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

## Aguanga Kangaroo Rat
## (*Dipodomys merriami collinus*)
## Survey Report 2011

**23 March 2012**

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**NOTE TO READER:**

This report is an account of survey activities conducted by the Biological Monitoring Program for the Western Riverside County Multiple Species Habitat Conservation Plan (MSHCP). The MSHCP was permitted in June 2004. The 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, and the Wildlife Agencies (i.e., 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.

MSHCP reserve assembly is ongoing and it is expected to take 20 or more years to assemble the final Conservation Area. The Conservation Area includes lands acquired for conservation under the terms of the MSHCP and other lands that have conservation value in the Plan Area (called public or quasi-public lands in the MSHCP). In this report, the term "Conservation Area" refers to the Conservation Area as understood by the Monitoring Program at the time the surveys were planned and conducted.

We would like to thank and 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 data collection activities were conducted in 2011 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.

While we have made every effort to accurately represent our data and results, it should be recognized that data management and analysis are ongoing activities. Any reader wishing 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.

The primary preparer of this report was the 2011 Mammal Program Lead, Jennifer Hoffman. 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. Further information on the MSHCP and the RCA can be found at www.wrc-rca.org.

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# INTRODUCTION

Aguanga kangaroo rat (*Dipodomys merriami collinus*; AKR) is a California species of special concern. The range of AKR stretches from the Mason Valley in eastern San Diego County north along the western edge of the Colorado Desert to Earthquake and San Felipe Valleys, and northwest into the Aguanga and Wilson Valleys of southwestern Riverside County (Williams et al. 1993). Within Riverside County this species is typically found in Riversidean alluvial fan sage scrub associated with the floodplains of Temecula Creek, Wilson Creek, and their tributaries, but may also be found in Riversidean sage scrub, chaparral and grassland vegetation in adjacent upland areas (Dudek & Associates 2003). AKR is often associated with sandy-loam soils that are common throughout the designated core drainages.

The Western Riverside County MSHCP calls for the conservation of 5484 acres (2219 ha) of suitable habitat for AKR in Temecula Creek, Wilson Creek, and their tributaries (Dudek & Associates 2003). The MSHCP species-specific monitoring objectives for AKR also require that at least 75% of conserved habitat must be occupied, with 20% of occupied habitat supporting a population of at least 5–15 individuals per ha, as measured over any 8-yr period.

Biological Monitoring Program biologists documented the distribution of AKR in portions of core drainages and tributaries that occur on conserved lands in autumn 2010. We used a repeat-visit survey design to estimate Percent Area Occupied (PAO) of suitable habitat based on a GIS-based model we previously created. We captured AKR on 4 of 36 grids sampled in 2010, including 2 grids in the Temecula Creek drainage, and 2 grids in the Tule Creek drainage. Our 2010 results showed cumulative detection probability (0.995) was high across trap nights with an estimated nightly grid-level probability of detection of 0.76 (SE = 0.13), and a grid occupancy of 0.111 (SE = 0.05). The extrapolated area of occupied moderate- to high-suitability habitat from our model-based estimates of grid occupancy was 10.9 ha. Although the area of confirmed occupied habitat was lower than the minimum required to meet the stated species objective, we wanted to determine whether or not the AKR population was at or above the minimum required density in order to better describe the current status of this species.

We initially targeted both areas occupied in 2010 (Temecula Creek and Tule Creek) for density-estimation sampling in 2011. However, the footprint of the small mammal trapping webs we use to acquire the data to estimate animal density was larger than the available land in conservation and available for access at the Tule Creek site. Therefore, in 2011, our goals and objectives for surveying AKR were as follows:

### Goals and Objectives:

1. Estimate population density of Aguanga kangaroo rat on occupied habitat at Temecula Creek.
    a. Use distance sampling methods and circular trapping webs in areas occupied by AKR.
    b. Estimate population density using Program DISTANCE.

## METHODS

### Study Site Selection

Site selection for the distribution-based sampling conducted in 2010 was based on a habitat suitability model we developed for Los Angeles pocket mouse (LAPM) surveys because this species shares similar habitat requirements with AKR. For those surveys, we had initially defined the study area as all conserved land in the floodplains of Temecula Creek, Wilson Creek, and their tributaries. We used GIS-based soil (Soil Survey Staff 2006) and vegetation maps (CDFG et al. 2005) of western Riverside County to identify suitable habitat within the potential study area. Targeted soil types included sand and loam associated with floodplains or drainages (Germano 1997, Bornyasz 2003), as well as gravelly strata but not rock, stone, or cobble (M'Closkey 1972, Meserve 1976, Winchell et al. 1999; Appendix A). Targeted vegetation types included grassland, coastal sage scrub, chaparral, desert scrub, Riversidean alluvial fan scrub, and wet meadow (e.g., playas, vernal pools) (Dudek & Associates 2003; Appendix A), but not shrubland or scrub with >60% cover density (Germano 1997). We modified the resulting model for LAPM by removing upland alluvial soils not associated with floodplains or drainage channels. In 2011, we conducted targeted trapping for AKR at sites where we captured AKR in 2010. Of the initial potential study area, approximately 13.5 ha along Temecula Creek and its tributaries met the above criteria for this project.

### Survey Locations

The configuration of accessible lands and suitable habitat patches in the floodplains of Temecula Creek made it difficult to fit 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 AKR was likely greater inside the boundary of our habitat-suitability model than outside (Buckland et al. 2007). To control for this bias, we ensured webs were completely within the boundaries of both conserved land and suitable habitat. We used Hawth's Tools extension (Beyer 2004) for ArcGIS v.9.3.1 (ESRI 2009) to create a negative buffer that extended 100 m from the edge of conserved lands, then non-randomly placed 2 trapping webs within the buffered area. The 2 webs combined covered 6.28 ha of the 13.5 ha that met our criteria.

Temecula Creek was the only site that met the necessary criteria for AKR trapping in 2011 (i.e., occupancy in 2010, and enough land in conservation to allow placement of trapping webs). We used 2 circular trapping webs with the objective of estimating population density (Figure 1). Each web consisted of 12 trap lines, each 100 m long and radiating from the center at 30-degree intervals (Figure 2). At each web location we established 148 trap stations, which consisted of a Sherman trap and a pin flag. We placed 4 trap stations at the center of the web, each opening in 1 of the 4 cardinal directions. We then placed 12 trap stations along each trap line. Four trap stations were placed at 5, 10, 15, and 20 m from the center of the web; the remaining 8 trap stations were spaced 10 m apart, between/from 30-100 m from the center. We labeled the pin flag

