs and by resetting grassland succession to earlier seral stages. Silverado Ranch may benefit the most from management action because maturing grasslands have retained patches of *Lupine*- and *Erodium*-dominated landscapes that held SKR in 2008. It seems plausible that SKR distribution could be improved by expanding these forb-dominated areas into

Table 6. Akaike Information Criterion (AIC) rankings, Akaike weights (w_i), number of parameters modeled (K), shape-criterion fit, and results of chi-square goodness of fit tests for 6 distance models used to estimate density and detection probability of Stephens' kangaroo rat at Anza-Cahuilla Valley and Potrero.

Model	AIC	ΔAIC	w_i	K	Shape Criterion	χ^2	df	α	Removed
Half-normal+Cosine	3825.79	0	0.49	2	Yes	5.34	4	0.25	No
Uniform+Cosine	3825.98	0.2	0.44	4	Yes	1.77	2	0.41	No
Half-normal+Simple-polynomial	3829.86	4.08	0.06	3	Yes	7.12	3	0.07	No
Uniform+Simple-polynomial	3830.71	4.92	-	4	No	12.9	3	0.01	Yes
Uniform+Hermite-polynomial	3856.59	30.81	-	2	No	46.65	5	<0.01	Yes
Half-normal+Hermite-polynomial	3864.84	39.05	-	1	No	61.36	4	<0.01	Yes

the surrounding grasslands and mixed patches of shrubs. Prescribed fire may provide the greatest immediate improvement by quickly reducing thatch and encroaching shrubs, and would best mimic natural processes in an area prone to wildfire (Price et al. 1995). Maintaining livestock that already exist at Silverado Ranch combined with mowing may also help preserve conditions if management action is taken there (O'Farrell and Uptain 1989; Kelt et al 2005; *but see* Johnston and Anthony 2008).

Our observations of vegetation cover generally supported the Dudek & Associates (2007) habitat index, but indicated that SKR may be less tolerant of shrub cover than suggested. We observed a sharp decline in expected occupancy when shrub cover was >10% while the habitat index often categorized densities of up to 60% as moderately-suitable habitat. We rarely encountered SKR in moderate-density (e.g., >25%) shrublands and never in shrub cover > 35%, suggesting that we may have exaggerated our estimates of available habitat by including areas of high-density (e.g., >40%) shrub cover in our survey area. Still, it is important to note that we surveyed relatively fewer grids with shrub cover > 10% than trap sites that were dominated by grassland. Expanding surveys to include more high-density shrub cover is likely needed to confirm our observations and to delineate a possible threshold of suitable SKR shrub cover. In contrast, percent ground cover had little effect on SKR distribution in our dataset. Proportion of annual forbs to grasses may have been a better indicator of grassland suitability than cover density because forbs were less likely to create thick layers of dead matter and represented an important food source (O'Farrell 1990). We were unable to distinguish between grass- and forb-dominated grasslands in our dataset, but density of *Erodium* did have a positive effect on SKR occupancy and received considerable support in our models.

Underlying site effect received overwhelming support in explaining SKR occupancy. Each site represented a unique landscape subject to disparate abiotic influences and vegetation communities, thus making the identification of unmeasured variables explaining SKR distribution difficult. A possible candidate that deserves further investigation may be the distribution and size of suitable habitat patches on the landscape. Stephens' kangaroo rat habitat was highly fragmented in Anza-Cahuilla Valley with 36% of it occurring in isolated patches too small to be randomly sampled. Patches that could be surveyed were also fairly small with only 1 parcel >100 ha and the rest averaging just 26 ha. In contrast, habitat at Potrero occurred in relatively large and contiguous blocks. Fragmentation may limit SKR dispersal, dictate viability of local populations, and conceivably influence distribution of the species in patchy landscapes (Price and Endo 1989; Goldingay and Price 1997).

Population density objectives for Stephens' kangaroo rat were met at both Anza-Cahuilla Valley and Potrero with >5 individuals per ha estimated on at least 30% of occupied habitat. Animals were especially abundant at Potrero with the population nearly 20 times more dense than at Anza-Cahuilla Valley. The large disparity in population density between regions could partially be explained by the fact that we only sampled the most abundant grids at Potrero in order to address species objectives. Relative abundance per 5x5 grid was also much greater at Potrero than Anza-Cahuilla Valley, and suggested that our density estimates represented the correct relationship if not an accurate magnitude of difference.

Our estimate of SKR density at Anza-Cahuilla Valley should be viewed with some caution because the confidence interval dipped below the 5-individual threshold defined by the species objectives, and SKR were not detected on 6 of the 15 trapping webs sampled. Stephens' kangaroo rats tend not to exhibit seasonal variation in spatial distribution when DKR, a coexisting competitor, is present (Goldingay and Price 1997). Size of suitable habitat patches may also influence the viability of local populations (Price and Endo 1989). We detected both SKR and DKR on two thirds of 5x5 grids where unproductive trapping webs were placed later in the year. Absence of SKR where they had previously been detected may have indicated that habitat was marginal or encompassed too small an area to sustain a local population. Indeed, unoccupied trapping webs were centered on grids that contained either moderate- to high-density shrub cover, or consisted of tall ground cover with thick litter. Also, all but 1 of the unoccupied trapping webs were placed on habitat patches that averaged only 28 ha, compared to occupied trapping webs that represented patches averaging 71 ha. The 1 unoccupied web that did occur on a large patch (209 ha) encompassed a dense stand of *Artemisia tridentata* situated near the patch boundary.

Recommendations for Future Surveys

Trapping webs and 5x5 grids worked well to address the species objectives of population density and occupied habitat, and should be strongly considered in future survey designs. Trapping webs were easier to set-up and operate than large cumbersome grids, and were more flexible in that they produce viable estimates from fewer captures and did not require that all individuals be detected across the entire trapping area. The use of 5x5 grids also produced a more comprehensive picture of SKR distribution than possible with a larger grid design because a greater number of plots representing homogenous habitat could be sampled.

Still, substantive questions remained concerning the roles that habitat fragmentation, shrub cover, and grassland quality played in determining the distribution of SKR on the landscape. We should incorporate variable patch size into future sampling designs with the goal of identifying the minimum area of suitable habitat required for presence of SKR. Grids should either be selectively installed within patches too small (e.g., < 1 ha) for random placement, or spacing reduced between traps (e.g., 10-m spacing) so that 5x5 grids can randomly fit within a greater number of fragments. We should also expand future surveys to include a greater sample of moderate- to high-density (e.g., < 25%) shrublands with the aim of delineating a threshold of suitable SKR shrub cover. Care should be taken to determine accessibility (e.g., distance from roads, slope, etc…) of shrublands a priori because it may be impractical to conduct night surveys in remote areas with high-density (e.g., >40%) chaparral, and inferences should be made to only those areas that can be sampled. Finally, we should consider using a point intercept method of collecting vegetation data to better quantify differences between grass- and forb dominated grasslands. Visual estimates of percent cover risked substantial observer bias without regular and time-consuming calibration among field personnel, and it was difficult to estimate cover of individual species on 0.4-ha plots. Point-intercept transects can help alleviate observer bias, but data should be collected on pilot plots to determine a minimum sampling intensity required to accurately describe trapping-grid footprints.

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Appendix A. Habitat Suitability Index Model.

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Habitat Assocations

The Stephens' kangaroo rat is found almost exclusively in open grasslands or sparse shrublands with cover of less than 50 percent during the summer (e.g., Bleich 1973; Bleich and Schwartz 1974; Grinnell 1933; Lackey 1967; O'Farrell 1990; Thomas 1973). O'Farrell (1990) further clarified this association and argues that the proportion of annual forbs and grasses is important because Stephens' kangaroo rats avoid dense grasses (for example, non-native bromes [Bromus spp.]) and are more likely to inhabit areas where the annual forbs disarticulate in the summer and leave more open areas. He also noted a positive relationship between the presence of the annual forb red-stemmed filaree (Erodium cicutarium), grazing, and the Stephens' kangaroo rat. O'Farrell and Uptain (1987) noted a decline in the abundance of Stephens' kangaroo rat in the Warner Ranch area when the livestock were changed from mixed Hereford stock to Holstein dairy cattle, thus reducing grazing pressure and allowing for the proliferation of three-awn grasses (Aristida sp.). On the other hand, the Stephens' kangaroo rat has been trapped in brittlebush (Encelia farinosa) dominated coastal sage scrub with an estimated shrub cover of over 50 percent (USFWS 1997).

Although there are no confirmatory data, it has been assumed that the Stephens' kangaroo rat historically occupied habitat dominated by native perennial grasses and forbs (e.g., Price and Endo 1989).

Soil type also is an important habitat factor for Stephens' kangaroo rat occupation (O'Farrell and Uptain 1989; Price and Endo 1989). As a fossorial (burrowing) animal, the Stephens' kangaroo rat typically is found in sandy and sandy loam soils with a low clay to gravel content, although there are exceptions where they can utilize the burrows of Botta's pocket gopher (Thomomys bottae) and California ground squirrel (Spermophilus beecheyi). Also, Price and Endo (1989) suggest that sandy soils may be necessary for sand bathing, which keeps oils from building up in their fur. Sand bathing also may serve an important social communication function (Randall 1993). As noted by others (e.g., Brown and Harney 1993), kangaroo rats tend to avoid rocky soils. Stephens' kangaroo rats may be found on rocky soils, but population densities generally are much lower.

Slope is a factor in Stephens' kangaroo rat occupation; the Stephens' kangaroo rat tends to use flatter slopes (i.e., < 30 percent), but may be found on steeper slopes in trace densities (i.e., < 1 individual per hectare). Furthermore, the Stephens' kangaroo rat may use steeper slopes for foraging, but not for burrows (Behrends, pers. obs.). In general, the highest abundances of Stephens' kangaroo rats occur on gentle slopes less than 15 percent.

Because open ground is an important habitat factor, the distribution and quality of Stephens' kangaroo rat habitat also is a function of periodic fires, range use by grazing animals (O'Farrell and Uptain 1987), year-to-year weather variations (Price and Endo 1989), and probably longer cycles of dry and wet periods. Although precipitation is positively related to primary production of food resources and breeding activities (McClenaghan and Taylor 1993; Price and Kelly 1994), several years of high rainfall can be detrimental. For example, dense matting of annual grasses, such as ripgut grass (Bromus diandrus), may exclude this species from certain areas after periods of high rainfall (USFWS 1997). Over the short term, however, Goldingay and Price (1997) did not detect seasonal differences in habitat use by the Stephens' kangaroo rat despite seasonal variation in the microhabitat.

Methods

In order to identify potential trapping grids for the SKR monitoring program, soils (Knecht 1971) and vegetation communities (CNPS 2005) mapped within the study areas were evaluated and ranked for their suitability as SKR habitat. These habitat suitability rankings are relatively subjective, but based on the literature cited above in the habitat description to the extent possible. They are also based on the field experience of the authors (Phil Behrends) based on many years of field experience with the SKR. These rankings are not meant to be definitive of suitable habitat, but rather provide a tool for the relative ranking of areas within the study area for establishing trapping grids that capture the environmental gradient used by the SKR.

Following from the description of SKR habitat above, both soils and vegetation communities were ranked on a scale of 1 to 4 as follows:

1	=	Very Low Suitability
2	=	Low Suitability
3	=	Moderate Suitability
4	=	High Suitability

Soils and vegetation communities ranked as Very Low Suitability almost always do not support the SKR, although there are rare exceptions. Soils and vegetation communities ranked as Low Suitability typically do not support the SKR, but occasionally the species may occur, but usually only in trace densities (< 1 SKR/hectare). Soils and vegetation communities ranked as Moderate Suitability more commonly support the SKR, but occupancy and populations densities may vary from season-to-season or year-to-year in relation to stochastic events (e.g., precipitation cycles, vegetation succession) and/or demographic factors. Soils and vegetation communities ranked as High Suitability typically support the SKR on the most consistent basis and at the highest population densities. Absence of the SKR from these areas only would be expected where local populations have been extirpated due to some other environmental pressure; e.g., a small isolated habitat patch subject to high predation levels.

As described above, the SKR typically uses friable soils on relatively level terrain; i.e., sandy and sandy loam soils with little clay and gravel content on slopes less than 30 percent (although exceptions to both criteria do occur). Table x shows the Habitat Suitability rankings for soils. Clays and Gullied Land were assigned Very Low Suitability. Generally rocky or cobbly soils and/or soils on steeper, eroded slopes (> 25 percent) and Terrace Escarpments (typically 30-70 percent slopes) were assigned Low Suitability. Loamy soils and sandy loam soils on somewhat steep slopes (e.g., 15-35 percent) were assigned Moderate Suitability. Sandy soils and sandy loams on gentle slopes (< 15 percent) were assigned High Suitability.

Table x show the Habitat Suitability rankings for vegetation communities. The Habitat Suitability ranking is based on a combination of the vegetation community type and the density rating for the particular mapping unit. The "N" under SKR Suitability indicates that the vegetation community typically does not support the SKR, such as riparian and sycamore and coast live oak woodland communities. Although the SKR is considered to be a grassland species, all shrubland communities were assigned "P" for potential habitat because where there are openings or disturbances within shrublands patches, or the community is sparsely distributed (such as after wildfire or extended drought), SKR occupation may occur, often in a dynamic fashion related to successional factors in the community (e.g., in relation to wildfire, grazing or other disturbances of vegetation, and precipitation cycles). For potential habitat, the Habitat Suitability ranking was then related to the following density values assigned to the community by CNPS (2005):

1	=	Greater than 60%
2	=	40-60%
3	=	25-40%
4	=	10-25%
5	=	2-10%

As noted above the SKR typically occupies habitat with less than 50 percent vegetation cover, although it may be found in areas with more than 50 percent cover, especially grasslands during the spring growing season, but also in some shrublands (USFWS 1997). Typically coastal sage scrub communities are more likely to support SKR than chaparral communities because, in the absence of direct disturbance, they tend to be more open. Generally chaparral communities with densities of "1" or "2" were assigned Low Suitability and densities with "3" or higher were assigned Moderate Suitability. Coastal sage scrub-chaparral communities with densities of "1" were assigned Low Suitability and densities of "2-5" were assigned Moderate Suitability. Coastal sage scrub communities with densities of "1" were assigned Low Suitability, densities of "2-3" were assigned Moderate Suitability, and densities of "4-5" were assigned High Suitability. Annual grassland communities were assigned High Suitability regardless of density because of seasonal and year-to-year variation in densities. Refinement of what grasslands are likely or unlikely to be highly suitable habitat for the SKR over the long-term requires more detailed field surveys to verify site conditions because some annual grassland areas remain too densely vegetated over the seasons and years to reliably support the SKR.

It is important to understand that the rankings provided in Tables x and x are only general and are only intended to identify a potential set of trapping grids. It is possible, and even likely, that SKR occur in areas ranked as having Very Low or Low Suitability for the species, such as where SKR use ground squirrel or gopher burrows in clayey soils, on steeper slopes (especially in areas adjacent High Suitability areas), and in areas where the vegetation communities have been mapped as having a dense cover, but at any given time are suitable for the SKR due to changing field conditions due to disturbances such as wildfire, grazing, extended drought and mechanical clearing.