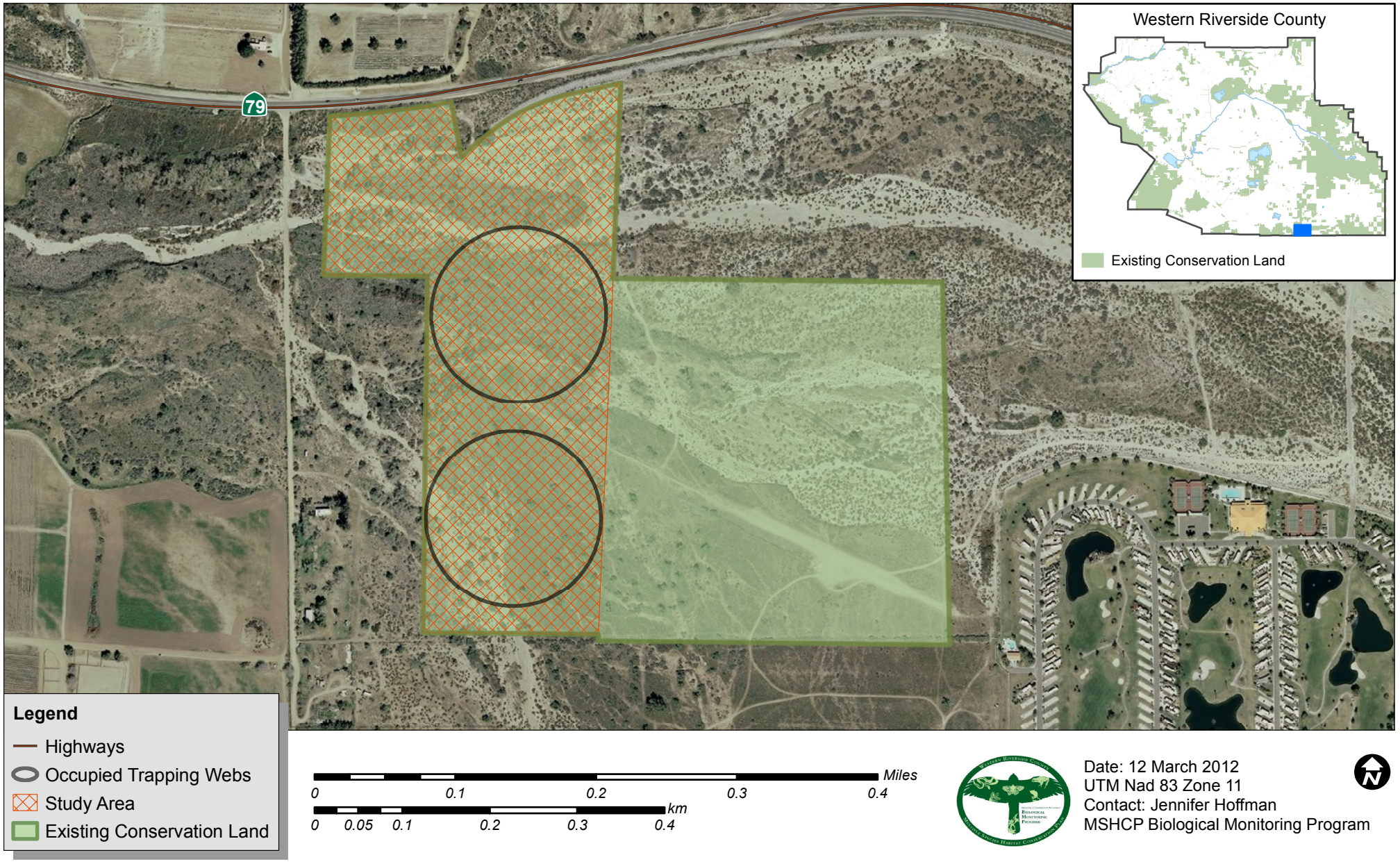


**Figure 1.** Aguanga kangaroo rat survey area with trapping webs, 22 - 26 August 2011.

at each trap station with the trap line (alpha code; A-H) and a categorical code for distance from the center (numeric code; e.g. "3" = 15 m).

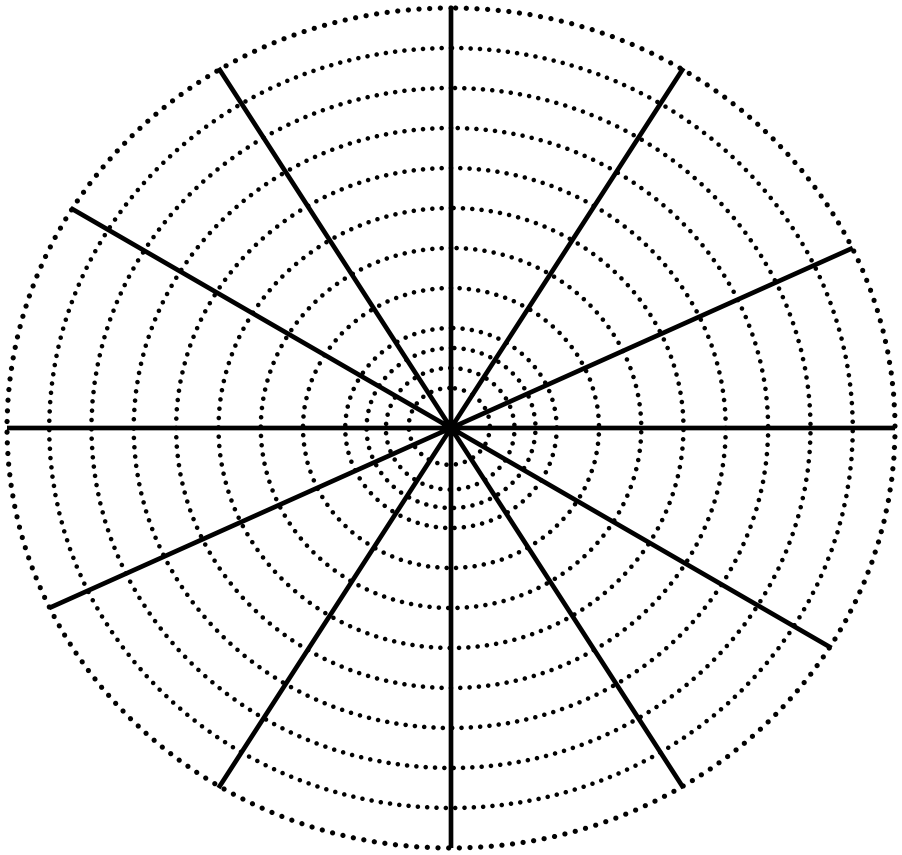

**Figure 2.** Trapping web design (area = 3.14 ha) used to survey for Aguanga kangaroo rat population density.

Distance sampling methods require that 3 assumptions are met before population density can be estimated: 1) all individuals near trapping web centers are detected, 2) distance from web centers to each trap are measured accurately, and 3) there is no directional movement of animals (e.g., movement toward the web's center) (Buckland et al. 2001). 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. The distance methods we 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 AKR distribution.

We surveyed for AKR in Temecula Creek for 1 week, 22-26 August 2011. We surveyed over one 4-night effort (Monday–Friday), controlling for sampling bias by semi-randomizing the order of nightly trap checks (time bias) and alternating field-crew web assignments (observer bias; MacKenzie and Royle 2005). We also scheduled this

effort to coincide with the new moon to control for the effect that lunar brightness may have on small-mammal activity (Daly et al. 1992).

**Field Methods**

We trapped AKR using 12″ x 3″ x 3.5″ Sherman live traps modified with paper clips to prevent trap doors from potentially damaging animals' tails. Traps were baited with 1 tablespoon of sterilized large-white Proso millet. We marked individual trap stations using pin flags labeled with an alpha-numeric code. We then placed traps ≤1 m from each trap station ($n$ = 148 traps per web).

We checked traps twice each night in accordance with U.S. Fish and Wildlife Service 10(a)(1)(B) permit specifications, because the targeted habitat was potentially occupied by the federally endangered Stephens' kangaroo rat (*Dipodomys stephensi*). We opened traps 1–3 hrs before sunset and started the first check near midnight. After checking all traps, we reset them and added fresh bait if necessary. The second check began 1 h before dawn, after which we closed traps and removed excess millet to avoid attracting ants. After the final dawn shift of the 4-night trapping cycle, we broke down webs by collecting all traps, excess bait, and pin flags.