TABLE X

HABITAT SUITABILITY RANKINGS OF SOILS OCCURRING IN STUDY AREA

Soil Code	Soil Series[1]	Habitat Suitability Rank
BfD	Bosanko clay, 8 to 15 percent slopes	1
BuD2	Buren fine sandy loam, 8 to 15 percent slopes, eroded	4
BxC2	Buren loam, deep, 2 to 8 percent slopes, eroded	3
CaC2	Cajalco fine sandy loam, 2 to 8 percent slopes, eroded	4
CaD2	Cajalco fine sandy loam, 8 to 15 percent slopes, eroded	4
CaF2	Cajalco fine sandy loam, 15 to 35 percent slopes, eroded	3
ChC	Cieneba sandy loam, 5 to 8 percent slopes	4
ChD2	Cieneba sandy loam, 8 to 15 percent slopes, eroded	4
CkF2	Cieneba rocky sandy loam, 15 to 50 percent slopes, eroded	2
EcC2	Escondido fine sandy loam, 2 to 8 percent slopes, eroded	4
EcD2	Escondido fine sandy loam, 8 to 15 percent slopes, eroded	4
EcE2	Escondido fine sandy loam, 15 to 25 percent slopes, eroded	3
EfF2	Escondido rocky fine sandy loam, 8 to 50 percent slopes, eroded	2
FaD2	Fallbrook sandy loam, 8 to 15 percent slopes, eroded	4
GzG	Gullied land	1
HcC	Hanford coarse sandy loam, 2 to 8 percent slopes	4
HuC2	Honcut loam, 2 to 8 percent slopes, eroded	3
LaC	Las Posas loam, 2 to 8 percent slopes	3
LcD2	Las Posas stony loam, 8 to 15 percent slopes, eroded	2
LoF2	Lodo gravelly loam, 15 to 50 percent slopes, eroded	3
LpF2	Lodo rocky loam, 25 to 50 percent slopes, eroded	2
MmC2	Monserate sandy loam, 5 to 8 percent slopes, eroded	4
MmE3	Monserate sandy loam, 15 to 25 percent slopes, severely eroded	3
PlD	Placentia fine sandy loam, 5 to 15 percent slopes	4
PrD	Porterville cobbly clay, 2 to 15 percent slopes	1
SmE2	San Timoteo loam, 8 to 25 percent slopes, eroded	3
TaF2	Temescal loam, 15 to 50 percent slopes, eroded	2
TbF2	Temescal rocky loam, 15 to 50 percent slopes, eroded	2
TeG	Terrace escarpments	2
VsC	Vista coarse sandy loam, 2 to 8 percent slopes	4
VsD2	Vista coarse sandy loam, 8 to 15 percent slopes, eroded	4
YbC	Yokohl loam, 2 to 8 percent slopes	3
YbD2	Yokohl loam, 8 to 15 percent slopes, eroded	3
YkE2	Yokohl cobbly loam, 2 to 25 percent slopes, eroded	2
YrD2	Ysidora very fine sandy loam, 2 to 15 percent slopes, eroded	4
YsE2	Ysidora gravelly very fine sandy loam, 8 to 25 percent slopes, eroded	3

[1] Knecht, A. A. 1971. Soil Survey of Western Riverside Area, California. U.S. Department of Agriculture, Washington, D.C.

TABLE X

HABITAT RANKINGS OF VEGETATION COMMUNITIES IN STUDY AREA

Vegetation Community Alliance Mapping Unit Name[1]	Habitat Suitability Rank	SKR Suitability	Cover Density
Coast Live Oak - Sycamore Riparian	1	N	1
Coast Live Oak - Sycamore Riparian	2	N	2
California Juniper - Coastal Sage Scrub	3	P	4
California Juniper - Coastal Sage Scrub	3	P	5
Willow	1	N	1
Willow	2	N	2
Willow	2	N	3
Willow	2	N	4
Chamise - Coastal Sage Scrub Disturbance	2	P	1
Chamise - Coastal Sage Scrub Disturbance	3	P	2
Chamise - Coastal Sage Scrub Disturbance	3	P	3
Chamise - Coastal Sage Scrub Disturbance	3	P	4
Chamise - Coastal Sage Scrub Disturbance	3	P	5
Laurel Sumac - California Buckwheat - Black Sage - White Sage - California Sagebrush	3	P	4
Mexican Elderberry - Mulefat	2	N	4
Mexican Elderberry - Mulefat	2	N	5
California Sagebrush - California Buckwheat - Annual Grass-Herb	3	P	2
California Sagebrush - California Buckwheat - Annual Grass-Herb	3	P	3
California Sagebrush - California Buckwheat - Annual Grass-Herb	4	P	4
California Sagebrush - California Buckwheat - Annual Grass-Herb	4	P	5
Brittlebush - California Buckwheat	3	P	3
Brittlebush - California Buckwheat	4	P	4
Brittlebush - California Buckwheat	4	P	5
Coast Live Oak	2	N	2
Coast Live Oak / Annual Grass-Herb Association	2	N	3
Coast Live Oak / Annual Grass-Herb Association	2	N	5
California Juniper / Annual Grass-Herb Association	4	P	5
California Juniper - California Buckwheat - California Sagebrush Association	4	P	4
California Juniper - California Buckwheat - California Sagebrush Association	4	P	5
Mixed Tree and Shrub Willow Super Alliance	1	N	1
Red Willow	1	N	1
California Sycamore	1	N	1
California Sycamore	2	N	2
California Sycamore	2	N	3

California Sycamore	2	N	4
Sugar Bush Alliance	4	P	4
Chamise Pure Association	2	P	1
Chamise - California Buckwheat Association	2	P	2
Chamise - Hoaryleaf Ceanothus - Black Sage Association	2	P	1
Chamise - Hoaryleaf Ceanothus - Black Sage Association	2	P	2
Chamise - Hoaryleaf Ceanothus - Black Sage Association	2	P	3
Chamise - Hoaryleaf Ceanothus - Black Sage Association	2	P	3
Chamise - Hoaryleaf Ceanothus - Black Sage Association	3	P	4
Chamise - Hoaryleaf Ceanothus - Sugar Bush Association	2	P	1
Mulefat	2	P	3
Mulefat	2	P	4
California Sagebrush - California Buckwheat	3	P	2
California Sagebrush - California Buckwheat	3	P	3
California Buckwheat	4	P	4
California Buckwheat	4	P	5
Brittlebush Alliance	4	P	4
California Sagebrush - White Sage	3	P	2
Brittlebush - California Sagebrush Association	3	P	2
Brittlebush - California Sagebrush Association	3	P	3
Brittlebush - California Sagebrush Association	4	P	4
Brittlebush - California Sagebrush Association	4	P	5
California Buckwheat - Brittlebush Association	3	P	3
California Buckwheat - Brittlebush Association	4	P	4
California Buckwheat - Brittlebush Association	4	P	5
California Sagebrush - Laurel Sumac Association	3	P	2
California Sagebrush - Laurel Sumac Association	3	P	3
California Sagebrush - Laurel Sumac Association	4	P	4
California Annual Grassland	4	P	1
California Annual Grassland	4	P	2

[1] CNPS. 2005. Vegetation Alliances of Western Riverside County, California.

The Habitat Suitability rankings for the soils and vegetation communities were then combined to generate an overall ranking score for the vegetation/soils polygon combinations as follows:

Score	**Ranking**
2	Very Low Suitability
3-4	Low Suitability
5-6	Moderate Suitability
7-8	High Suitability

Appendix B. Western Riverside County MSHCP Monitoring Program Standard Operating Procedures: Small Mammal Trapping

These are the standard procedures developed by the Western Riverside County MSHCP Biological Monitoring Program for trapping small mammals covered by the Conservation Plan. Individual projects may have specific procedures and requirements that vary from those described here. Variations from these standard procedures will be described in the Methods section of individual project protocols.

I. Site Selection

Site selection criteria will be project specific, but generally involve the use of Geographic Information Systems (GIS) software (e.g., ArcGIS) to generate random points based on the current available knowledge of target species occurrence. Universal Transverse Mercator (UTM) coordinates will be assigned to each random point and field crews will use a Global Positioning System (GPS) unit to navigate to each site and verify that they conform to individual project selection criteria (e.g., species specific suitable habitat). Grids will be placed at each random point and consist of only one vegetation community (e.g., grassland) and soil type (e.g., sandy loam) specific to the target species to be surveyed. Grids will also be placed at least 100 m from each other and at least 70 m from vegetation communities that differ from those found on the grid site to avoid edge effects.