Before checking each web we recorded moon phase, sky code and ground moisture. We did not bait or open traps during significant precipitation. We also noted the visit number, trap check, web ID, recorder, and start and end times of each web check. One 4-person team checked webs, and the status of individual trap stations was recorded on a quality-control form as either open, occupied by an animal, closed-empty, robbed, or missing. We recorded status of traps with animals using the 4-letter species code of the animal captured. After checking the entire web, we reviewed all entries on the quality control form to ensure that we had checked and closed all traps. Before leaving the web, we recorded ambient air and soil temperature (°C).

We processed captured animals using standard operating procedures developed by the Biological Monitoring Program for handling animals and collecting data (Appendix B). We recorded weight, ear length, hind foot length (*Chaetodipus* spp. only), sex, age class, reproductive condition, capture history, and trap location of each AKR and non-target Covered Species 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, indicating that the animal had been previously captured during that survey. We released recaptured animals after recording species and trap location. We released all non-covered species, unmarked, after recording trap location and species. Processing times ranged from 30 s to 3 min, depending on the species and capture history. Only field personnel with prior animal handling experience or demonstrated proficiency combined with training from experienced Biological Monitoring Program staff processed animals. Volunteers occasionally assisted with recording data throughout the trapping season and processed animals under supervision if they had previous small mammal handling experience.

## Training

Program training focused on proper animal handling and identification, and data collection procedures. Field-based training included 1 trap night of demonstrating species identification and processing animals captured on practice grids (5 traps x 5 traps) at the Potrero Unit of the San Jacinto Wildlife Area (Potrero). Training took place in June 2011, prior to Los Angeles pocket mouse surveys, and only crew members with this LAPM training, or those trained on-site, were allowed to handle animals during the AKR effort. Office-based training was self-paced, with crew members learning the identifying characteristics of the target species and other non-target species they were likely to encounter.

After completing the above training, crew members were able to identify 7 covered and 6 non-covered small mammal species in-hand. Crew members could also safely and proficiently handle and measure live animals according to standard operating procedures developed by the Biological Monitoring Program. Moreover, crew members were able to perform surveys for AKR according to the protocol described in this document. Only crew members that successfully completed training processed animals. The Regional Conservation Authority funded Biological Monitoring Program personnel; volunteers are noted. Biologists conducting AKR surveys in 2011 included:

- Jennifer Hoffman (Project Lead, Biological Monitoring Program)
- Betsy Dionne (Biological Monitoring Program)
- Esperanza Sandoval (Biological Monitoring Program)
- Joe Sherrock (Biological Monitoring Program)
- Talula Barbee (Volunteer, Santa Ana Watershed Association)
- Nicole Housel (Volunteer, Santa Ana Watershed Association)
- Tara Graham (Biological Monitoring Program)
- Lynn Miller (Biological Monitoring Program)
- Michele Felix (Biological Monitoring Program)
- Mari Paramo (Biological Monitoring Program)
- Jonathan Reinig (Biological Monitoring Program)
- John Dvorak (Biological Monitoring Program)

## Data Analysis

We planned to analyze AKR data collected in 2011 with the same methods as those used in our Stephens' kangaroo rat population study (see *2008 Biological Monitoring Program Stephens' Kangaroo Rat Survey Report* ). However, we did not have a large enough sample size to complete the analysis as planned. This analysis would have used Program DISTANCE (Buckland et al. 2007) to estimate population density (AKR per ha) and detection probability of AKR at sites surveyed in 2011. These analyses will be postponed until future survey efforts are able to produce an appropriate sample size for population density estimation (at least 60 animals; Buckland et al. 2001). The data analysis, as planned, along with further details regarding the AKR survey protocol employed in 2011 can be found in the *Western Riverside County MSHCP Biological*

*Monitoring Program 2011 Protocol for Estimating Population Density of Aguanga Kangaroo Rat* (Appendix C).

## RESULTS

We captured 6 AKR across both trapping webs at Temecula Creek. We also captured San Diego pocket mouse (*Chaetodipus fallax fallax*), Dulzura kangaroo rat (*Dipodomys simulans*), Los Angeles pocket mouse, San Diego desert wood rat (*Neotoma lepida intermedia*), and 3 non-covered species (Table 1, Appendix D)

**Table 1**. Summary of species detected while surveying for Aguanga kangaroo rat, 22–26 August 2011. Total reflects the minimum number of unique individuals captured not the total number of captures.

| Scientific Name | Common Name | Covered | Total |
|---|---|---|---|
| *Dipodomys merriami collinus* | Aguanga kangaroo rat | Y | 6 |
| *Chaetodipus fallax fallax* | Northwestern San Diego pocket mouse | Y | 74 |
| *Dipodomys simulans* | Dulzura kangaroo rat | Y | 6 |
| *Perognathus longimembris brevinasus* | Los Angeles pocket mouse | Y | 1 |
| *Neotoma lepida intermedia* | San Diego desert woodrat | Y | 8 |
| *Mus musculus* | House mouse | N | 1 |
| *Peromyscus maniculatus* | Deer mouse | N | 70 |
| *Microtus californicus* | California vole | N | 2 |
| *Neotoma* sp. | Unidentified woodrat | - | 1 |

We could not estimate population density (AKR per ha) for Temecula Creek as the sample size of AKR was too small to analyze with Program DISTANCE.

## DISCUSSION

We were unable to document that population density objectives were being met for Aguanga kangaroo rat because our sample size was too small to complete the analysis as planned. The number of trapping webs ($n = 2$) and detections ($n = 16$) were much lower than recommended (≥15–20 and ≥60–100, respectively) for proper density analysis of small mammals (Buckland et al. 2001). During a study quantifying the efficacy of obtaining proper density estimates using trapping grids and trapping webs, Parmenter et al. (2003) found trapping webs may be better able to estimate small mammal density due to higher capture probabilities and larger size. However, our crew covered a larger area in the Temecula Creek Core Area with trapping webs (6.28 ha) than trapping grids (0.014 ha) and caught fewer animals with webs ($n = 6$) than grids ($n = 17$). The decreased numbers of AKR may have indicated that habitat was either marginal or encompassed too small an area to sustain a local population. Viability of local populations may be influenced by size of suitable habitat patches, with smaller habitat patches subject to stochastic events which could be detrimental to small mammal populations (Price and Endo 1989). Furthermore, differences in captures may be due to natural yearly fluctuations in rodent populations (Lima et al. 2008).

The number of trapping webs we were able to distribute was limited to fitting trapping webs within patches of habitat known to be occupied by AKR. The total area of suitable habitat for AKR in the Conservation Area is approximately 200 ha, and trapping webs were placed on the largest occupied habitat patch, approximately 15 ha in size. Habitat patches ($n$ = 3) occupied by AKR ranged in size from 1.42–15 ha, with 2 of the occupied patches smaller than the area of the trapping web (i.e., <3.14 ha). Centering trapping webs on occupied trapping grid centers, as was the protocol for past MSHCP density surveys (see *2008 Biological Monitoring Program Stephens' Kangaroo Rat Survey Report*), would have resulted in large portions of the webs falling out of access. As a result, protocol was changed and trapping webs were placed only on the largest occupied habitat patch where entire trapping webs would remain on conserved land.

This survey effort did not meet the first assumption of distance sampling because we did not capture AKR in the center of either trapping web. The trap closest to the web center in which we caught AKR was 60 m from the center. If, by way of future land acquisition, we are able to place trapping webs closer to occupied grid centers we can increase our chances of meeting this assumption during future AKR surveys.

The remaining 2 assumptions of distance sampling were met during our AKR surveys in 2011. Marked animals did not appear to exhibit movement toward web centers. Additionally, captured animals did not move far in relation to the size of the web, with captures occurring on only 2 arms of the web for both trapping webs, and more specifically in the 5 outermost trap rings. We were able to satisfy the third assumption because field crews used measuring tapes and compasses to ensure the accuracy of trap placement in each distance category. This method of trap placement was maintained throughout the effort.

**Recommendations for Future Surveys**

We will use data collected in 2011 to design expanded future efforts that will improve our ability to estimate population density of AKR. We did not detect many AKR in 2011 despite a high cumulative detection probability (99%) in our 2010 occupancy study. Trapping webs and the survey design used this year did not work well to address the density objective for Aguanga kangaroo rat. We should modify future sampling designs to identify the minimum area of suitable habitat required for AKR while also being able to obtain density estimates. This can be accomplished by selectively installing grids within patches too small (i.e., <0.4 ha, or <30 m wide) for random placement, or reducing the spacing between traps (e.g., 7-m spacing), so that 5 x 5 grids can randomly fit within a greater number of habitat fragments. Grid spacing of this size will allow for results comparable to other small mammal trapping efforts (e.g., Los Angeles pocket mouse, San Bernardino kangaroo rat, etc.) completed by the Biological Monitoring Program. To increase the chances of obtaining best possible density estimates, and to decrease chances of encountering fluctuations in local populations due to weather, disease, etc., occupancy analysis using trapping grids should take place within the same season as density analysis using trapping webs. We should increase the spacing between trapping grids (<110 m) or decrease the size of trapping webs to ensure no overlap of trapping webs during density surveys. The number of trapping webs should be at least 15–20.

Care should be taken to determine accessibility (e.g., distance from roads, slope, etc) *a priori* because it may be impractical to conduct night surveys in remote areas with high-density vegetation (i.e., >60% for Riversidean alluvial fan scrub, coastal sage scrub, and chaparral, and >5% for riparian scrub), and inferences should be made to only those areas that can be sampled. Soil data in future trapping efforts should be collected, analyzed, and added to the habitat model. Substantial questions still remain regarding the roles that shrub cover, ground cover, and herbaceous cover type play in influencing the distribution of AKR across the landscape. The Regional Conservation Authority has recently acquired a parcel of land adjacent to Temecula Creek (Gellar Phase III) that should be surveyed for AKR (located immediately east of the study area identified in Figure 1). Additionally, arrangements should be made to obtain access to the Wilson Creek Mitigation Bank and determine if AKR are present on this property. Understanding the extent of the AKR range within the Plan Area, as well as the species' relationship with the environment, is a crucial step in appropriate management of AKR. We will be able to better understand and quantify that relationship through further trapping efforts.

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## **Appendix A.** Soil and Vegetation Attributes Used to Delineate Aguanga Kangaroo Rat Habitat.

Soil (Table 1) and vegetation (Table 2) attributes described below represent feature classes included in GIS-based map layers (CDFG 2006; Soil Survey Staff et al. 2006) clipped to the 2010 Conservation Area east of Vail Lake. Represented soil and vegetation reflect habitat characteristics believed to support the occurrence of Aguanga kangaroo rat (*Dipodomys merriami collinus*). We used Arc GIS v. 9.3.1 (ESRI 2009) to select the described features, and merged layers to create a single habitat model for portions of Temecula Creek, Wilson Creek, and tributaries in Conservation. We then defined an area of inference based on modeled habitat that accounted for inaccessible slopes (e.g., >24 degrees), road disturbance, and distance from roads. Grid centers were randomly distributed across the defined area of inference according to survey design.

**Table 1.** Soil attributes and area (ha) included in the suitable-habitat model for Aguanga kangaroo rat on Conserved lands in designated core drainages.

| Series | Soil Classification | Symbol | Area (ha) |
|---|---|---|---|
| Gorgonio | loamy sand | GhC | 1.8 |
| | | GhD | 0.1 |
| | | GlC | 1 |
| Grangeville | fine sandy loam | GrB | 0.2 |
| | | GtA | 0 |
| | | GvB | 0.7 |
| Greenfield | sandy loam | GyC2 | 14.1 |
| Hanford | loamy fine sand | HaC | 6.2 |
| | coarse sandy loam | HcC | 38.2 |
| | | HcD2 | 65.9 |
| | | HeC2 | 5.6 |
| Honcut | sandy loam | HnD2 | 0.4 |
| Metz | fine sandy loam | MgB | 0.8 |
| Mottsville | loamy sand | MoD | 0 |
| Pachappa | fine sandy loam | PaC2 | 1.2 |
| Ramona | sandy loam | RaB3 | 0.1 |
| | | RaD2 | 5 |
| | | RdD2 | 9 |
| | | RdE3 | 2.5 |
| Riverwash | n/a | RsC | 12.7 |
| San Emigdio | sandy loam | SdD | 2.2 |
| | fine sandy loam | SeC2 | 2.9 |
| | | SeD2 | 12.6 |
| Tujunga | loamy sand | TuB | 0.1 |
| | | TvC | 19.2 |

# Appendix A. Continued.

**Table 2.** Vegetation attributes and area (ha) included in suitable-habitat model for Aguanga kangaroo rat on Conserved lands in designated core drainages. Vegetation categories are based on the Wildlife Habitat Relationships (Mayer and Laudenslayer 1988) classification system unless otherwise noted.

| Code[1] | Name | Density[2] | Area (ha) |
|---|---|---|---|
| ACS | Alkali Desert Scrub - Riversidean Alluvial Fan Scrub[3] | 3 | 0.44 |
| | | 4 | 5.08 |
| AGS | Annual Grassland | 1 | 9.07 |
| | | 4 | 0 |
| COV | Cropland and Orchard-Vineyard | 9 | 14.94 |
| CRC | Chamise-Red Shank Chaparral | 2 | 1.04 |
| | | 4 | 0.22 |
| | | 5 | 2.86 |
| CSC | Coastal Scrub | 2 | 21.5 |
| | | 3 | 73.05 |
| | | 4 | 30.17 |
| | | 5 | 1.39 |
| CSC | Coastal Scrub - Riversidean Alluvial Fan Scrub[4] | 2 | 1.59 |
| | | 3 | 9.11 |
| | | 4 | 7.74 |
| | | 5 | 4.02 |
| MCH | Mixed Chaparral | 2 | 11.82 |
| | | 3 | 0.11 |
| | | 4 | 1.55 |
| | | 5 | 0.29 |
| RIV, LAC | Riverine, Lacustrine | 9 | 0.32 |
| VRI | Valley Foothill Riparian | 5 | 6.13 |

[1] see Mayer and Laudenslayer 1988
[2] 0 = unknown, 1 = > 60%, 2 = 40 - 60%, 3 = 24 - 40%, 4 = 10 - 25%, 5 = 2 - 10%, 9 = not applicable
[3] MSHCP designates alkali desert scrub as Riversidean alluvial fan scrub
[4] MSHCP classifies coastal scrub with *Lepidospartum squamatum* dominant as Riversidean alluvial fan scrub.

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# **APPENDIX B.** Small Mammal Trapping Standard Operating Procedures V.3.

These are standard procedures developed by the Western Riverside County MSHCP Biological Monitoring Program for trapping small mammals. 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.

All of the procedures described below require training and experience. You are responsible for alerting the Mammal Program Lead or other lead staff if you are not comfortable with the training you have received. Alert the Mammal Program Lead or other lead staff if you are scheduled for an activity that you do not feel qualified to conduct.

## I. SITE SELECTION

Site selection criteria is project specific, but generally involve the use of Geographic Information Systems (GIS) software to stratify Core Areas by suitable habitat based on vegetation, soil, and slope characteristics known to be associated with the target species. An area of inference is drawn from modeled habitat that accounts for site accessibility (e.g., distance from road, slope, land ownership), and points are randomly distributed across this area. Universal Transverse Mercator (UTM) coordinates are assigned to each random point, and field crew verify accessibility of points. Area of inference is adjusted and points redistributed in the event that plots can not be accessed. Trapping plots are then centered on each random point.