II. Setting out Trap Lines

Equipment:

- Modified Sherman traps
- Millet
- List of random UTM points
- Ant powder
- Transect tape 100m
- Sharpie pens
- Flagging/Pin flags
- Trap carrying bags
- Handheld GPS unit/ Compass
- Trash bags

Trap Grid Layout: Grids will vary in size according to project specific goals, but will be installed following identical procedures regardless of design. Grids will be placed so that the area sampled comprises a homogenous vegetation community with random points representing southwest corners. We will adjust grid corners and record the new UTM coordinates in the event that the random point would result in a grid footprint covering multiple vegetation types. Diagonal distance between corners will be measured to ensure the gird is square ($a^2 + b^2 = c^2$), and the north-south and east-west lines will be marked with 100-m tapes. Pin-flags will be labeled and placed according to location within the grid and project specific intervals (e.g., SKR = 15 m). Trap lines will be labeled alphabetically and increasing eastward, with trap stations within a line labeled numerically (e.g., A1, A2…A7) and increasing northward (Figure 1). Note: the number of trap lines within a grid and the number of stations on a line will differ according to project specific goals.

Trap Placement and Setting: Unfold the trap and push the front door until it engages with the treadle tab. The front door can easily be found by noticing that there is a crease on the left side of the trap when the door is facing you. There is also a "lip" at the top of the same side.

Lightly tap on the side or bottom of trap. A light tap will be about as hard as if you were trying to make a spider fall off the side of the trap. The door should snap shut If the trap is set properly. You can adjust the sensitivity of the trap by pulling the tab forward or pushing it backward. Pushing back will make the door more sensitive, a forward pull will make it less sensitive. Please ask if you cannot find the tab.

Place the trap on the ground at the station with the opening facing northward once you are sure the sensitivity is correct (placing all the traps facing the same direction reduces the number of variables). Traps should be placed on a level surface so that the trap does not teeter and the trap entrance is flush with the ground. Use your boot to scrape out an even space if necessary. Traps should be placed parallel to the trap line as indicated in the trap placement diagram (Figure 1). Take about 1 tablespoon of millet and toss most of it into the trap. Make sure that the millet is in the back of the trap, behind the treadle; otherwise an animal is likely to be too close to the door when it shuts and damage

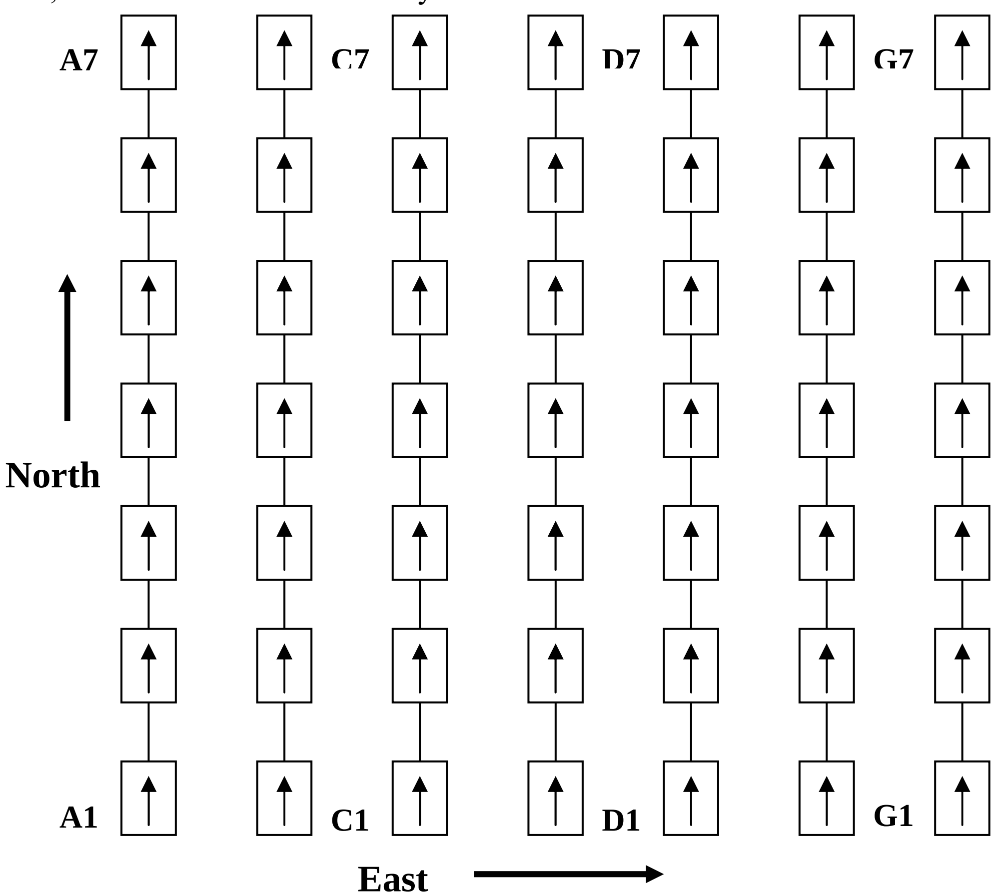

Figure 1.Grid design (7x7) for trapping small mammals. Boxes represent individual traps and arrows indicate direction that open doors face. Traps are labeled alphabetically and increasing to the east, numerically and increasing to the north.

its tail

Ant Caution: Ants can kill animals in a trap. Sprinkle provided ant powder liberally under and in front of traps if ants are present. Make sure that there are no ants inside the trap before you add bait. Apply ant powder if there are ants even if you are doing the last trap check of the day/night unless the grid is being closed. Do not set a trap if the ants are particularly thick and you feel they are too numerous for the powder to be effective. Be sure to record that the trap was not set.

III. Checking Traps

Note: All of the procedures described below require training and experience. If you are not comfortable with the training you have received, or you are fearful that the methodologies used at your last job are not the ones used here, it is your responsibility to alert the Mammal Program Lead (Bill) or the Monitoring Program Coordinator (Karin). If you are scheduled for an activity you do not feel qualified to conduct, alert Karin or Bill as soon as possible. Do not ever conduct a procedure you are not comfortable with.

Equipment per handler:

1 Headlamp per person
3 Pesola® Scales: 20g, 100g and 300g
2 Rulers (1 short 1 long, 0 at edge)
1 Kestrel per handler
1 Manicure scissors for hair clipping
4 Animal handling bags (Ziplock®)
Datasheets (>2 per grid, extras better)
Grid quality control sheets (>1 per grid)
Animal Mortality Record
Clipboard 1 per recorder
Several pens
Species field guide/key
Digital camera
Waste bags for used millet
Ant powder (pre approved only)
Backpack
Extra batteries
Mag light flash light

Traps will be checked either once or twice per night. The first check (i.e., midnight check) will be approximately 5 hours after sunset and the second check will be just before dawn. Traps may be closed after the midnight check, but the midnight check cannot be skipped in favor of a morning only check.

Note pin-flag number and whether each trap was open, closed and empty, or closed with a capture while checking trap lines. Make note of the status of each trap in the appropriate box on your trap-check quality control sheet to ensure that no traps are missed. Mark "O" for open traps, "C" for closed with no capture, "R" for robbed traps, (traps that are open with no bait inside), and use the four-letter species alpha code for traps closed with an animal inside. Be sure to physically pick-up each trap to check for bait and ensure that treadles are set properly. Only record the status of the traps you or your handling/recording partner checked. Adjust the treadle on robbed traps.

When there is no animal in the trap: Visually check each open trap to verify that there is not a pocket mouse in the trap. We have captured several pocket mice in seemingly open traps when the treadle was tripped while being handled. Also, place your hand inside the trap and push the treadle to the bottom of the trap to ensure that no mice are hiding under the treadle. Never close a trap without looking inside and checking the treadle first. Dispose of excess bait in your waste bag if the grid is being closed, otherwise reset and bait traps if another check is to occur later that night. Place closed and empty traps perpendicular to the trap line after the final check of the night and grids will be reopened later that day. Otherwise, fold traps and put them into a trap bag if it is the final check of the survey effort.