## II. INSTALLING TRAP PLOTS

### Equipment:

Modified Sherman traps
Millet
Coordinates
Ant powder
50-m or 100-m tape
Flagging/Pin flags
Reflecitve tape
Sharpie pens
Trap carrying bags
Handheld GPS unit/ Compass
Trash bags

### Plot Layout

Trap grids vary in size according to project-specific goals, but are installed following identical procedures. Coordinates of points randomly generated in the office represent trapping grid centers (e.g., trap station C3 for a 5 x 5 grid). Trap lines are labeled alphabetically, increasing eastward, with trap stations within a line labeled numerically (e.g. A1, A2…A7) and increasing northward (Figure 1). Each trap station is marked with a labeled pin flag and, when necessary, flagging and reflective tape. Trap lines are also marked with reflective tape if landscape features make it difficult to follow them in the dark. Trap spacing, number of trap lines within a grid, and the number of stations on a line varies according to project-specific goals.

Grid lines are installed by stretching 2 measuring tapes (e.g., 50 m, 100 m) north-south and east-west from the random point, using a declinated compass as a guide.

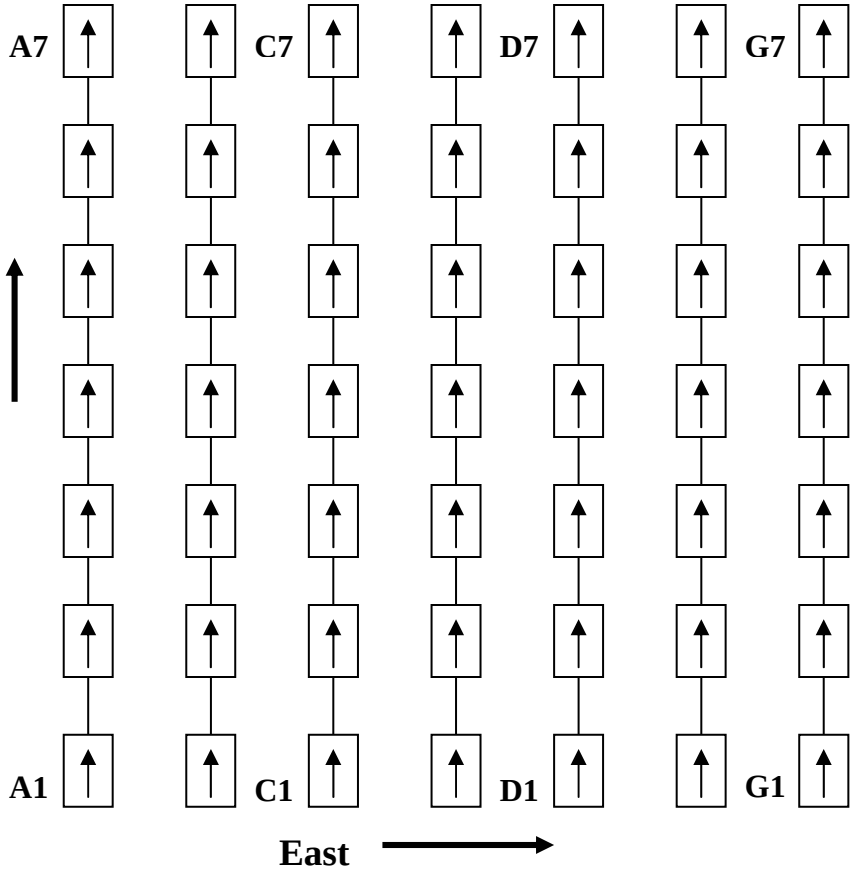


**Figure 1.** Grid design (7 x 7) for trapping small mammals. Boxes represent individual traps and arrows indicate direction of open doors. Traps are labeled alphabetically, increasing eastward; and numerically, increasing northward.

Measuring tapes are held taut, close to the ground, and secured with survey pins. Pin flags are then distributed along the tapes at the appropriate intervals, depending on project-specific protocol. Finally, measuring tapes are stretched north-south from each of the pin flags placed along the east-west line described above. Pin flags are then distributed along these north-south lines to fill out the rest of the grid (Figure 1).

We may also use a trapping web design, depending on project-specific goals. Trap lines within a web radiate from a central point at regular intervals, with a greater density of traps occurring near the center relative to the edges (Figure 2). Trap stations along each trap line are assigned an alpha-numeric label similar to that used for grids, with numbers increasing radially from the web center. Trap stations and lines are marked as described above for grids, and routes between lines at the web perimeter are marked with reflective tape. Trap spacing, number of trap lines, and number of traps per line varies depending on the target species.

Trapping webs are installed by stretching a measuring tape from the random point in a predetermined bearing. The tape is held taut, close to the ground, and secured with survey pins. Additional tapes are stretched from the center point at regular intervals until the circle is complete. Pin flags are distributed along each line according to project-specific protocol.

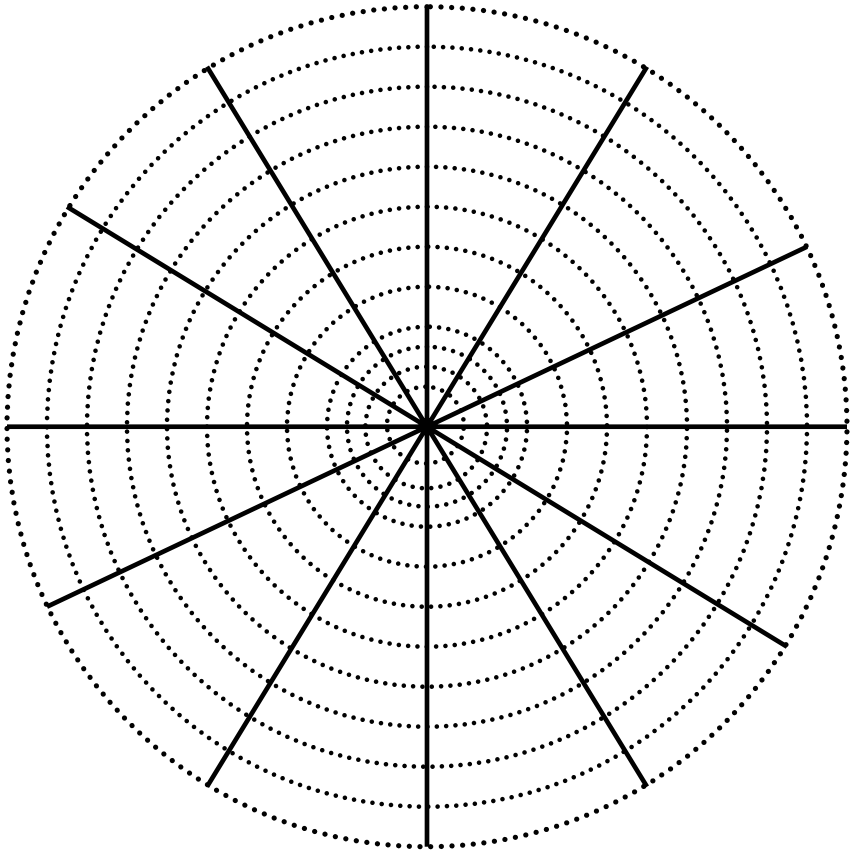

**Figure 2.** Trapping web design where solid lines represent trap lines radiating from a central point, and dashed lines represent concentric trap rings set at defined distances. Traps are placed where solid and dashed lines intersect.

## 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 seam on the left side of the trap when the door is facing you. There should also be a paperclip that prevents that door from completely closing and potentially damaging animal tails (replace paperclip if missing).

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 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 can not find the tab.

After adjusting the trap sensitivity, place the trap on the ground at the station (marked with labeled pin flag), parallel with the trap line, and with the opening facing northward. Traps should be placed on a level surface so that the entrance is flush with the ground and does not teeter. Use your boot to scrape out an even space if necessary. Traps should be placed parallel to the trap line. 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, which could damage its tail. Place the remainder of the millet in a line just in front of the trap (e.g., about 5–10 seeds).

### 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. Unless the grid is being closed, apply ant powder if there are ants, even if you are doing the last trap check of the day/night. 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

### Equipment per handler

1 Headlamp
3 Pesola® Scales: 20g, 100g and 300g
1 Ruler (clear 6-inch)
1 Kestrel (per team)
3 Animal handling bags
PDA (1 per team if grids)
Non-toxic marker
Animal Mortality Record
Species field guide/key
Digital camera
Waste bags for used millet
Ant powder (pre approved only)
Extra batteries

Traps are checked twice per night. The first check (i.e., midnight check) is approximately 5 hours after sunset, and the second check is just before dawn. Grids are typically checked in teams of 2, and webs in teams of 4–8. Grid teams consist of a single recorder, with both crew members handling animals. Handlers typically record their own data on trapping webs, depending on trap-line assignments. Each trap line is typically checked by a single person regardless of trap design used.

Walk along trap lines noting pin flag number and whether each trap is open, closed and empty, or closed with a capture. 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. Only record the status of the traps you or your handling/recording partner checked. Adjust the treadle on robbed traps.

### Empty Traps

Visually check each open trap to verify that it is not occupied by a pocket mouse. We have captured several pocket mice in seemingly open traps because the animal had not tripped the treadle. Physically pick-up the trap to check for bait and ensure that

treadles are set properly. Place the trap parallel to the trap line and facing north if you are conducting a midnight check. See instructions below for closing traps after a dawn check.

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. Set treadle, replace bait (in necessary) and place trap parallel to trap line if empty. Follow animal handling procedures described below if there is an animal in the trap.

**Occupied Traps**

Pick up the trap if the door is closed, and take notice of the weight. Follow the directions below if it feels like an animal is inside. Use caution, as non-mammal species may occasionally be captured (see Rattlesnakes below).

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 handling bag over the top of the trap so that the crease at the bag's 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. Be careful of wire hinges on the trap tearing into the plastic bag.

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

**Closing Traps**

Traps should be closed after dawn checks by disposing of excess bait in a waste bag, closing traps, and placing them on the ground perpendicular to trap lines. Closed traps must be placed perpendicular to distinguish them from non-checked parallel traps, and to ensure that we do not leave an animal in a trap during the day. Also, each trap must be checked for animals before closing by placing your hand inside and pushing the treadle to the bottom. Animals sometimes hide under the treadle and go undetected. Never close a trap without looking inside and checking the treadle first.

Animals left in traps after the dawn check will die as a result of extreme heat exposure. Animals that enter and trip traps left open after the dawn check will also perish. Take precautions to ensure that all traps are empty and closed after each dawn check.

### 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 a 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 a 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 a predator will likely return for a second helping if it had moved the trap.

### Rattlesnake in Trap

Traps will feel abnormally heavy when occupied by a snake. 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 do not tend to 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 a 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; and 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 a distance of one-third to one-half of 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. PROCESSING ANIMALS

### 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.

Seal opening in the handling bag by folding the corners inward and the top down over the folded corners. Wait until the animal is calm, then clip the scale to the top flap of the bag, making sure that each flap is within the grasp of the scale's clamp. Record weight in grams under 'Total wt' on the data sheet. Save bag contents to weigh later.

### Handling the animal

Work the animal to the bottom of the handling bag, trying to avoid trapping its head in a corner. This is best accomplished by placing the bag against your thigh, and decreasing the amount of open space by sliding your hand downward from the top of the bag against your leg. Secure the animal through the bag in the palm of your working hand (e.g., right-handed, left-handed), being careful to avoid the head and biting teeth. Open

bag and grasp the animal firmly by the scruff of the neck with your non-working hand. Alternatively, grasp the animal's tail *at the base* after you have secured it through the bag with your non-working hand. Never 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. Let the animal rest on your upper leg or chest (you are still holding its tail at the base) and scruff it snugly.

**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. Use a marker to label the outer bag with the date, time, site, grid ID, trap ID, and observer initials. Bring the animal back to the office to be placed in the freezer for later disposition. 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 Federally listed species (SKR, SBKR), also put a copy of the Mortality Record on the Program Administrator's desk. Designate one crew member to call the Program Administrator 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**

If a female gives birth while in a trap, place the mother on the ground and watch her. If she enters a burrow, place the babies in the entrance of that burrow and leave them alone. If you do not see where the female goes following her release, place the babies outside the trap and record the incident in the notes section on the data sheet.

**Hot or cold animals**

Place cold animals (lethargic and unresponsive) in a pocket close to your body until they are active. 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, 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.

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

PIT tag: See separate protocol for marking PIT tags. Do not attempt this procedure without training and permission from lead staff.

Ear tag: See protocol for applying ear tags. Do not attempt this procedure without training and permission from lead staff.

**Recaptured animals**

An animal is considered a "recapture" if it was previously captured during the current trapping effort. Recaptured animals are identified by the color mark on their ventral side that is unique to a particular trapping effort. Other marks will vary between projects and may even vary between nights. Be sure you are clear on the marking scheme being used anytime you are trapping. Only record species, sex, and reproductive condition for recaptured animals.

**Identify the species**

You should be comfortable with identification of local small mammal species before conducting surveys. 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, 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 boney spur protrudes from the genitalia, the animal is a male. Record the sex on the data sheet.

**Reproductive status of the animal**

The categories of reproductive status are: scrotal or not reproductive for males; pregnant, perforate, lactating, plugged, or not reproductive for females. 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. 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, and 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.

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.

Take all measurements on all animals whenever possible. Weather conditions, personnel shortages, or other unforeseen reasons may require that some data not be recorded; at a minimum, record species, sex, and reproductive status. You should make educated decisions about what to record and how to protect animals if a crisis occurs (e.g., trap predation). See separately provided Mammal Trapping Guidelines for weather guidance. The following measurements can be used to identify species, and are the minimum measurements that are to be recorded for each:

- *Chaetodipus* – weight, ear at notch, hind foot length (guard 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.

Record species and measurements taken for purpose of identifying all other species not listed above.

Remove the animal from the bag after processing, and gently release it by placing it on the ground at the trap station where it was captured. Weigh the bag with the contents, and record that weight under 'bag wt.' Do not remove millet, waste, etc. from bag before obtaining bag weight. Transfer excess millet or feces from the handling bag to a waste bag. The handling bag is then reused for the next animal unless it is torn or soiled. Record the fate of the animal as released (R), escaped (E), or dead (D).

**Grid quality control**

Trapping teams must verify that all traps have been checked by reviewing the quality-control form when a grid is completed. Each crew member 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). If using paper data sheets, sign the sheet recording that you verified that all traps had been checked. Count robbed and closed-but-empty traps after you have ensured that all traps have been checked, 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 pin flags by letter and place rubber bands around sorted groups if they are to be collected. Make sure that all pin flags, flagging tape, and reflective tape are removed, as 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 used at new 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 direct sunlight. Place the folded traps into the plastic buckets with lids when dry.