Pick-up closed traps and gently shake with the door facing upwards so that the contents move to the back of the trap. This will ensure that very small animals (e.g., pocket mouse) will not be crushed when you open the trap door. Slowly open traps that seem too light to contain an animal to ensure that a pocket mouse or small Peromyscus is not inside. Gently depress the treadle to check for animals underneath. Harvest mice, pocket mice and determined Peromyscus fit easily under the treadle. Fold traps and put them into a trap bag, or return it to the trap station as appropriate if you are absolutely certain that they contain no animals.

When there is an animal in the trap: If the door is closed pick up the trap and take notice of the weight. If it feels like an animal is inside follow the directions below. Use caution as occasionally non-mammal species may be captured (see rattlesnakes below).

Removing small mammals: Hold the trap parallel to your body with the door facing upward and the side of the trap with the split panel facing you (solid panel should be facing you if left handed). Place a Ziplock® bag over the top of the trap so that the crease at the bags opening fits snugly into a trap corner. Wrap the excess portion of the bag around the trap so that there are no spaces and hold it securely against the trap with your working hand (e.g., right hand). Extend the bag so that there is a large and unobstructed space opening into the bag from the trap door. Gently shake the trap downward so that the animal moves to the back of the trap and will not be crushed by the door as you open it inwards. Open and hold the trap door through the bag with the fingers on your working hand. Invert the trap quickly and firmly with a downward shake so that the animal falls into the bag. Be firm but remember you have a live animal in the trap. Quickly grasp the plastic bag and form a tight barrier between the animal and the trap as soon as it enters the bag and is completely clear from the trap door. Many species have very long tails and you should be careful that these too are clear from trap doors before allowing them to close. Remove the bag completely from the trap. Watch for trap wires hooked into the bag.

Be aware of ants! Treat as needed as specified above.

Missing Traps: Make a methodical search if you can not find a trap at a station. Do another search once you are finished checking the grid and make note for bait and trapping crews if the trap can not be located. You should look until you either find the trap or you are very certain it is not in the area. Involve other crew members in the search if they are available. Leave notice for the morning or bait crews if the trap can not be found so that a daylight search can occur. You should be very reluctant to leave a trap unaccounted for because captured animals will die from daytime heat, or if a predator has moved the trap it will likely return for a second helping.

If you suspect there is a Rattlesnake in the trap: The first thing you will notice when a snake is in a trap is that is feels abnormally heavy. Tap on the trap lightly and listen for a rattle if you are uncertain if a snake is in the trap. Note, however, that rattlesnakes tend to not rattle, even when disturbed, if the ambient temperature is particularly cold. Do the following if you hear a rattle or are otherwise certain that a rattlesnake is in a trap: 1) Look around and choose location that is free of obstacles. 2) Place the trap on the ground with the door facing you. 3) Pull the pin out of the bottom-left side of the trap being careful to move backwards away from the trap. 4) The trap should collapse and the snake will be free to exit. 5) Cautiously use a shovel handle (located in field vehicle) to collapse the trap from a safe distance if needed (note that rattlesnakes can strike to distance of 1/3 to ½ their body length!). You can turn the trap upside down if that makes it easier for you to remove the pin. This procedure will free all snakes in a trap, but you need to be alert and prepared to move when you are releasing a rattlesnake. Do not attempt to remove a rattlesnake if you are at all uncomfortable with the procedure. Rather, ask an experienced crew member for help.

Make note of the incident on the data sheet in the notes section. Either repair the trap in the field or replace it with an extra one and repair it in the office.

IV. Filling out the datasheet

Trap ID: Record the letter and the number of the trap where you catch an animal under 'Trap ID' on the data sheet.

Weighing the animal: Be sure to zero the Pesola® scale each night before attempting to weigh animals. Look at the scale while it is empty and see that it reads zero. Use the knob at the top of the scale to adjust as necessary. To use the scale, fold the bag with animal in it down then sideways and attach the clip of the scale in the center. Wait until the animal is calm before reading the scale. Record this weight in grams under 'Total wt' on the data sheet. Save bag contents to weigh later.

Handling the animal: Place the bag with an animal inside against your thigh or the ground and trap the animal in a section of the bag without allowing its nose to get into a corner. Grasp the animal firmly by the scruff of the neck with the bag between your fingers and the animal. Be sure to grasp the animal with your non-working hand (e.g left) so that you can still effectively use equipment. Unfold the bag to expose the animal. Identify the genus and species, mark the animal if appropriate, as discussed below, take the standard measurements as listed below and record them on the data sheet. Some species may require only one or two of the measurements. You will memorize these. Animals may also be color marked on their ventral side with a non-toxic marker or receive a more permanent unique tag (e.g., PIT tag, ear tag). NOTE: you may find it easier to handle the animal while outside of the plastic bag. This method is also acceptable.

To remove an animal from the handling bag: Secure the animal with your non-working hand (e.g., left) while in the bag. Reach into the bag with your free hand and grasp the animal's tail at the base. Never ever hold an animal by its tail away from the base! The tail can easily break off or, more likely, the skin will slide away and leave a bloody appendage that will give you nightmares. Let the animal rest on your upper leg or chest (you are still holding its tail at the base) and scruff it snugly. Measure the animal as described above.

Recaptured animals: An animal is considered a "recapture" if it was previously captured during the particular survey effort that you are trapping. Recaptured animals are identified by the color mark on their ventral side that is unique to a particular trapping effort. Other marks will vary from project to project and may even vary from night to night. Be sure you are clear on the marking scheme being used any time you are trapping. For recaptured animals, record the species, sex, and reproductive condition only. Marking is further discussed below.

Incidental deaths: Record the species and sex and under fate record "dead" if an animal is found dead in a trap. Place the deceased animal in two Ziploc® bags (one inside the other, both zipped closed) if it is a Covered Species. Bring the animal back to the office to be placed in the freezer for later disposition. Write the date, site, station and species on the bag with a sharpie. Fill out a mortality record form located in the trap kits for each dead animal or incident while you are in the field. Place the completed form on the Mammal Program Lead's desk when you return to the office. If the dead animal is a listed species (SKR, SBKR), also put a copy of the Mortality Record on Karin's desk. Designate one crew member to call Karin at home on Saturday morning if the mortality occurs on a Friday night. We are required to notify the Fish and Wildlife Service within 24 hours of finding a listed animal that is dead.

Incidental births: Place the mother on the ground and watch her if she enters a burrow if an animal gives birth while in the trap. Place the babies in the entrance of that burrow and leave them alone. Place the babies outside the trap and record the incident in the notes section on the data sheet if you do not know where she went.

Hot or Cold animals: Place cold animals (lethargic and unresponsive) in a pocket close to your body until it is revived. You can bring the animal into a heated vehicle if you are really worried, but be careful about placing the animal directly in front of heater vents.

They are small and can overheat quickly. Release the animal at the station where it was captured once it begins to warm up and move around. An animal that is overheated will also be lethargic and may have moisture around its mouth. Cool down an overheated animal by wetting its fur with plain water and fanning or blowing on the animal. Record the species and sex of the animal and make note of the incident and the outcome.

Marking the animal: Animals are marked by injecting a PIT tag, trimming fur, applying an ear tag, or coloring with a non-toxic marker. Always be clear about the marking method being used when you are checking traps or recording data.

Trimming fur: Mark the animal by clipping a small amount of guard hair on the right hind quarter (or other identified area). Though it is not necessary to clip down to the skin, the mark must be obviously visible. Other clipping patterns may be used (different location on the animal) you will be informed if this is necessary. Circle on the data sheet yes 'Y' or no 'N' for hair sample. Only Mark yes if a hair sample is collected. Place the collected hair in a coin envelope and record the following on the envelope: station number, grid name, date, morning or midnight trap check.

Marker: Write on the ventral surface of the animal with a specified color.

PIT tagging: See separate written instructions. Do not attempt this procedure without training and permission.

Identify the species: You should be comfortable with identification of local small mammal species. Use the field guide included in your mammal packet to help with identification as needed. You can also consult crew mates if there is confusion. Record the species on your data sheet using the 4-letter alpha code. Species codes are included in your mammal packet if you forget one. If you cannot identify a species, take and record all standard measurements, and take photographs of the animal for later identification. Do not spend too much time on this task. Record the capture as new or recapture on the data sheet.

Sexing the animal: Males and females can be differentiated using the following cues:

- Look first for an enlarged scrotum or signs of lactation (bare skin around enlarged nipples).
- Males have a greater distance between anus and genitals than females (in females the genitalia is typically within 1-2 mm of the anus). The skin between the anus and genitals tends to be hairless in females.
- Check for baculum: Using your finger or the tip of a pencil, gently push the genitalia upward (toward the animal's head). If a tiny bony spur protrudes from the genitalia, the animal is a male. Record the sex on the data sheet.

Reproductive status of the animal: For males, the reproductive category can be either scrotal or not reproductive. For females, the categories are pregnant, perforate, lactating, plugged, or not reproductive. Record the status on the data sheet under 'condition'.

Females: Note if the individual is lactating by the presence of enlarged nipples with an area of bare skin immediately surrounding the nipple. A large extended abdomen indicates possible pregnancy. Perforate means the vagina is open. Plugged means a copulatory plug is present. This is a mucous plug that forms in the vaginal orifice a few hours after mating. It looks like a big mucus scab over the vaginal area.

Males: Look for the presence of an enlarged, deflated, or small wrinkled scrotum in males. Any visual indication of a scrotum is to be considered a reproductive individual.

Age: Note the age as juvenile 'J' or adult 'A' depending on pelage. Juveniles of all species are smaller and usually quite gray. They may appear to have large ears and feet in relation to the body size.

Measuring the animal: Be sure you are comfortable with all of these procedures. We follow Ingles, Mammals of the Pacific States. See attached Fig.A1, from p. 448.

Tail length: measure from the dorsal side (top) to the end of the tail bone (not the end of the hair).

Hind foot: Measure from the heel to the tip of the longest claw.

Ear: Distance from notch at front base of ear to distal-most border of the fleshy part of the ear. Do not push on or deform the ear with your ruler.

After processing the animal, remove it from the bag and gently release the animal by placing it on the ground at the trap station where it was captured. Weigh the bag and the contents and record that weight under 'bag wt'. Do not remove millet, waste, etc. from bag before obtaining bag weight. Carry a waste bag with you and after weighing the contents and the bag place the waste into your waste bag. The bag is then reused for the next animal unless it is torn or soiled. Record the fate of the animal as 'R' released, 'E' escaped, or 'D' dead on the data sheet.

Minimum Measurements: In most cases take all measurements on all animals. However, sometimes due to weather conditions, personnel shortages or other legitimate reasons minimum data may be recorded. At a minimum record species, sex, and reproductive status. If there is a crisis, you are authorized to make decisions about what to record and how to protect animals. See separately provided Mammal Trapping Guidelines for weather guidance.

The following measurements can be used to identify species. In most cases they should be collected, as a minimum.

- Chaetodipus – weight , ear at notch, hind foot length. (guards hairs on rump distinguish from Perognathus)
- Peromyscus – all measurements on data sheet
- Neotoma – weight, color of top of hind foot, color of hairs on the throat at their base.

- Dipodomys – weight, ear length, number of toes
- Reithrodontomys – weight, spots on ear bases? Grooves on upper incisors?
- Microtus – weight
- Perognathus – LAPM: weight, spots on ears, and lacking guard hairs.

All other creatures, record species if known and release. Pictures should be taken if time permits.

Closing Traps: Follow check procedures but do not re-bait or re-set the traps. Instead, empty all bait and waste from the trap into a designated trash bag, close the trap and leave the trap perpendicular to the trap line. Treat for ants as needed.

Grid quality control: Once all traps are checked, verify that all traps have been checked by reading through the control sheet out loud. Each party that checked traps will say out loud which traps they checked starting with trap A-1 and finishing at the last trap (G-7 or H-8 or whatever). Sign the sheet recording that you verified that all traps had been checked.

After you are sure that all of the traps have been checked, count robbed and closed-but-empty traps and subtract them from the total number of traps on the grid. Record that number as the number of trap nights.

V. Picking up Trap lines

Equipment:

Shoulder bags for carrying traps and pin flags
Rubber bands/Trap boxes
Waste bag for emptying traps

Collect traps as you check grids on the final check of a survey effort. Empty remaining millet and waste into a trash bag, and collapse the trap for easy carrying in the shoulder bags. Pin flags are to be left in the field, only during ongoing projects. Flagging placed to mark trails must be picked up on the way out of the grid for the last time during that trapping session. If we are using the grid again, the trail can be remarked when the grid is reopened. Count the traps at the end of the collection effort. Make sure all of the traps are accounted for after collection at each grid.

Sort them by letter and place rubber bands around sorted groups if they are to be collected. Again, make sure you have them all. We do not want to be responsible for trash in the Conservation Area.

VI. Cleaning and storing traps

All traps must be cleaned and disinfected before being between sites. Make sure all millet and waste material are knocked out of the traps before soaking them in a 10% bleach and water solution for 10 minutes. Thoroughly rinse the traps with water and allow them to air dry outside preferably in the sun. Place the folded traps into the plastic buckets with lids once dry.

Appendix C. Western Riverside County MSHCP Monitoring Program Vegetation Assessment Protocol for Small Mammal 5x5 Trapping Grids

Many small mammal objectives of the Western Riverside County MSHCP require that populations be monitored among suitable and/or high quality habitats. We will initially determine the distribution of species-specific habitat using models constructed with Geographic Information System (GIS) software. We will then continually refine our GIS-based models by measuring habitat attributes at survey sites when mammal populations are sampled. These habitat data will be incorporated into our analyses as covariates when estimating animal population attributes (e.g., occupancy). We describe here the methods that will be used to measure vegetation cover at 5x5 small mammal trapping grids.

METHODS

We will use ocular estimate to measure percent tree, shrub, and ground cover on 11.9-m-radius circular plots (0.1 acres) centered on each 5x5 grid (trap station C3). We will also identify and estimate percent total cover of the dominant and co-dominant (>5% of cover class) species in each of the three cover classes. Ground cover will be defined as any low lying forb or grass ≤ 30 cm in height, shrubs as any woody species < 2 m or non-woody plant >30 cm in height, and trees as any woody plant > 2 m. Note that yucca plants (*Yucca* spp.) should be included within shrub estimates. We will also record the phenology of dominant species in each cover class as either green/non-flowering, flowering, seeding, or desiccated. We will then estimate total percent cover of litter (i.e., dead vegetative matter laying < 45 degrees to the ground or any uprooted material), bare ground, gravel (2 mm to 3.3 cm), pebble (3.3 cm to 6.4 cm), gravel (6.5 cm to 250 cm), and rock (>250 cm).

We will use a combination of 4 methods to visually estimate percent cover. First, we will divide each plot into quarters by placing 2 measuring tapes perpendicular to each other along the diameter of the plot, estimate percent cover within each quarter (each totaling 25%), and then combine the 4 estimates for total percent cover. We will also randomly toss a calibrated 30 cm x 60 cm PVC frame ≥ 3 times per plot, estimate percent cover laying within each frame, and average estimates across frames for total percent cover. A third method to derive estimates will be to compare each plot with percent cover charts (Terry and Chilingar 1955). Finally, patchy cover will be estimated by taking the circular area under a person's arm span as being 1% the area of a 0.1-acre plot. Cover type, approximate area, and percent cover of heterogeneous vegetation that occurs outside of the sample plot, but inside the trapping grid, will also be noted. We will estimate erodium (*Erodium* spp.) ground cover and/or litter whenever present since this plant species is a favored food source for Stephens' kangaroo rat (*Dipodomys stephensi*).