# **Appendix C**. Western Riverside County MSHCP Biological Monitoring Program Protocol 2011 for Estimating Population Density of Aguanga Kangaroo Rat

**Goal:** Estimate population density of Aguanga kangaroo rat in occupied habitat at Temecula Creek.

**Objectives:**

1. Center circular-trapping webs (148 traps, 12 trap lines, 100-m radius, 3.14 ha) on occupied 5x5 grids.
2. Estimate population density according to distance sampling methods using program DISTANCE.

Western Riverside County MSHCP species-specific objective 1 for Aguanga kangaroo rat (AKR) calls for the combined conservation of 5,484 acres of occupied habitat within the historic flood plains of Temecula Creek and Wilson Creek, and their tributaries (Dudek & Associates 2003). Moreover, a population density of medium or higher (i.e. ≥ 5-15 individuals per ha) must be maintained over 20% of occupied areas. We addressed these objectives by first estimating Percent Area Occupied (PAO) of suitable habitat that occurs at Temecula Creek and Wilson Creek from September to October 2010. We will then return to a sub-sample of grids where AKR were detected to estimate population density using trapping webs in August 2011.

We present here a survey design for estimating density only. Please refer to *Western Riverside County MSHCP Biological monitoring Program 2008 Protocol for Estimating Occupancy of Stephens' Kangaroo Rat* for a detailed description of site selection methods and survey design for estimating occupancy.

## METHODS

We will estimate population density during 22 – 26 August by randomly placing two circular trapping webs ($A$ = 3.14 ha) within Temecula Creek; an area where AKR were captured in 2010. Protocol was changed from previous density studies as conserved land parcels where AKR were captured were too small to allow the 100 m radius webs to be placed at all occupied grids. Each web will consist of 12 trap lines ($l$ = 100 m) radiating from the center at 30˚ intervals (Figure 1). We will place 12 traps along each line and 4 directly at the web's center for a total of 148 traps per web. We will place the first 4 traps on each line at 5-m intervals (5, 10, 15, 20 m from the center) and increase spacing between the last 8 stations to 10 m (30, 40, 50, 60, 70, 80, 90, 100 m from the center; Parmenter et al. 2003). Each trap station will be marked with a uniquely labeled pin flag indicating trap line (alpha code) and radial-distance category (numeric code).

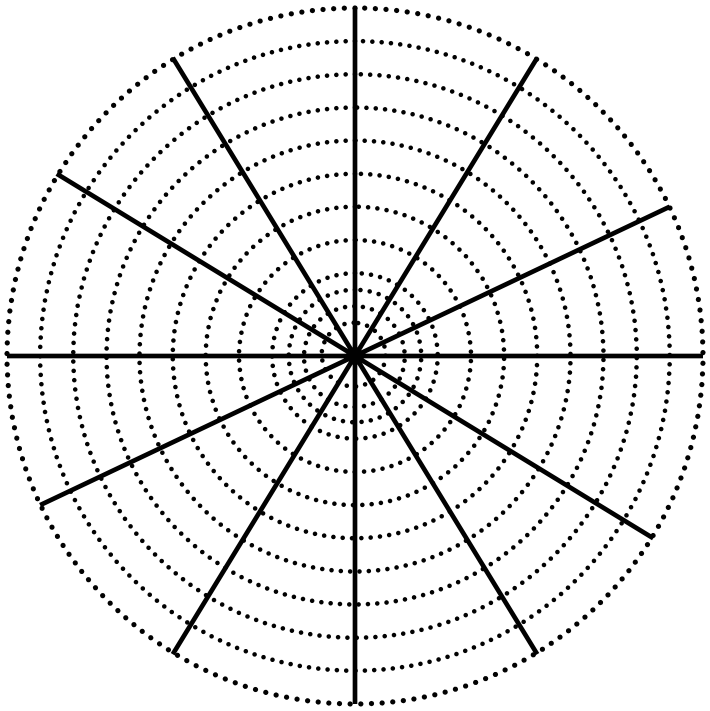

Figure 1. Trapping web design with 144 traps distributed along 12 trap lines and 4 traps at the center. Traps will be spaced along each 100-m line at 5-m intervals for the first 4 stations and at 10-m intervals for the last 8. Dotted circles represent radial-distance categories and solid lines indicate 100-m trap les.

We insured that trapping fell within moderate-to high suitability habitat by buffering conserved land within this habitat quality type and randomly placing trapping web centers in the buffered area. Including any data from captures outside of moderate-to high suitability habitat can potentially bias our population estimates high because low- and non-suitability habitat will likely contain only trace amounts of AKR (see Dudek & Associates 2007), thus skewing the probability of detecting animals near the web's center high relative to the perimeter and in relation to webs that fall completely within higher quality habitat (see Data Analysis discussion below).

Distance sampling methods of estimating density require that data be collected so that 3 assumptions are met: 1) individuals near the center of the trapping web are detected with a probability of 1, 2) there is no directional movement of animals (e.g. movement toward the web's center), and 3) distances from the web's center to each trap are measured accurately (Buckland et al. 2001). We will address the first assumption by batch marking individuals ventrally with a non-toxic marker, thus allowing us to determine if trapping-web centers are being trapped out. Finally, we will measure the distance to each trap with a 100-m tape when installing webs. This design was tested in 2008 with Stephens' kangaroo rat (SKR) (*Western Riverside County MSHCP Biological Monitoring Program 2008 Protocol for Estimating Population Density of Stephens' Kangaroo Rat*).

We will sample webs (n = 2) on small area of conserved land at Temecula Creek in random order from 22 - 26 August. This trapping-web effort will be over 4 nights with trap checks occurring twice nightly following U.S. Fish and Wildlife Service 10(a)(1)(A) permit guidelines. Only field personnel with prior animal handling experience and/or

having demonstrated proficiency in this area after being trained by experienced Biological Monitoring Program staff will process animals (Table 1).

Table 1. Western Riverside County Multiple Species Habitat Conservation Plan Biological Monitoring Program field staff currently scheduled to conduct Aguanga kangaroo rat surveys in 2011.

| Name | Position | Agency |
|---|---|---|
| Jennifer Hoffman | Mammal Program Lead | Regional Conservation Authority |
| Betsy Dionne | Field Biologist | Regional Conservation Authority |
| Espie Sandoval | Field Biologist | Regional Conservation Authority |
| Joe Sherrock | Field Biologist | Regional Conservation Authority |
| Tara Graham | Field Biologist | Regional Conservation Authority |
| Mari Paramo | Field Biologist | Regional Conservation Authority |
| John Dvorak | Field Biologist | Regional Conservation Authority |
| Lynn Miller | Field Biologist | Regional Conservation Authority |
| Michele Felix | Field Biologist | Regional Conservation Authority |
| Jonathan Reinig | Field Biologist | Regional Conservation Authority |
| Talula Barbee | Volunteer | Santa Ana Watershed Association |
| Nicole Housel | Volunteer | Santa Ana Watershed Association |

## Data Analysis

We will estimate population density (AKR per ha) for Temecula Creek using distance-based models found in Program DISTANCE (Thomas et al. 2006). In general, DISTANCE will estimate density by first fitting observed data to a modeled detection curve (e.g. half-normal) and then modifying the number of detected animals by the probability of observing individuals near the web's center relative to distances further away based on the fitted model (Buckland et al. 2001). We will examine histograms of first-time detections and remove any distance categories from our analysis that may indicate 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 will then construct 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 (Parmenter et al. 2003). We will 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 will be removed if they 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 will rank 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 ($\hat{\bar{P}a}$) across the candidate set (Burnham and Anderson 2002). Confidence intervals were calculated for $\hat{\bar{D}}$ and $\hat{\bar{P}a}$ using formulas described in Buckland et al. (2007).

**TIMELINE**

August

15 – 19: Install trapping webs at Temecula Creek.