All 4 methods of visually estimating cover will be calibrated in the field against point intercept derived estimates (two 23.8-m tapes placed perpendicular to each other along the plots diameter) until accuracy and precision among crew members is consistently within ± 5%. A combination of methods will subsequently be used once the acceptable level of precision/accuracy is achieved, keeping in mind the need for regular calibration among observers.

Finally, we will measure slope and aspect (compass degree), and take a digital photo of each sample plot centered on C3. Photo should include a survey pin at C3 to indicate where the plots center is.

Equipment

- Calibrated 1-m2 PVC frame
- 2 measuring tapes
- 6 survey pins
- Percent cover charts
- Compass
- Clinometer
- Datasheets
- Field maps

REFERENCES

Terry, R.D. and G.V. Chilingar. Comparison charts for visual estimation of foliage cover. Journal of Sedimentary Petrology. 25(3):229-234.

FIELD PROCEDURE

1. Place field equipment outside of the plot area to minimize trampling of vegetation.
2. Stretch 2 perpendicular measuring tapes 23.8 m along the 'C' and '3' trap lines. Each tape should be centered on trap station 'C3'. Use survey pins to secure tapes at each end, and run tapes through the head of a single survey pin at trap station 'C3'.
3. Take a digital photo from outside of the circular plot that you just created. Center the photo on trap station 'C3' and try to get the whole plot in the frame. Also, try to keep the sun behind you while taking the photo.
4. Use a clinometer to measure slope (percent) and aspect of the sample plot/grid. Take slope in an area that is indicative of the entire sampling plot/grid.
5. Visually estimate percent vegetation cover using the 4 methods described in the above protocol. Begin with broad categories of tree, shrub and ground cover estimates. Then, identify dominant species in each cover class and estimate total percent cover of each.
6. Estimate percent cover using point-intercept method. Record cover type occurring at each meter along the perpendicular measuring tapes that you stretched out. You should have 46 'hits' when finished. Then, divide the number of 'hits' that you

have in each cover type by 46 to determine percent cover. You may need to adjust estimates if cover types occur in patches (e.g., shrub patches).

7. Compare percent covers derived from point-intercept against ocular estimates. Point-intercept will usually be a closer estimate of what is actually on the ground, but may be misleading if the tape crosses or misses a patchy cover type (e.g., large bare ground patches).

8. Work towards estimating percent cover with ocular methods only as these will be the most efficient use of time. HOWEVER, we want to maintain a healthy balance between efficiency and accuracy. So, continue to calibrate your estimates among yourselves and against the point-intercept.

MISCELANEOUS

1. Cover types that occur at a density < 1% will be considered 'trace' and should be recorded as 0.1%.

Appendix D. Relative Abundance of Small-mammals Captured on 5x5 Grids at Anza-Cahuilla Valley and Potrero Unit of San Jacinto Wildlife Area.

I. Anza-Cahuilla Valley

Silverado Ranch

Grid	Species	*n*
SO008	NONE	0
SO009	NONE	0
SO010	deer mouse*	5
SO011	Dulzura kangaroo rat	1
	deer mouse*	1
SO012	Dulzura kangaroo rat	4
	Stephens' kangaroo rat	3
	deer mouse*	8
	Los Angeles pocket mouse	2
SO013	deer mouse*	5
SO014	deer mouse*	2
	Los Angeles pocket mouse	1
SO015	Dulzura kangaroo rat	2
	deer mouse*	5
SO016	Dulzura kangaroo rat	2
SO017	NONE	0
SO018	NONE	0
SO019	Los Angeles pocket mouse	1
SO020	Los Angeles pocket mouse	1
SO021	deer mouse*	1
SO022	deer mouse*	2
SO023	**Stephens' kangaroo rat**	2
SO024	NONE	0
SO025	NONE	0
SO026	**Stephens' kangaroo rat**	2

Grid	Species	*n*
SO027	**Stephens' kangaroo rat**	1
	deer mouse*	1
SO028	Dulzura kangaroo rat	1
	deer mouse*	1
SO029	San Diego pocket mouse	1
	deer mouse*	1
	Los Angeles pocket mouse	1
SO030	NONE	0
SO031	Los Angeles pocket mouse	1
SO032	NONE	0
SO033	Dulzura kangaroo rat	2
	deer mouse*	1
SO034	deer mouse*	8
SO035	Dulzura kangaroo rat	3
	deer mouse*	8
SO036	deer mouse*	2
SO037	NONE	0
SO038	NONE	0
SO039	Dulzura kangaroo rat	4
	deer mouse*	4
SO040	Dulzura kangaroo rat	1
SO041	Dulzura kangaroo rat	2
	deer mouse*	20
SO042	deer mouse*	8
SO043	NONE	0

Wilson Valley

Grid	Species	*n*
WV001	San Diego pocketmouse	7

Gird	Species	*n*
WV015	San Diego pocketmouse	12

Grid	Species	n
WV002	San Diego pocketmouse	2
	Stephens' kangaroo rat	1
WV003	San Diego pocketmouse	3
	Dulzura kangaroo rat	1
	Stephens' kangaroo rat	1

Grid	Species	n
	Stephens' kangaroo rat	1
WV016	deer mouse*	3
WV017	Dulzura kangaroo rat	4
	Stephens' kangaroo rat	2
	San Diego pocketmouse	1

Wilson Valley - continued

Grid	Species	*n*
WV004	Dulzura kangaroo rat	1
	Stephens' kangaroo rat	6
WV005	San Diego pocketmouse	1
WV006	NONE	0
WV007	San Diego pocketmouse	1
	Stephens' kangaroo rat	1
WV008	San Diego pocketmouse	5
WV009	San Diego pocketmouse	15
WV010	San Diego pocketmouse	8
WV011	San Diego pocketmouse	4
	Stephens' kangaroo rat	2
WV012	San Diego pocketmouse	3
WV013	San Diego pocketmouse	15
WV014	San Diego pocketmouse	4
	Audobons' cottontail rabbit*	1

Gird	Species	*n*
WV018	**Stephens' kangaroo rat**	4
WV019	San Diego pocketmouse	10
	Dulzura kangaroo rat	4
	Stephens' kangaroo rat	1
	San Deigo desert wood rat	1
WV020	San Diego pocketmouse	8
	Dulzura kangaroo rat	5
	Stephens' kangaroo rat	1
	San Deigo desert wood rat	1
LV001	NONE	0
LV002	Stephens' kangaroo rat	5
LV003	NONE	0
LV004	**Stephens' kangaroo rat**	2
LV005	NONE	0

* Non-covered species that was not batch marked and *n* may represent individuals captured multiple times.

II. Potrero

Grid	Species	*n*
PR070	deer mouse*	6
PR071	deer mouse*	6
	Stephens' kangaroo rat	2
PR072	**Stephens' kangaroo rat**	3
	Dulzura kangaroo rat	2
PR073	deer mouse*	3
PR074	**Stephens' kangaroo rat**	4
	San Diego pocket mouse	1
PR075	**Stephens' kangaroo rat**	1
	deer mouse*	1
PR076	**Stephens' kangaroo rat**	3
	deer mouse*	1
PR077	deer mouse*	3
	Dulzura kangaroo rat	1

Grid	Species	*n*
PR106	**Stephens' kangaroo rat**	1
PR107	**Stephens' kangaroo rat**	15
PR108	**Stephens' kangaroo rat**	14
PR109	**Stephens' kangaroo rat**	16
PR110	**Stephens' kangaroo rat**	8
PR111	**Stephens' kangaroo rat**	5
PR112	**Stephens' kangaroo rat**	2
PR113	**Stephens' kangaroo rat**	1
PR114	**Stephens' kangaroo rat**	9
	western toad	1
PR115	**Stephens' kangaroo rat**	7
PR116	**Stephens' kangaroo rat**	6
	deer mouse*	2
PR117	**Stephens' kangaroo rat**	12

PR078	**Stephens' kangaroo rat**	1
PR079	**Stephens' kangaroo rat**	3
	San Diego pocket mouse	1
PR080	San Diego pocket mouse	6
	Dulzura kangaroo rat	5
PR081	Dulzura kangaroo rat	2
	San Diego pocket mouse	1
PR082	San Diego pocket mouse	2
	Dulzura kangaroo rat	2
	deer mouse*	1
PR118	**Stephens' kangaroo rat**	3
	San Diego pocket mouse	1
PR120	Dulzura kangaroo rat	1
	Stephens' kangaroo rat	1
	deer mouse*	1
PR121	**Stephens' kangaroo rat**	4
PR122	**Stephens' kangaroo rat**	1
PR123	**Stephens' kangaroo rat**	1
PR124	deer mouse*	1
PR125	San Diego pocket mouse	3
	Stephens' kangaroo rat	1

II. Potrero - continued

Grid	Species	*n*
PR083	San Diego pocket mouse	2
	Dulzura kangaroo rat	1
	Stephens' kangaroo rat	1
PR084	San Diego pocket mouse	1
PR085	**Stephens' kangaroo rat**	2
PR086	**Stephens' kangaroo rat**	1
PR087	**Stephens' kangaroo rat**	6
PR088	**Stephens' kangaroo rat**	5
PR089	**Stephens' kangaroo rat**	2
PR090	**Stephens' kangaroo rat**	2
PR091	**Stephens' kangaroo rat**	1
PR092	**Stephens' kangaroo rat**	2
PR093	**Stephens' kangaroo rat**	4
	Dulzura kangaroo rat	1
PR094	**Stephens' kangaroo rat**	10
	San Diego pocket mouse	1
PR095	**Stephens' kangaroo rat**	2
PR096	**Stephens' kangaroo rat**	6
	unknown kangaroo rat	1
PR097	San Diego pocket mouse	1
	deer mouse*	1
PR098	**Stephens' kangaroo rat**	4
PR099	Dulzura kangaroo rat	1
	deer mouse*	1
PR100	**Stephens' kangaroo rat**	4
PR101	**Stephens' kangaroo rat**	6
PR102	**Stephens' kangaroo rat**	3

Grid	Species	*n*
PR126	deer mouse*	2
	Stephens' kangaroo rat	1
	San Diego pocket mouse	2
PR129	**Stephens' kangaroo rat**	1
PR131	**Stephens' kangaroo rat**	10
	unknown kangaroo rat	1
PR132	**Stephens' kangaroo rat**	8
	Dulzura kangaroo rat	1
PR133	**Stephens' kangaroo rat**	4
PR134	San Diego pocket mouse	1
	Stephens' kangaroo rat	1
PR135	Dulzura kangaroo rat	3
	San Diego pocket mouse	1
PR137	San Diego pocket mouse	6
	Dulzura kangaroo rat	5
	deer mouse*	4
PR138	Dulzura kangaroo rat	4
PR139	**Stephens' kangaroo rat**	1
PR140	San Diego pocket mouse	3
PR141	**Stephens' kangaroo rat**	1
PR142	San Diego pocket mouse	6
	Stephens' kangaroo rat	3
PR143	**Stephens' kangaroo rat**	4
	San Diego pocket mouse	1
PR144	**Stephens' kangaroo rat**	8
PR145	**Stephens' kangaroo rat**	3
	San Diego pocket mouse	6

PR103	**Stephens' kangaroo rat**	8	PR146	**Stephens' kangaroo rat**	3
PR104	**Stephens' kangaroo rat**	18			
	California ground squirrel	1			

* Non-covered species that was not batch marked and *n* may represent individuals captured multiple times.

Appendix E. Relative Abundance of Small-mammals Captured on Trapping Webs at Anza-Cahuilla Valley and Potrero Unit of San Jacinto Wildlife Area.

I. Anza-Cahuilla Valley

Silverado Ranch

Web	Species	*n*
SO044	Los Angeles pocketmose	21
	deer mouse*	9
	Dulzura kangaroo rat	7
SO046	Los Angeles pocketmose	4
	Stephens' kangaroo rat	2
	deer mouse*	1
SO047	California pocketmouse*	2
	Dulzura kangaroo rat	1
	Stephens' kangaroo rat	1
	dusky-footed wood rat*	1
SO048	deer mouse*	5
	California pocketmouse*	2
	Stephens' kangaroo rat	2
	Dulzura kangaroo rat	1
	Los Angeles pocketmouse	1
	western harvest mouse*	1

Wilson Valley

Web	Species	*n*
WV022	San Diego pocketmouse	24
	Stephens' kangaroo rat	5
	Dulzura kangaroo rat	2
WV023	San Diego pocketmouse	41
	Stephens' kangaroo rat	10
	California pocketmouse*	1
	Dulzura kangaroo rat	1
WV024	San Diego pocketmouse	58
	Stephens' kangaroo rat	8
	Dulzura kangaroo rat	1
WV025	San Diego pocketmouse	54
	Dulzura kangaroo rat	2
	San Diego desert wood rat	1
	deer mouse*	1
WV026	San Diego pocketmouse	94
	western toad	1
	deer mouse*	1
WV027	San Diego pocketmouse	48
	Dulzura kangaroo rat	38
	deer mouse*	6
WV028	Dulzura kangaroo rat	12
	Stephens' kangaroo rat	12
	San Diego pocketmouse	11
	San Diego desert wood rat	1
WV029	San Diego pocketmouse	149
	Dulzura kangaroo rat	17
	deer mouse*	6
	cactus mouse*	1
WV030	San Diego pocketmouse	117
	Dulzura kangaroo rat	19
	California pocketmouse*	1
	San Diego desert wood rat	1
LV006	Los Angeles pocketmouse	3
	San Diego pocketmouse	1
LV007	**Stephens' kangaroo rat**	14
	Los Angeles pocketmouse	2
	San Diego pocketmouse	1

	Stephens' kangaroo rat	2
	cactus mouse*	2
	California pocketmouse*	1

* Non-covered species that was not batch marked and *n* may represent individuals captured multiple times.

II. Potrero

Web	Species	*n*
PR152	**Stephens' kangaroo rat**	76
PR153	**Stephens' kangaroo rat**	41
PR154	**Stephens' kangaroo rat**	56
	California ground squirrel*	4
	San Diego pocketmouse	1
	Dulzura kangaroo rat	1
PR155	**Stephens' kangaroo rat**	32
	San Diego pocketmouse	5
	Dulzura kangaroo rat	2
PR156	**Stephens' kangaroo rat**	40
	San Diego pocketmouse	5
	deer mouse*	5
PR157	**Stephens' kangaroo rat**	87
	San Diego pocketmouse	2
PR158	**Stephens' kangaroo rat**	95
	Dulzura kangaroo rat	1
PR159	Stephens' kangaroo rat	35
	San Diego pocketmouse	5
	Dulzura kangaroo rat	1
PR160	**Stephens' kangaroo rat**	50
	deer mouse*	12
	San Diego pocketmouse	3
	Dulzura kangaroo rat	1
PR161	**Stephens' kangaroo rat**	112
	San Diego pocketmouse	8
PR162	**Stephens' kangaroo rat**	117
PR163	**Stephens' kangaroo rat**	80
	Dulzura kangaroo rat	2
PR164	**Stephens' kangaroo rat**	42
	San Diego pocketmouse	36
	Dulzura kangaroo rat	5
	deer mouse*	1
PR165	**Stephens' kangaroo rat**	85
	San Diego pocketmouse	33
	deer mouse*	13
	Dulzura kangaroo rat	2
	California pocketmouse*	1
PR166	**Stephens' kangaroo rat**	55
	San Diego pocketmouse	23
	Dulzura kangaroo rat	1
	deer mouse*	1
PR167	**Stephens' kangaroo rat**	93
	San Diego pocketmouse	3
	cactus mouse*	1
	deer mouse*	1
PR168	**Stephens' kangaroo rat**	108
	deer mouse*	22
	San Diego pocketmouse	7
	Dulzura kangaroo rat	7
	rock wren*	2
PR169	**Stephens' kangaroo rat**	79
	San Diego pocketmouse	4
	rock wren*	1

* Non-covered species that was not batch marked and *n* may represent individuals captured multiple times.