22 – 26: Trap webs at Temecula Creek.

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## Trapping-web Field Procedure

*-Installation (refer to Diagram 1 and Protocol for Estimating Density)*:

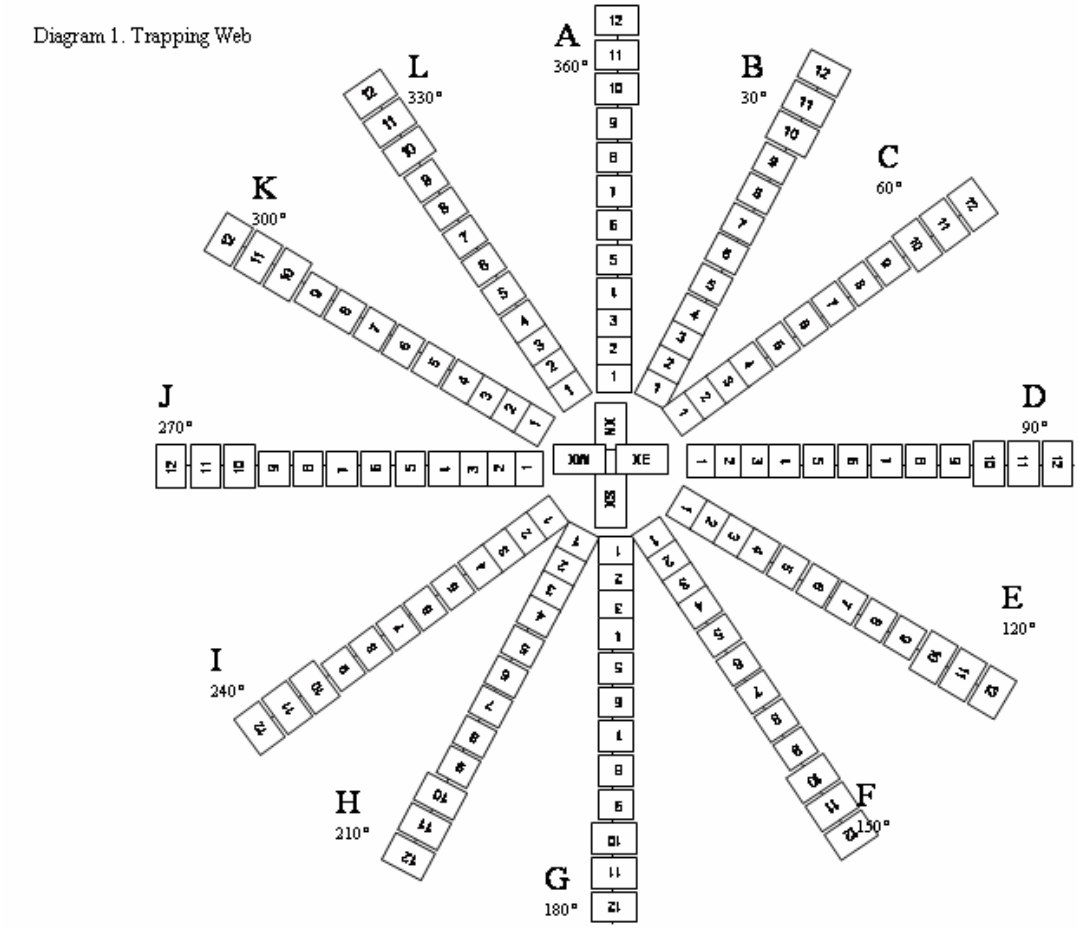
1. Insert a survey pin firmly into the ground at the trapping web center (station C3 of 5x5 grids). This pin will be the point from which each of the 12 trap lines will be measured, so it is important not to move it while installing the web.
2. Attach a 100-m tape to the center pin and stretch it along the length of a 100-m trap line using a delineated compass. Trap lines radiate from the center pin at 30˚ intervals beginning at north.
3. Pin the 100-m tape firmly into the ground once you have stretched it out along a trap line.
4. Place a labeled pin flag every 5 m for the first 4 trap stations (i.e. 5, 10, 15, 20 m from the center), then increase spacing to 10 m for the remaining 8 stations (i.e. 30, 40, 50, 60, 70, 80, 90, 100 m from the center). Stations along each trap line (A through L) should be numbered 1 through 12; increasing as you move away from the web's center.
5. Pin flags should alternate colors between trap lines (orange, green, and pink). Traps become closer as you move toward the web center. Alternating pin-flag color should make it easier to stay on one particular trap line while conducting surveys.
6. Routes between trap lines at the web's perimeter should be clearly marked w/ reflective tape.
7. Place 4 labeled pin flags (XN, XE, XS, and XW) together at the trapping web center (i.e. in place of survey pin). These flags will be used to mark 4 traps facing north, east, south, and west at the trapping web center.
8. A major assumption for the analysis of trapping webs requires that distances from the web's center to each trap are measured accurately. Failing to meet this assumption can greatly compromise our data and result in failure to fit a statistical model that will generate a reliable estimate of population density.
9. Equipment:
    - 100-m tape(s)
    - Survey pins
    - Delineated compass(s)
    - Pin flags (yellow, pink, and orange)
    - Reflective tape
    - Flagging tape
    - Sharpie(s)

*-Trap set-up*:

1. Traps should be set at labeled pin flags along each trap line at the radial-distance categories defined above.
2. Trap doors should open toward the trapping web perimeter (i.e. trap doors should *not* face the trapping web center).
3. Place an additional 4 traps directly at the trapping web center with trap doors facing outward to the north, east, south, and west.
4. Refer to Small Mammal Standard Operating Procedures if you are unsure how to properly set a Sherman live trap.

*-Checking traps during a survey*:

1. Individual webs will be checked by 3 to 5 Field Biologists working independently along each trap line.
2. Trap checks should be conducted by walking along trap lines, both away and toward the web's center.
3. One Field Biologist should be designated to check the 4 traps at the web's center.
4. Animals will be batched marked upon each initial encounter and if mark has faded.
5. Trap checks should otherwise follow Standard Operating Procedures.



**Appendix D.** Summary of species recorded per trapping web during surveys for Aguanga kangaroo rat, 22-26 August 2011.

| Web | Scientific Name | Common Name | Covered | Total[1] |
|---|---|---|---|---|
| AKRweb1 | *Dipodomys merriami collinus* | Aguanga kangaroo rat | Y | 3 |
| | *Chaetodipus fallax fallax* | Northwestern San Diego pocket mouse | Y | 33 |
| | *Dipodomys simulans* | Dulzura kangaroo rat | Y | 1 |
| | *Neotoma lepidus intermedia* | San Diego desert woodrat | Y | 5 |
| | *Microtus californicus* | California vole | N | 1 |
| | *Mus musculus* | House mouse | N | 1 |
| | *Peromyscus maniculatus* | Deer mouse | N | 22 |
| AKRweb2 | *Dipodomys merriami collinus* | Aguanga kangaroo rat | Y | 3 |
| | *Chaetodipus fallax fallax* | Northwestern San Diego pocket mouse | Y | 41 |
| | *Dipodomys simulans* | Dulzura kangaroo rat | Y | 3 |
| | *Neotoma lepidus intermedia* | San Diego desert woodrat | Y | 3 |
| | *Perognathus longimembris brevinasus* | Los Angeles pocket mouse | Y | 1 |
| | *Microtus californicus* | California vole | N | 1 |
| | *Neotoma* spp | Unidentified woodrat | N | 1 |
| | *Peromyscus maniculatus* | Deer mouse | N | 48 |

[1] Total reflects the minimum number of unique individuals captured not the total number of captures.